Review

False memories and aging

Daniel L. Schacter, Wilma Koutstaal and Kenneth A. Norman

Although memory processes and systems usually operate reliably, they are sometimes prone to distortions and illusions. Here we review evidence indicating that cognitive aging is often associated with increased susceptibility to various kinds of false recollections. Accumulating data indicate that older adults frequently have special difficulties recollecting the source of information, which in turn renders them vulnerable to confusing perceived and imagined experiences, and to related kinds of memory distortions. Evidence from studies of false recall and recognition indicate that older adults are sometimes more likely than younger adults to remember events that never happened, reflecting the influence of indistinct encoding of events and the use of lenient criteria during retrieval. Neuroimaging studies suggest that age-related changes in medial temporal and frontal regions may play a role in the altered functioning of specific encoding and retrieval processes that give rise to memory distortions. Future studies of aging and false memories are likely to provide a promising avenue for illuminating basic mechanisms of memory distortion.

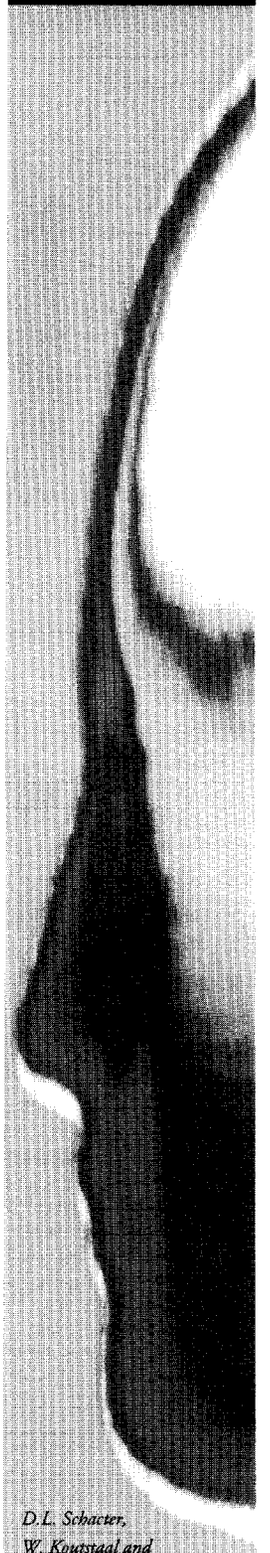
Memory is an adaptive function that supports the acquisition and retrieval of many different kinds of information. Although memory processes and systems usually operate reliably, producing mainly accurate representations of the past, psychologists have long known that memory is sometimes susceptible to various kinds of errors and distortions (for reviews, see Refs 1,2). Research concerning these false or illusory memories is important theoretically because it can provide key insights into the constructive nature of encoding and retrieval processes[3,4]. Such research also has important practical applications for a variety of everyday issues, including the reliability of eyewitness testimony (e.g. Ref. 5), the suggestibility of children's recollections (e.g. Ref. 6) and the accuracy of traumatic memories recovered in psychotherapy (e.g. Refs 7,8).

In this article we consider a domain in which issues concerning memory distortion are beginning to emerge as a major research topic: cognitive aging. Numerous studies have examined the nature and characteristics of aging memory, addressing such questions as whether long-term memory is more impaired by aging than short-term memory; whether recall is affected more than recognition; or whether explicit memory is affected more than implicit memory (for reviews, see Refs 9,10). Studies concerning memory distortion and aging are beginning to raise new questions that have not been explored extensively: Are older adults more susceptible to false recollections than younger adults, and if so, under what conditions? What underlying processes and impairments are responsible for such effects? And what can age-related changes in susceptibility to memory distortion tell us more generally about the nature of constructive memory processes?

To address these questions, we begin by reviewing studies that have documented an age-related decrease in source memory – recollection of when and where, or in what form, information was acquired. Recent studies have shown that failure to gain access to source information plays an important role in memory distortion[3,11,12] and, hence, is critical to understanding the relation between aging and false memories. We next turn to research that has examined false recall and false recognition in older and younger adults, and conclude by considering explanations and implications of the evidence considered in previous sections.

Source memory and aging

During the 1980s, results from numerous experiments indicated that older adults often have difficulties remembering various kinds of source information, including which of two experimenters imparted a fictitious fact (e.g. Ref. 13), whether an event was suggested or perceived (e.g. Ref. 14), or temporal and spatial attributes of recently studied information (e.g., Refs 15,16; for review, see Ref. 17). However, in these studies older adults often showed deficits in overall levels of recall or recognition, thereby raising the possibility that the observed source memory deficits are simply reflections of a more generalized memory decline. To determine whether older adults exhibit disproportionate impairments of source memory – above and beyond their recall and recognition deficits – more recent studies have attempted to equate the recall or recognition performance of older adults



D.L. Schacter, W. Koutstaal and K.A. Norman are at the Department of Psychology, Harvard University, 33 Kirkland Street, Cambridge, MA 02138, USA.

tel: +1 617 495 3855
fax: +1 617 496 3122
e-mail: dls@wjh.harvard.edu

 1364-6613/97/$17.00 PII: S1364-6613(97)01068-1

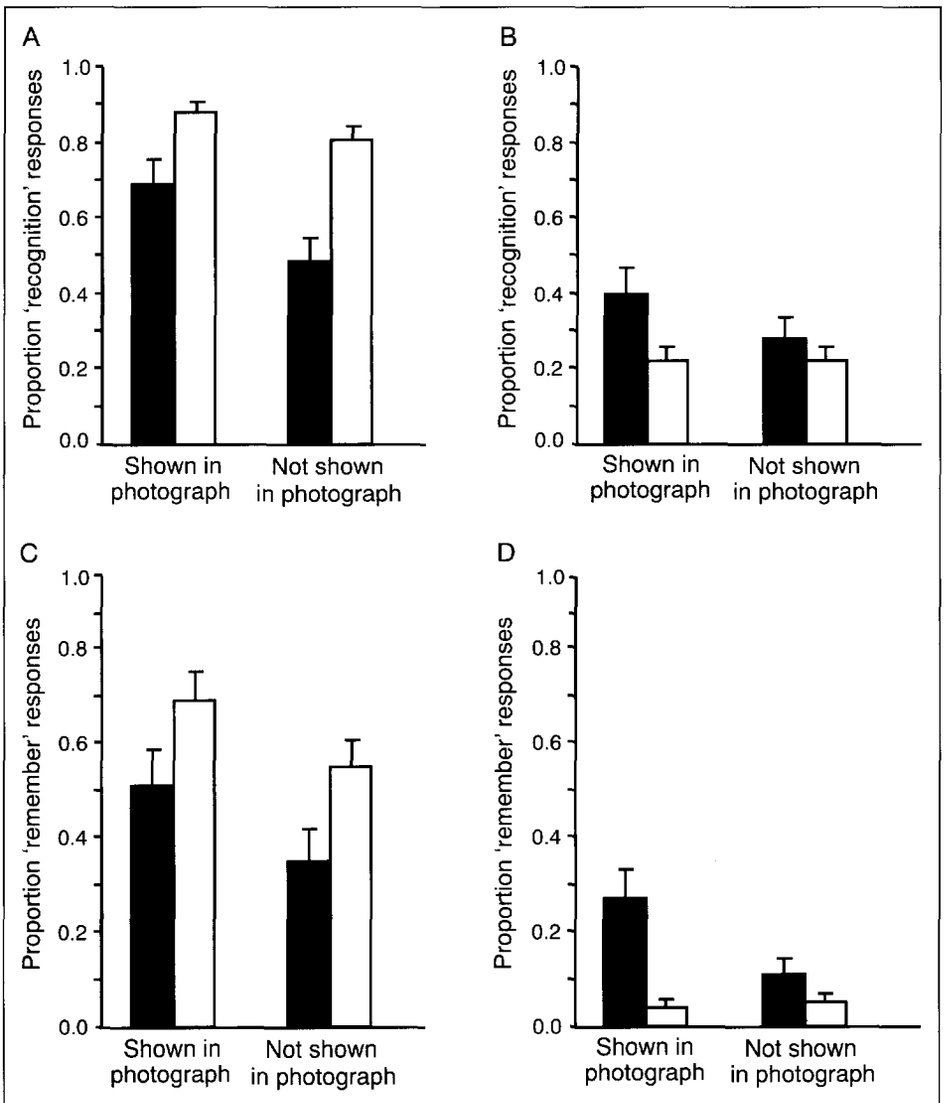


Fig. 1 Older and younger adults' false recognition of events shown in photographs. The mean proportion of correctly and falsely recognized events for older (black bars) and younger (white bars) adults in the false photographs paradigm (from Ref. 28, Expt. 2). Participants watched a series of videotaped events and were later shown photographs of some of the events, together with photographs of other 'false' events that were not part of the videotape. In a later recognition test subjects were asked to determine whether a verbal description matched an event that was depicted in the original videotape. Data are presented as the proportion of 'recognition' responses that were **(A)** correctly recognized, **(B)** falsely recognized, **(C)** correctly recognized and 'remembered' **(D)** falsely recognized and 'remembered', as appearing in the original videotape. Older adults falsely recognized verbal descriptions of events that had only been presented as photographs more often than younger adults, as measured by overall false recognition (B) or by false recognition accompanied by a judgement of 'remembering' specific details of the event (D). Error bars denote the standard error of the mean.

and assess whether elderly participants still show impaired source memory.

Studies using such a strategy have generally found some evidence for impaired source memory in older adults under conditions in which recall or recognition performance of older and younger adults has been equated experimentally[18–21]. However, the relation between source memory and recall/recognition performance varies across conditions, with older adults showing disproportionately poor source memory in some experimental conditions, but not in others[18,20,22].

Whereas the aforementioned studies require an explicit source judgment, links between source recall and memory distortion have also been explored in paradigms that test memory for source indirectly. One such procedure is known as the 'false fame' paradigm[23]. In this procedure, people are first exposed to a series of famous and nonfamous names, and are later asked to make fame judgments about various famous and nonfamous names. When a previously presented nonfamous name seems familiar, but participants have forgotten that the name was presented earlier in the experiment, they may incorrectly claim that a nonfamous name is famous. Thus, source memory failure is inferred when false fame errors occur. Dywan and Jacoby[24] reported that older adults are more susceptible to the false fame effect than are younger adults. Bartlett, Strater and Fulton[25] reported a similar age effect using nonfamous faces. Multhaup[26] reported that older adults exhibited increased susceptibility to the false fame effect when they were simply asked to indicate whether a name is famous or not, as was done in Dywan and Jacoby's[24] study. But when a more fine-grained source monitoring judgment was required, in which subjects were asked to indicate, on an item-by-item basis, whether each name was a nonstudied nonfamous name, a studied nonfamous name, or a famous name, no age differences were observed. These results raise the possibility that older adults sometimes rely on relatively lax source monitoring criteria, failing to spontaneously or consistently consider evidence that could help them avoid source errors. However, because neither older nor younger adults exhibited a false fame effect in the 'strict criterion' condition of Multhaup's study, resulting in a kind of floor effect, it is difficult to determine unambiguously whether the source monitoring performance of older adults improved differentially as a result of the criterion manipulation.

In the false fame paradigm, memory errors can be avoided by using source recollection to counter or oppose the sense of familiarity that may arise when judging a previously studied nonfamous name. Jennings and Jacoby[27] used a related type of opposition procedure to examine source memory errors produced by repetition. After studying a list of words, older and younger adults were given an old/new recognition test in which each old word was provided once, but each new word occurred twice with a varying lag between its first and second occurrence. Participants were instructed to respond 'old' only when a word had appeared on the study list; they were also told that if a word occurred twice on the test, it was safe to conclude that it could not be a study word because studied words would appear only once. Thus, source recollection was required to oppose any

familiarity produced by the repeated presentation of a new word on the recognition test. Older adults responded 'old' to repeated new words significantly more often than did younger adults, even when the lag between repetitions was as small as four intervening items (older and younger adults responded 'old' equally often to nonrepeated new words).

Schacter *et al.*[28] explored links between source memory failure and false recollection with more naturalistic materials. They presented older and younger adults with videotaped scenes of everyday events, and later showed them photographs of some previously viewed actions, as well as actions that had not been seen previously but that took place in the identical setting and involved the same people as the videotaped events[28]. On a later recognition test, participants were given brief verbal descriptions of individual objects or actions, and were instructed to respond 'old' only when they specifically remembered seeing the object or action in the videotape; participants were explicitly warned that some of the objects and actions occurred only in photographs. Older adults were more likely than younger adults to falsely remember that objects and actions that had appeared only in photographs were part of the original videotape (see Fig. 1), even when the overall level of recognition accuracy was similar in the two groups[28]. Additional analyses showed that elderly adults were less able than younger adults to recall perceptual and contextual details that could be used to differentiate sources when they were explicitly asked to do so. Therefore, in this paradigm source confusions are not simply a matter of recollecting useful contextual information and then failing to make use of it[26].

The relation between source confusions and false recognition has also been examined recently by Henkel, Johnson and DeLeonardis (unpublished observation). They showed older and younger adults pictures of objects and asked them to imagine other objects. On a later recognition test, elderly adults were more likely than younger adults to claim that they had actually seen previously imagined items (e.g. lollipop, banana) that were related to pictures they had seen, either conceptually (apple) or perceptually (e.g. magnifying glass, which in overall shape and form resembles a lollipop). In both the Schacter *et al.*[28] and Henkel *et al.* studies, older adults were disproportionately prone to source confusions, and associated false recollections, even when their overall level of recognition accuracy was matched to that of younger adults.

In summary, there is an emerging consensus that older adults are often prone to source memory failure, and that such failures can produce increased susceptibility to memory distortions.

False recall and recognition

False recall refers to the spontaneous production or intrusion of nonstudied information, whereas false recognition refers to the erroneous claim that a nonstudied word or object was presented previously. Several early studies of aging memory examined false recognition using variants of a paradigm developed by Underwood[29] in which test words are preceded by a semantically or physically related word[30–32]. Young adults show a small but reliable false recognition effect in this paradigm (i.e. more false alarms for new test words that are related to previously shown words than for new test words that are unrelated to previously shown words); older adults exhibit significantly greater false recognition of related words than do younger adults.

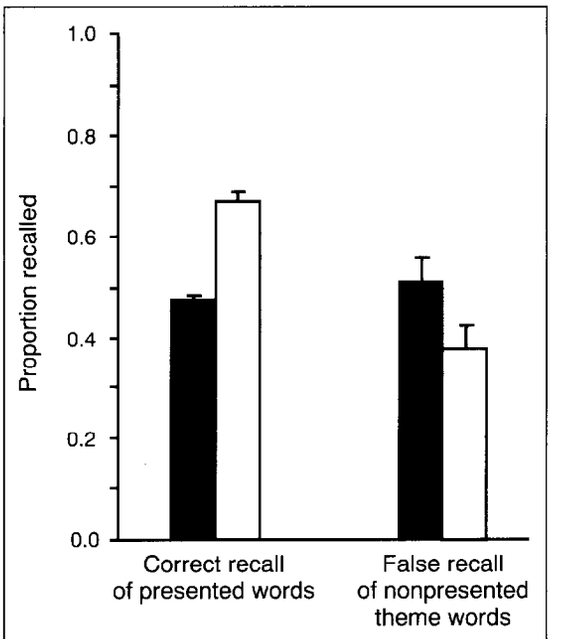


Fig. 2 False recall of semantically related words in older and younger adults. Mean proportion of correctly recalled targets and falsely recalled nonpresented theme words for older (black bars) and younger (white bars) adults (from Ref. 35, Expt. 1), using the converging associates paradigm[33,34]. Individuals first listened to lists of semantically related words (e.g. candy, sour, sugar, bitter, etc.) and were then tested with free recall. Whereas younger adults recalled more of the actually presented words than did older adults, the reverse was true for the never-presented theme words: older adults intruded more of these items than did younger adults. Error bars denote the standard error of the mean.

A number of recent studies have used procedures initially introduced by Deese[33], and modified by Roediger and McDermott[34], to elicit exceptionally high levels of false recall and recognition. In the Deese/Roediger–McDermott paradigm, people initially study sets or lists of approximately 15 semantically related words (e.g. candy, sour, sugar, bitter, etc.), all of which converge on a nonpresented 'theme' word (e.g. 'sweet'); later, they are given free recall or old/new recognition tests that include both previously presented target words and nonpresented 'theme' words. In free recall testing, Roediger and McDermott[34] reported that young subjects intruded approximately 55% of theme words – slightly more than the proportion of words correctly recalled from the middle serial positions of the study list. Norman and Schacter[35] found that older adults recalled fewer study list words and intruded more theme words than did younger adults (see Fig. 2). Tun *et al.* (unpublished observation) reported that older adults recalled fewer study list words than younger adults, but intruded approximately equal numbers of theme words. Thus, both of the latter studies indicate that older adults are relatively more susceptible to false recall of semantic associates than are younger adults. These results complement other evidence indicating

Box 1. False memory and aging: interpretative and methodological issues

Research concerning the relation between aging and false memories raises a number of methodological issues that need to be confronted in order to interpret age-related changes (or the lack thereof) in susceptibility to memory distortion. Because several different factors may contribute to comparatively elevated levels of false recognition in older adults, methods for differentiating between those factors, and determining their relative contributions to recognition performance, are essential. For example, in any one instance, relatively greater levels of false recognition in older than younger adults might derive from:

(a) an overall age-related shift in individuals' willingness to designate items as 'old,' that is, a comparatively global shift towards the use of more lenient response criteria in older adults

(b) an age-related shift in individuals' willingness to say 'old' based on 'gist' – memory for having studied items that are related to the test probe

(c) an overall age-related decrease in sensitivity, that is, a comparatively global change in the ability to discriminate target from nontarget items

(d) an age-related decrement in item-specific memory – the ability to discriminate studied items from related lures

(e) a combination of any of the above. For example, compared with younger adults, older adults might show *both* an overall decrease in sensitivity and, superimposed on this, an especially large decrease in item-specific memory; further, age-related changes in the ability to discriminate target from nontarget items might, or might not, also be accompanied by criterion changes.

To illustrate some of these possibilities, consider data from one of the experiments of Koutstaal and Schacter[a] using the related pictures paradigm. In this paradigm, older adults (aged 64–75 yrs) and younger adults (aged 18–25 yrs) were shown detailed colored pictures from various categories (e.g. cars, dogs and chairs); either 1, 9 or 18 pictures from each category were presented in a randomly intermixed (nonblocked) order. An incidental encoding task was used in which participants rated how much they liked each picture. Three days later, participants were shown a subset of these previously presented pictures, together with new pictures that were either related to the presented pictures, or were novel. The figure shows the proportion of correct recognition and false recognition responses for older and younger adults separately for where 1, 9 or 18 items from a given category had been presented during study, as well as false alarms for novel (nonstudied) categories.

Examination of the figure suggests that older adults clearly showed heightened false recognition of related lures; indeed, their rate of false recognition for items when 18 related pictures had been presented at study (63%) approached their correct recognition rate for items from '1-item' categories (68%). How can we

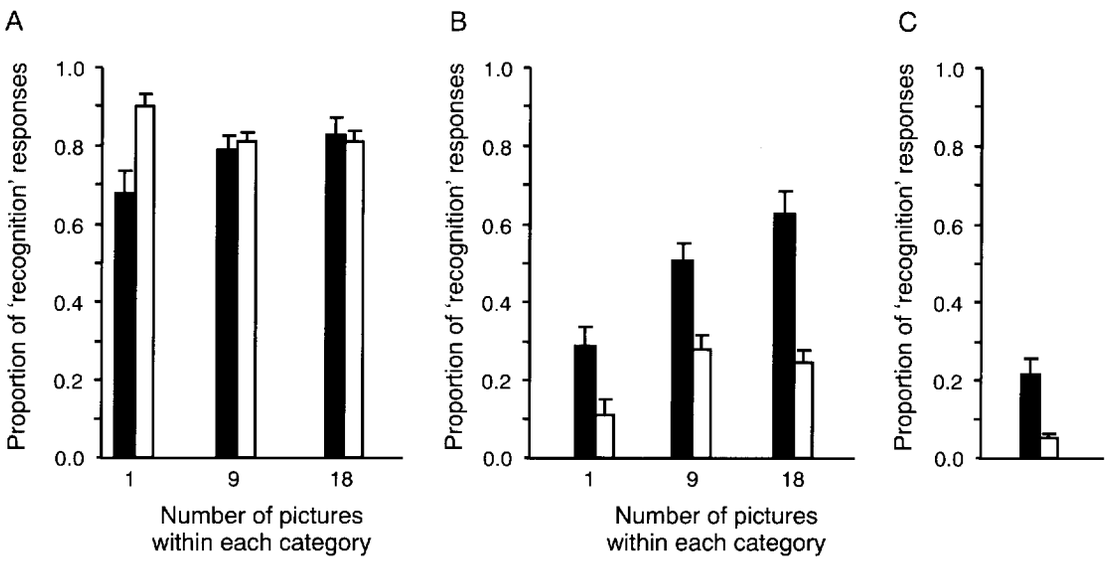


Fig. False recognition of related pictures in older and younger adults. Mean proportion of correctly recognized and falsely recognized items for older (black bars) and younger (white bars) adults in the related pictures paradigm (from Ref. a, Expt. 3). **(A)** Hits and **(B)** false alarms are shown separately for conditions where 1, 9 or 18 pictures from a category (e.g. cats, chairs) were presented during the study. **(C)** The baseline rate of false alarms to pictures from nonstudied or 'Novel' categories. Whereas older and younger adults showed similar correct recognition rates (hits) when 9 or 18 pictures from a category had been studied, older adults showed markedly impaired correct recognition of items from categories where only one picture was studied; older adults also showed much higher levels of false recognition than younger adults. Error bars denote the standard error of the mean.

that older adults sometimes produce more intrusions in recall of sentences than do younger adults[36].

Results concerning age-related differences in false recognition of semantic associates in the Deese/Roediger–McDermott paradigm show similar trends, although they are not as consistent. In an initial experiment, Norman and Schacter[35] found age-related decreases in true recognition of studied words together with similar levels of false recognition of semantic associates in younger and older adults. In a second experiment, they found that older adults showed decreased levels of true recognition and increased levels of false recognition. Note that in half of the conditions in Norman and Schacter's experiments, the recognition test was preceded by a free recall test, raising the possibility that the observed age effects in false recognition are partly attributable to source confusions concerning the origin of previously

understand this in terms of the hypotheses outlined above? First, can changes in older adults' response criteria account for the data in the figure? If the only effect of aging was to increase elderly adults' *overall* tendency to designate items as 'old,' then age-related differences in criteria should be relatively uniformly found regardless of the number of related items that were presented at study. Further, these differences in response criteria should not be accompanied by any differences in sensitivity (the ability to discriminate target from nontarget items). However, signal detection analyses reported by Koutstaal & Schacter[a] suggested that, rather than a simple across-the-board age difference in response criteria, older adults employed particularly lenient criteria when responding to items for which they had seen many (9 or 18) items from that category under study. Moreover, although older adults showed decreased sensitivity relative to younger adults (averaging across all of the conditions), this overall difference in sensitivity was also modified by an interaction of age with category size, reflecting the fact that the ability of older adults to discriminate targets from nontargets was especially impaired for the items for which only one item from that category had been presented. These results suggest that older adults were responding more often on the basis of gist-like representations than were younger adults, and that this was associated with age-related changes in *both* sensitivity and criteria that were dependent on the particular type of items being tested.

These descriptions of the patterns of age-related differences in sensitivity and response criteria do not themselves point to why these differences emerge. Nonetheless, they suggest ways to reduce false recognition in the elderly. For example, it might be possible to induce older adults to employ more conservative recognition criteria at the time of retrieval through instructions emphasizing that studied and new items may be highly similar to one another, with the consequent need for careful scrutiny before designating items as 'old'. Similarly, it might be possible to remediate elderly adults' item specific memory deficits by providing encoding tasks that direct their attention to distinctive features of the stimuli. In addition, because simple tests of old/new recognition do not allow us to establish exactly what participants are remembering in conjunction with studied items and related lures, the use of more specific probes of memory, such as remember/know judgments[b,c], could provide additional opportunities to see precisely where older adults' performance diverges most – and least – from that of younger adults, and thereby provide further clues to the nature of underlying deficits in older adults.

References

a Koutstaal, W. and Schacter, D.L. Gist-based false recognition of pictures in older and younger adults *J. Mem. Lang.* (in press)

b Tulving, E. (1985) Memory and consciousness *Can. J. Psychol.* 26, 1–12

c Gardiner, J.M. and Java, R.I. (1993) Recognition memory and awareness: An experiential approach *Eur. J. Cogn. Psychol.* 5, 337–346

recalled items (i.e. whether items were originally presented, or were produced on the prior recall test). However, Norman and Schacter reported similar results even when no prior recall test was given, suggesting that the effects of prior recall cannot account for all age-related differences in susceptibility to false recognition. Like Norman and Schacter, Tun *et al.* (unpublished observation) reported two experiments in which older adults showed less true recognition, and either similar or greater levels of false recognition, than younger adults. However, they reported no age differences in true or false recognition in another experiment. In addition, Tun *et al.* recorded latencies to respond to test items, and found that older adults responded relatively more quickly than younger adults when falsely recognizing semantic associates. Recognition was preceded by a recall test in each of their experiments.

Norman and Schacter[35] also asked participants to rate various qualitative features of their memories for items they claimed to recognize. Older adults – like younger adults – indicated that false recognitions were based primarily on recollection of associated items. However, reported memory for what words sounded like when they were presented at study (the study lists were presented auditorily) discriminated less well between true and false recollections in older than in younger adults, suggesting that failure to retrieve specific sensory details is related to age-related increases in false recognition.

To the extent that older adults are relatively more susceptible to false recognition in the Deese/Roediger–McDermott paradigm, impaired source memory processes are a likely culprit, even when a recognition test is not preceded by a recall test. False recognition in this paradigm may occur, at least in part, because subjects 'think of' the related lure word during the study phase of the experiment, and later confuse this internal source with an external one (i.e., presentation by the experimenter; see Ref. 29). To evaluate whether older adults would exhibit increased susceptibility to false recognition under conditions that minimize this type of source confusion, Koutstaal and Schacter[37] developed a paradigm in which participants study differing numbers of pictures from various categories (e.g. 1, 9 or 18 pictures of children, chairs, dogs or items from other categories). After a three-day delay, subjects make old/new recognition judgments about previously studied pictures, related lure pictures, and unrelated lure pictures. Koutstaal and Schacter reasoned that during the study phase of the experiment, it is unlikely that subjects would 'think of' one of the similar lure pictures from the later recognition test, in the same sense that they might generate a related lure word such as 'sweet' during the study phase of a Deese/Roediger–McDermott experiment. Although individuals might spontaneously generate the category labels of the items during the study phase, and this might influence later decisions about whether a particular lure item was presented, the lures are, in fact, new – unlike an event or word that was itself previously encountered or generated but not in the required context.

In each of three experiments, older adults consistently exhibited much higher levels of false recognition of related pictures than did younger adults. In addition, older adults showed normal hit rates to studied pictures from large categories and impaired hit rates to pictures for which only one item from each category was presented (for further data and general discussion of issues concerning the interpretation of false recognition differences in aging studies, see Box 1). Overall, this pattern of results appears to indicate (a) age-related preservation of access to general similarity or 'gist' information[38–40] that is common to pictures from studied

categories where several items were presented, and that supports both hits and false alarms to items from these studied categories, and (b) age-related impairment of access to distinctive information about particular items, thereby explaining impaired hit rates to pictures where only one item from each category was presented.

Theoretical explanations

Although research on false memories and aging is still at an early stage of development, the evidence reviewed here strongly supports the conclusion that conditions exist in which elderly adults are more susceptible than younger adults to memory distortions and false recollections. What remains uncertain concerns the range of conditions under which such effects are observed, the critical variables that control them, and the mechanisms that underlie them. Nonetheless, a number of theoretical accounts have been suggested.

Norman and Schacter[35] suggested that older adults are less likely than younger adults to carry out strategic retrieval or monitoring processes that are required to evaluate source information, and thus are less likely to successfully counteract the tendency to respond positively to new items on the basis of general similarity information. Recent neuroimaging data have revealed that specific regions within the frontal lobe are involved in strategic or effortful aspects of retrieval[41,42], including source monitoring processes that are especially important for evaluating the veracity of retrieved information[43–45]. Several studies have provided evidence that source memory deficits are linked to frontal lobe dysfunction, both in brain damaged patients[46,47] and in elderly adults[20,48,49] (for review and discussion, see Ref. 50). Increased susceptibility to false recognition, too, has been linked to frontal lobe dysfunction[51,52]. These findings and ideas are consistent with neuroimaging evidence showing abnormal frontal lobe activations in the elderly in test conditions that require effortful retrieval[42,53].

A related account that also focuses on the retrieval stage holds that older adults generally use liberal response criteria, perhaps related to a compensatory strategy in which they tend to respond 'old' more often than younger adults because they are aware their memories are failing[32,54]. As noted earlier, some evidence consistent with the use of comparatively lax response criteria has been obtained in studies of the false fame effect[26]. However, signal detection analyses of true and false recognition have revealed either no evidence for the use of generally liberal response criteria on the part of elderly adults[32] or inconsistent evidence of liberal criteria[37].

Whereas the foregoing possibilities focus on criterion changes operative at retrieval, it has also been suggested that increased false recognition in elderly adults may reflect an age-related tendency to encode information less distinctively and more stereotypically than younger adults[32,37,55,56]. Evidence that age-related increases in false recognition are directly attributable to indistinct encoding is not yet available. Signal detection analyses examining discrimination between studied items and related lures[32,37] have revealed large and consistent age-related reductions in sensitivity, suggesting a role for processes other than (or in addition to) criterion changes, but these analyses do not implicate encoding processes specifically. Although the brain mechanisms of a possible encoding deficit are not known, Schacter *et al.*[4] hypothesized that hippocampal pattern separation mechanisms (responsible for minimizing interference between different memory traces[57]) work less efficiently in older adults. This idea is consistent with PET evidence indicating decreased hippocampal activation during encoding of novel faces in the elderly[58]. Thus, encoding and retrieval deficits may both contribute to age-related increases in susceptibility to false memory effects.

It may be more useful to focus on *interactions* between encoding and retrieval to understand false recognition effects in both older and younger adults. For example, extremely high rates of false recognition tend to be observed following encoding conditions that promote poor pattern separation (i.e. high levels of overlap between traces) by emphasizing similarities among target materials (e.g. Ref. 34). When relatively little distinctive, item-specific information is available to guide responding, people may employ more liberal recognition criteria. Consistent with this suggestion, Israel and Schacter[59] compared a 'high distinctiveness' condition (in which semantic associates were each accompanied by a distinctive picture during encoding) with a 'low distinctiveness' condition (in which semantic associates were presented without pictures), and found that young adults were less able to discriminate between old and new items and used more liberal recognition criteria in the low distinctiveness condition than in the high distinctiveness condition. Analogously, older adults may use more liberal criteria when encoding conditions promote poor pattern separation.

Finally, Tun *et al.* (submitted) proposed that because of age-related decreases in the efficacy of inhibitory mechanisms, older adults may be plagued by irrelevant information that comes to mind at the time of encoding, perhaps including associative information that is later falsely recalled or recognized. Although evidence of age-related deficits in suppression of no-longer-relevant information has been obtained, both for information that was presented by the experimenter (e.g. Refs 60,61) and for inferences produced by participants themselves (e.g. Ref. 62), direct evidence bearing on this inhibitory account in application to false recognition and recall is not yet available.

Outstanding questions

- How are age-related changes in brain function related to changes in susceptibility to false recognition?
- Under what conditions is source memory in older adults differentially impaired?
- What are the 'underlying functional components' of age-related memory impairment? (Some candidates are: overly generic encoding, lax or inappropriate retrieval monitoring, deficits in inhibitory processes during encoding and/or retrieval, pattern separation failure, and difficulties in binding different forms of information together to form a coherent trace.) How do these different deficits relate to one another, and how do interactions between these deficits conspire to make elderly adults more susceptible to source misattributions and other memory distortions?
- Can age-related changes in susceptibility to false recognition be reduced or eliminated? If so, how?

Conclusion

In this article we have considered converging lines of evidence that suggest that older adults are often more prone to memory distortions than are younger adults. A variety of deficits may contribute to this age-related increase in susceptibility to memory distortion, including indistinct encoding, use of lenient response criteria, and failure to link together or 'bind' the different elements of an episode (e.g. facts and sources) into a coherent trace. However, it seems clear that age-related memory impairment is not a homogeneous construct; different processes may be impaired to differing degrees in different older adults[10,49]. As such, in addition to conducting studies that pool data from large groups of elderly participants, it is important to examine individual differences between elderly adults for clues regarding how to 'carve age-related memory impairment at its joints'. This approach is well illustrated by Glisky *et al.*'s[49] studies that distinguish between elderly adults who perform poorly on memory tests that are primarily sensitive to medial temporal lobe damage, and elderly who perform poorly on tests that are primarily sensitive to frontal lobe damage.

Studies that attempt to disentangle and characterize memory processes compromised in elderly adults may not only inform our understanding of aging memory, but could also provide important insights into basic encoding and retrieval processes that are relevant to memory distortion across the life-span. Consistent with this suggestion, the understanding of basic memory processes has been informed by the study of populations with various kinds of memory deficits. For example, studies of patients with organic amnesic syndromes have provided crucial theoretical insights into such fundamental issues as the distinction between explicit and implicit forms of memory[63,64]. The age-related increases in susceptibility to various kinds of false memory effects reviewed here suggest that future studies of aging and false memory may provide important clues concerning the nature of the constructive processes that are an essential feature of human memory.

Acknowledgements

Preparation of this article was supported by grant AG08441 from the National Institute on Aging. We thank Lissa Galluccio for help with preparation of the manuscript.

References

1 Roediger, H.L., III (1996) Memory illusions *J. Mem. Lang.* 35, 76–100
2 Schacter, D.L. (1995) Memory distortion: History and current status, in *Memory Distortion: How Minds, Brains, and Societies Reconstruct the Past* (Schacter, D.L., ed.), pp. 1–43, Harvard University Press
3 Johnson, M.K., Hashtroudi, S. and Lindsay, D.S. (1993) Source monitoring *Psychol. Bull.* 114, 3–28
4 Schacter, D.L., Norman, K.A. and Koutstaal, W. The cognitive neuroscience of constructive memory *Annu. Rev. Psychol.* (in press)
5 Ross, D., Read, J.D. and Toglia, M.P. (1994) *Adult Eyewitness Testimony: Current Trends and Developments* (Ross,D., Read, J.D. and Toglia M.P., eds), Cambridge University Press
6 Ceci, S.J. and Bruck, M. (1995) *Jeopardy in the Courtroom*, APA Books
7 Lindsay, D.S. and Read, J.D. (1994) Psychotherapy and memories of childhood sexual abuse: A cognitive perspective *Appl. Cogn. Psychol.* 8, 281–338
8 Loftus, E.F. (1993) The reality of repressed memories *Am. Psychol.* 48, 518–537
9 Craik, F.I.M. *et al.* (1995) Memory changes in normal ageing, in *Handbook of Memory Disorders* (Baddeley, A.D., Wilson, B.A. and Watts, F.N., eds), pp. 211–241, Wiley
10 Light, L.L. (1991) Memory and aging: Four hypotheses in search of data *Annu. Rev. Psychol.* 42, 333–376
11 Schacter, D.L. (1996) *Searching for Memory: The Brain, the Mind, and the Past*, Basic Books
12 Zaragoza, M.S. and Lane, S.M. (1994) Source misattributions and the suggestibility of eyewitness memory *J. Exp. Psychol. Learn. Mem. Cogn.* 20, 934–945
13 McIntyre, J.S. and Craik, F.I.M. (1987) Age differences in memory for item and source information *Can. J. Psychol* 41, 175–192
14 Cohen, G. and Faulkner, D. (1989) Age differences in source forgetting: Effects on reality monitoring and eyewitness testimony *Psychol. Aging* 4, 10–17
15 Light, L.L. and Zelinski, E.M. (1983) Memory for spatial information in young and old adults *Dev. Psychol.* 19, 901–906
16 Park, D.C., Puglisi, J.T. and Lutz, R. (1982) Spatial memory in older adults: Effects of intentionality *J. Gerontol.* 37, 330–335
17 Spencer, W.D. and Raz, N. (1995) Differential effects of aging on memory for content and context: A meta-analysis *Psychol. Aging* 10, 527–539
18 Ferguson, S.A., Hashtroudi, S. and Johnson, M.K. (1992) Age differences in using source-relevant cues *Psychol. Aging* 7, 443–452
19 Johnson, M.K. *et al.* (1995) Aging and single versus multiple cues in source monitoring *Psychol. Aging* 10, 507–517
20 Schacter, D.L. *et al.* (1991) The relation between source memory and aging *Psychol. Aging* 6, 559–568
21 Schacter, D.L. *et al.* (1994) Source memory: Extending the boundaries of age-related deficits *Psychol. Aging* 9, 81–89
22 Hashtroudi, S. *et al.* (1994) Aging and the effects of affective and factual focus on source monitoring and recall *Psychol. Aging* 9, 160–170
23 Jacoby, L.L. *et al.* (1989) Becoming famous overnight: Limits on the ability to avoid unconscious influences of the past *J. Personality Soc. Psychol.* 56, 326–338
24 Dywan, J. and Jacoby, L.L. (1990) Effect of aging and source monitoring: Differences in susceptibility to false fame *Psychol. Aging* 3, 379–387
25 Bartlett, J.C., Strater, L. and Fulton, A. (1991) False recency and false fame of faces in young adulthood and old age *Mem. Cogn.* 19, 177–188
26 Multhaup, K.S. (1995) Aging, source, and decision criteria: When false fame errors do and do not occur *Psychol. Aging* 10, 492–497
27 Jennings, J.M. and Jacoby, L.L. (1997) An opposition procedure for detecting age-related deficits in recollection: Telling effects of repetition *Psychol. Aging* 12, 352–361
28 Schacter, D.L. *et al.* (1997) False recollection induced via photographs: A comparison of older and younger adults *Psychol. Aging* 12, 203–215
29 Underwood, B.J. (1965) False recognition produced by implicit responses *J. Exp. Psychol.* 70, 122–129
30 Rankin, J.S. and Kausler, D.H. (1979) Adult age differences in false recognitions *J. Gerontol.* 34, 58–65
31 Smith, A.D. (1975) Partial learning and recognition memory in the aged *Int. J. Aging Hum. Dev.* 6, 359–365
32 Isingrini, M. *et al.* (1995) Aging and encoding in memory: False alarms and decision criteria in a word-pair recognition task *Int. J. Aging Hum. Dev.* 41, 79–88
33 Deese, J. (1959) On the prediction of occurrence of particular verbal intrusions in immediate recall *J. Exp. Psychol.* 58, 17–22
34 Roediger, H.L., III and McDermott, K.B. (1995) Creating false memories: Remembering words not presented in lists *J. Exp. Psychol. Learn. Mem. Cogn.* 21, 803–814
35 Norman, K.A. and Schacter, D.L. False recognition in young and older adults: Exploring the characteristics of illusory memories *Mem. Cogn.* (in press)
36 Wingfield, A., Tun, P.A. and Rosen, M.J. (1995) Age differences in veridical and reconstructive recall of syntactically and randomly segmented speech *J. Gerontol. B. Psychol. Sci. Soc. Sci.* 50, 257–266
37 Koutstaal, W. and Schacter, D.L. Gist-based false recognition of pictures in older and younger adults *J. Mem. Lang.* (in press)
38 Brainerd, C.J., Reyna, V.F. and Kneer, R. (1995) False-recognition reversal: When similarity is distinctive *J. Mem. Lang.* 34, 157–185

39 Curran, T. *et al.* (1997) False recognition after a right frontal lobe infarction: Memory for general and specific information *Neuropsychologia* 35, 1035–1049

40 Hintzman, D.L. and Curran, T. (1994) Retrieval dynamics of recognition and frequency judgments: Evidence for separate processes of familiarity and recall *J. Mem. Lang.* 33, 1–18

41 Nyberg, L. *et al.* (1995) Functional brain maps of retrieval mode and recovery of episodic information *NeuroReport* 6, 249–252

42 Schacter, D.L. *et al.* (1996) The role of hippocampus and frontal cortex in age-related memory changes: A PET study *NeuroReport* 7, 1165–1169

43 Johnson, M.K. *et al.* (1997) Test format can affect the similarity of brain activity associated with true and false recognition memory *Psychol. Sci.* 8, 250–257

44 Rugg, M.D. *et al.* (1996) Differential activation of the prefrontal cortex in successful and unsuccessful memory retrieval *Brain* 119, 2073–2083

45 Schacter, D.L. *et al.* (1996) Neuroanatomical correlates of veridical and illusory recognition memory: Evidence from positron emission tomography *Neuron* 17, 267–274

46 Janowsky, J.S., Shimamura, A.P. and Squire, L.R. (1989) Source memory impairment in patients with frontal lobe lesions *Neuropsychologia* 27, 1043–1056

47 Schacter, D.L., Harbluk, J.L. and McLachlan, D.R. (1984) Retrieval without recollection: An experimental analysis of source amnesia *J. Verbal Learn. Verbal Behav.* 23, 593–611

48 Craik, F.I.M. *et al.* (1990) Relations between source amnesia and frontal lobe functioning in older adults *Psychol. Aging* 5, 148–151

49 Glisky, E.L., Polster, M.R. and Routhieaux, B.C. (1995) Double dissociation between item and source memory *Neuropsychology* 9, 229–235

50 Spencer, W.D. and Raz, N. (1994) Memory for facts, source, and context: Can frontal lobe dysfunction explain age-related differences? *Psychol. Aging* 9, 149–159

51 Parkin, A.J. *et al.* (1996) Verification impairment in the generation of memory deficit following ruptured aneurysm of the anterior communicating artery *Brain Cognit.* 32, 14–27

52 Schacter, D.L. *et al.* (1996) False recognition and the right frontal lobe: A case study *Neuropsychologia* 34, 793–808

53 Cabeza, R. *et al.* (1997) Age-related differences in neural activity during memory encoding and retrieval: A positron emission tomography study *J. Neurosci.* 17, 391–400

54 Reder, L.M., Wible, C. and Martin, J. (1986) Differential memory changes with age: Exact retrieval versus plausible inference *J. Exp. Psychol. Learn. Mem. Cogn.* 12, 72–81

55 Hess, T.M. (1984) Effects of semantically related and unrelated contexts on recognition memory of different-aged adults *J. Gerontol.* 39, 444–451

56 Rabinowitz, J.C., Craik, F.I.M. and Ackerman, B.P. (1982) A processing resource account of age differences in recall *Can. J. Psychol.* 36, 325–344

57 McClelland, J.L., McNaughton, B.L. and O'Reilly, R.C. (1995) Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory *Psychol. Rev.* 102, 419–457

58 Grady, C.L. *et al.* (1995) Age-related reductions in human recognition memory due to impaired encoding *Science* 269, 218–221

59 Israel, L. and Schacter, D.L. Pictorial encoding reduces false recognition of semantic associates *Psychonomic Bull. Rev.* (in press)

60 Zacks, R.T., Radvansky, G. and Hasher, L. (1996) Studies of directed forgetting in older adults *J. Exp. Psychol. Learn. Mem. Cogn.* 22, 143–156

61 Greenhut-Wertz, J. and Manning, S.K. (1995) Suffix effects and intrusion errors in young and elderly subjects *Exp. Aging Res.* 21, 173–190

62 Hasher, L., Quig, M.B. and May, C.P. (1997). Inhibitory control over no-longer relevant information: Adult age differences *Mem. Cogn.* 25, 286–295

63 Schacter, D.L., Chiu, C.Y.P. and Ochsner, K.N. (1993) Implicit memory: A selective review *Annu. Rev. Neurosci.* 16, 159–182

64 Squire, L.R. (1992) Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans *Psychol. Rev.* 99, 195–231