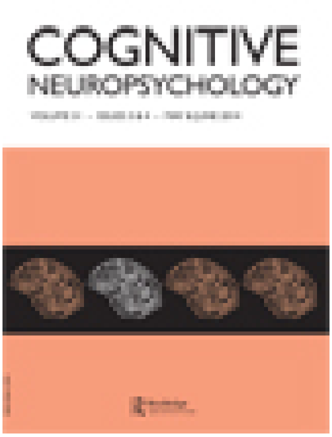

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Elizabeth A. Kensinger & Daniel L. Schacter
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Elizabeth A. Kensinger and Daniel L. Schacter
Harvard University, Cambridge, USA

After studying a list of words that are all associated to a nonpresented target word, people often falsely recall or recognise the nonpresented target. Previous studies have shown that such false memories are greatly reduced when study lists are presented and tested several times compared to a single study/test trial. We report that older adults, who are sometimes more susceptible to memory distortions than are young adults, failed to exhibit any reduction in false recall or false recognition after five study/test trials compared to a single trial. By contrast, younger adults showed robust suppression of false memories after five study/test trials compared to a single trial. These results are consistent with the idea that older adults rely on memory for the general features or gist of studied materials, but tend not to encode or to retrieve specific details of individual items.

INTRODUCTION

Numerous studies of ageing memory have documented that older adults exhibit lower levels of veridical recall and recognition of recently studied information than do younger adults (for reviews, see Craik, Anderson, Kerr, & Li, 1995; Light, 1991). But a growing body of evidence converges on the conclusion that, compared to younger adults, older adults sometimes show equal or greater levels of false recall and false recognition of items not previously studied. Early studies by Smith (1975) and Rankin and Kausler (1979) investigated false recognition using a procedure in which subjects make old/new decisions about previously studied words, new words that are related to a previously studied associate (related lures), and new words that are not related to previously studied words (unrelated lures). Both Smith and Rankin and Kausler reported higher levels of false recognition in older adults than in younger adults, although the overall magnitude of the false recognition effect was small (see also Isingrini, Fontaine, Taconnat, & Duportal, 1995).

More recent research has shown that larger false recognition effects can be obtained when subjects study numerous items that are conceptually or perceptually similar to a novel test item (Hintzman, 1988; Shiffrin, Huber, & Marinelli, 1995). Particularly striking demonstrations of robust false recognition and false recall have been reported by Roediger and McDermott (1995). They revived and modified a procedure, described initially by Deese (1959), in which subjects are initially exposed to lists of semantic associates (e.g., *candy, sour, sugar, bitter, good, taste,* and so forth) that all

Requests for reprints should be addressed to Daniel L. Schacter, Department of Psychology, Harvard University, 33 Kirkland St., Cambridge, MA 02138, USA.

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converge on a nonpresented theme word or "false target" (e.g. *sweet*). Deese found that subjects frequently introduced the false target on a recall test. Roediger and McDermott replicated Deese's findings concerning false recall and extended them to false recognition, showing exceptionally high levels of false alarms (e.g. 80%) to the theme word.

In studies of ageing memory using the Deese/Roediger-McDermott paradigm, Norman and Schacter (1997) and Tun, Wingfield, Rosen, and Blanchard (1998) reported that older adults are relatively more susceptible to false recall and false recognition than are younger adults: Older adults showed lower levels of veridical recall or recognition than did younger adults, together with either equivalent or higher levels of false recall or false recognition.

Even more striking age differences in false recognition have been reported by Koutstaal and Schacter (1997). In their paradigm, younger and older adults studied detailed coloured pictures from various categories. When given a recognition test after a 3-day delay, older adults showed considerably higher levels of false recognition to nonpresented pictures from studied categories than did younger adults. The age differences were most pronounced when subjects studied large numbers of pictures (18) from a given category, with older adults showing approximately twice as many false alarms (60–70%) as younger adults (e.g. 25–35%).

Why are older adults sometimes more susceptible to robust false recall and recognition than are younger adults? Although a variety of factors are likely to play some role (for review and discussion, see Schacter, Koutstaal, & Norman, 1997c), one probable contributor to the observed effects involves age-related deficits in the ability to recall specific details of previously studied items, together with increased reliance on memory for general features of studied items—what has been termed gist (Brainerd, Reyna, & Kneer, 1995; Reyna & Brainerd, 1995) or general similarity information (Hintzman & Curran, 1994). Several investigators have argued that false recall and recognition in the Deese/Roediger-McDermott paradigm depends, at least in part, on memory for the semantic gist of studied items (cf. Brainerd & Reyna, 1998; Payne, Elie, Blackwell, & Neuschatz, 1996; Schacter, Norman, & Koutstaal, 1998a; Schacter, Verfaellie, & Pradere, 1996b). Similarly, Koutstaal and Schacter (1997) hypothesised that false alarms to nonpresented categorised pictures reflects reliance on gist or general similarity information. Previous studies have shown that older adults have difficulties recollecting specific details of previously studied information (e.g. Glisky, Polster, & Routhieaux, 1995; McIntyre & Craik, 1987; Schacter, Osowiecki, Kaszniak, Kihlstrom, & Valdiserri, 1994), relying instead on encoding of generic features of target materials (Rabinowitz, Craik, & Ackerman, 1982).

Schacter et al. (1997c; see also Reyna & Brainerd, 1995; Schacter et al. 1998a) noted that impaired recollection of item-specific information, together with preserved retention of general similarity or gist information, should lead to a relatively greater susceptibility to robust false recall and recognition in older than in younger adults. This hypothesis is supported by findings from Norman and Schacter (1997), who probed qualitative features of true and false memories with the memory characteristics questionnaire (MCQ) developed by Johnson, Foley, Suengas, and Raye (1988). Elderly adults showed less discrimination between studied items and related lure words than did younger adults on MCQ categories concerned with perceptual and contextual features of remembered items. If the elderly have less access to item-specific information than do younger adults, then it follows that they would have less ability to discriminate presented items from nonpresented items based on that information.

Two recent studies have shown that increasing the availability of item specific information by repeatedly presenting lists of semantic associates can produce significant reductions in levels of false recall and false recognition. McDermott (1996) found that college students showed increased veridical recall rates and decreased false recall rates across five study/test trials: the proportion of items correctly recalled nearly doubled across trials, and the proportion of items falsely recalled was reduced by nearly one-half. In a study comparing true and false recognition in anmesic patients and normal controls, Schacter, Verfaellie, Anes, and Racine (1998b) observed across-trial patterns in the control group that were similar to those reported by McDermott, with true recognition increasing and false recognition decreasing across trials. However, amnesic patients failed to show any evidence of decreasing false recognition with increasing study/test trials; in fact, there were trends for increasing false recognition across trials in the amnesic group.

The overall pattern of results from McDermott (1996) and Schacter et al. (1998b) suggests that when healthy volunteers show increasing recollection of the items that actually appear on a particular list, they are also better able to remember which items did not appear, thereby reducing levels of false memories. As access to item-specific information builds across trials, subjects may rely less on gist or general similarity information and instead depend increasingly on their ability to remember information about specific items on the list. By contrast, Schacter et al. (1998b) suggested that amnesic patients retain little or no item-specific information that can be used to suppress the strengthening influence of gist information with increasing repetitions.

In the present experiments, we examine whether repeated presentation and testing of lists of semantic associates reduces false recall and recognition in older adults. We assume that repetition of associate lists increases the accessibility of *both* gist *and* item-specific information. We thus expect that, with repeated trials, elderly adults will increase their veridical recall and recognition rates because veridical memories can be enhanced both by gist and item-specific information. If, however, increasing levels of veridical recall and recognition across trials in elderly adults depend more on gist and less on item-specific information than in younger adults, then older adults should be less able than younger adults to use item-specific information to suppress false recognition across trials. By this view, older adults should show smaller repetition-related decreases in false recall and false recognition than younger adults. In the present study, we examine this possibility using false recall (Experiment 1) and false recognition (Experiment 2).

EXPERIMENT 1

In Experiment 1 we used the false recall paradigm reported previously by McDermott (1996). Elderly and young adults were presented with a 45-word list, consisting of three 15-word associate sets that were each related to a nonpresented related lure or false target (e.g. *table, sit, legs, seat, couch, desk, recliner, sofa, wood, cushion, swivel, stool, sitting, rocking, bench* for the false target *chair*). Study lists were presented in a blocked format, with all items of an associate set presented together. All subjects studied the same list five times, and after each list presentation completed a free recall test.

Method

Subjects

Twenty-nine Harvard Summer School students and Harvard undergraduates and 25 elderly subjects from the Boston/Cambridge area participated in the experiment. Elderly subjects were recruited via posters and fliers and were individually screened so as to exclude those with a history of alcoholism or substance abuse, any present or past treatment for a psychiatric illness, current treatment with psychoactive medications, drug toxicity, primary brain degenerative disorders, and brain damage sustained earlier from a known cause. Young subjects were recruited through sign-up sheets posted at Harvard University and were screened for current treatment with psychoactive medications. All subjects were native English speakers and had normal or corrected to normal vision and normal hearing. Each subject was paid $10/hour for his/her participation. The data from 5 young adults and 1 elderly adult who did not follow the testing procedures correctly were eliminated, and the data for the remaining 24 young adults (ages 17–25; mean age = 19.9; range of education = 11–17 years; mean years of education = 13.4) and 24 elderly adults (ages 60–75; mean age = 67.4; range of education = 12–19 years; mean years of education = 14.8) were included.

Materials and Design

Six of the 15-word associate sets used by Roediger and McDermott (1995) were used. These sets were divided into two 45-word lists, consisting of three 15 word associate sets per list (as in McDermott, 1996). Each subject listened to the 45-word list over a headset; words were presented in the same order for all 5 trials. All words of an associate set were presented together, with words in each set always presented in order of decreasing associative relatedness to the false target (i.e. most strongly to least strongly associated). Subjects listened to lists associated with either the false targets *chair, fruit,* and *mountain*, or with the false targets *cold, needle,* and *sleep*.

Subjects in each age group were randomly assigned to one of the two 45-word lists. The 15-word associate sets within these 45-word lists were presented in 3 separate orders (sets 1, 2, 3; sets 2, 3, 1; sets 3, 1, 2) to eliminate the possibility of presentation order effects. For each 45-word list, 4 subjects from each age group were assigned to each of these orders. Each of the five 45-word list presentations was followed by a free recall test.

Procedure

Subjects were tested individually. They were informed that they would be hearing a list of words presented a total of five times, and that after each presentation of the words they would be asked to recall as many words as possible. Study list words were recorded by a female speaker and were presented auditorily at a rate of one word every 2 seconds. The three lists were presented as one long list, without a break between them. After study list presentation, subjects were told to write down all of the words they could remember from the list, and to try to include only those that they were confident appeared on the list. Four minutes were provided for this free recall test. The same study-test sequence was repeated on each of the five trials.

Two scoring systems were used: In the lenient scoring system, small alterations such as "sleepy" or "fruits" for the words "sleep" and "fruit" were counted as true or false recalls for presented words and related lures, respectively; in the strict scoring system, these words were not scored as true or false recalls.

Results

Mean proportions of studied items (true targets) and related lures (false targets) were recorded for each trial. There were only slight differences between the lenient and strict scoring systems, and there were no substantial differences in statistical analyses between the two systems, so all results are reported using the lenient scoring system. Intrusions of items other than the false targets were virtually non-existent for both age groups (1 % or less of total responses) and so are not reported.

Veridical Recall

As Fig. 1 shows, younger adults recalled more true targets than did older adults on the first trial, both groups showed an increase in veridical recall across the five trials, and the magnitude of the increase was greater in younger than older adults (increasing from a difference of .11 in the first trial to a difference of .25 in the fifth trial). An overall ANOVA performed on the veridical recall rates with Age as a between-subjects variable and Trial as a within-subjects variable confirms these patterns, showing a significant effect of Age [$F(1,46) = 36.49$, $MSe = 0.064$ $P < .0001$], Trial [$F(4,184) = 257.17$, $MSe = 0.005$, $P < .0001$], and a Trial × Age interaction [$F(4,184) = 10.95$, $MSe = 0.005$, $P < .0001$]. Separate ANOVAs show significant effects of Trial on veridical recall for both elderly adults [$F(1,115) = 24.31$, $MSe = 0.017$, $P < .0001$] and young adults [$F(1,115) = 56.98$, $MSe = 0.017$, $P < .0001$], and a focused contrast shows that the young adults remembered significantly more true targets on Trial 1 as compared to the elderly adults [$F(1,23) = 11.67$, $MSe = 0.009$, $P < .003$].

False Recall

On Trial 1, older and younger adults showed the same rate of false recall (.38). For the young, this false recall rate was approximately equal to their rate of veridical recall (.37). However, older adults intruded a marginally greater proportion of false targets compared to the true targets they correctly recalled [.28; $F(1,23) = 2.64$, $MSe = 0.04$, $P < .13$].

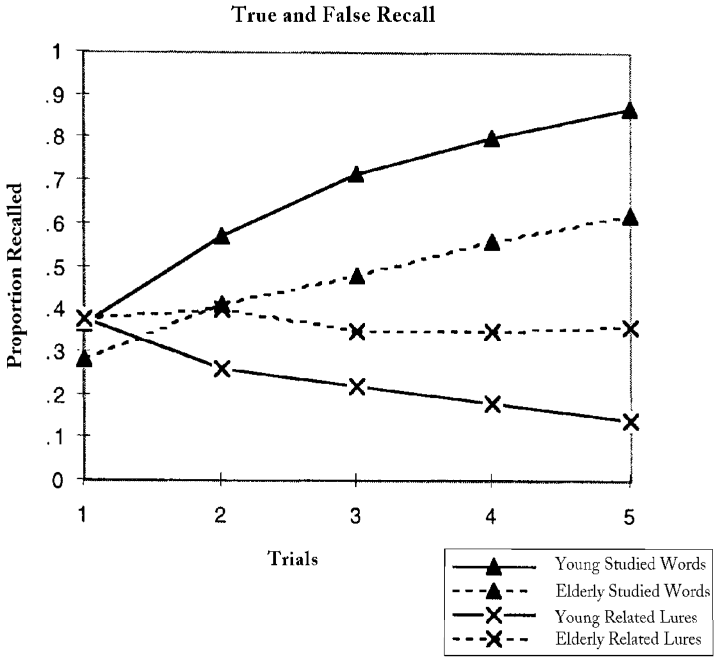

Fig. 1. *Proportion of studied words and related lures recalled as a function of study/test trials in Experiment 1. Both the young and elderly adults increased their veridical recall across the trials, although the elderly adults showed a more modest increase than did the young adults. The young adults reduced their false recall across the trials, whereas the elderly adults did not show any such reduction.*

As Fig. 1 shows, although older and younger adults began with identical false recall rates, the young adults sharply reduced their false recall responses across trials, from .38 on Trial 1 to .14 on Trial 5. In contrast, however, elderly adults continued to intrude similar proportions of false targets across the five trials, with no indication of any across-trials reductions. An overall ANOVA shows an effect of Age that approaches significance [$F(1,46) = 3.10$, $MSe = 2.97$, $P < .09$], an effect of Trial [$F(4,184) = 3.38$, $MSe = 0.34$, $P < .02$] and a Trial × Age interaction that approaches significance [$F(4,184) = 2.11$, $MSe = 0.34$, $P < .09$]. Separate ANOVAs that were performed for younger and older groups indicate a significant effect of Trial on false recall rates for young adult [$F(4,115) = 2.43$, $MSe = 0.73$, $P = .05$] but no such effect for the elderly adults [$F < 1$]. A focused contrast reveals that, by the fifth trial elderly adults showed significantly higher false recall rates than did young adults [$F(1,23) = 8.36$, $MSe = 0.638$, $P < .009$.

DISCUSSION

The results of Experiment 1 replicate the findings of McDermott (1996), with young adults showing a significant reduction in false recall across trials. Such a reduction suggests that the young adults are able to acquire increasing amounts of item-specific information across trials, and to use that information to suppress some of their false recollection responses. in contrast, the elderly adults did not show any reduction in false recall across trials, thereby suggesting that they may be less capable of using item-specific information to distinguish between presented words and related, but nonpresented, false targets.

Impaired acquisition of item-specific information not only contributes to impaired suppression of false recall, but could also be responsible for the elderly adults' smaller across-trial increases in veridical recall. Whereas young adults presumably rely on both gist and item-specific information to increase veridical recall across the trials, elderly adults may rely more on gist information, leading to more modest increases in veridical recall compared to younger adults.

Results from Trial 1 revealed patterns similar to those reported previously by Norman and Schacter (1997) and Tun et al. (1998), who reported that younger adults recalled more studied items than did older adults, whereas older adults produced as many (Tun et al.) or more (Norman & Schacter) related lures than did younger adults. Although the observed Trial 1 effects did not attain statistical significance, this is probably attributable to the small number of observations per subject for the false recall analysis: There were only three false targets that could possibly be intruded. The relatively small number of observations may also be why the Age × Trial interaction in false recall achieved only marginal levels of significance. To increase the numbers of observations, and to explore the generality of the age-related effects we did observe, Experiment 2 examines across trial suppression of false recognition in older and younger adults.

EXPERIMENT 2

In Experiment 2, we used a recognition paradigm similar to the one described by Schacter et al. (1998b). Subjects initially heard a 90-word list (consisting of six 15-word associate sets) and were then given an old/new recognition test of previously studied words (true targets), related lures (false targets), and unrelated lures (target controls); as in Experiment 1, there were a total of 5 study/test trials. We hypothesised that young and elderly adults would show the same general trends as in Experiment 1: An increase in veridical recognition across trials for both the young and elderly adults—possibly with a more pronounced increase for the young adults—together with a greater decrease in false recognition across trials for the young adults than for the elderly adults.

Method

Subjects

Twenty-two Harvard Summer School students and Harvard undergraduates and 21 elderly adults from the Boston/Cambridge area participated in the experiment. All participants were recruited, screened, and reimbursed in the same manner as described in Experiment 1. The data from two undergraduates and one elderly adult who did not conform to testing procedures were eliminated. Data were analysed for the remaining 20 undergraduates (ages 17–25; mean age = 19.3; range of education = 11–18 years; mean years of education = 13.6) and 20 elderly adults (ages 60–75; mean = 68.2; range of education = 12–20 years; mean years of education = 14.6). None of the subjects participated in both Experiments 1 and 2.

Materials and Design

Twelve of the Roediger and McDermott (1995) 15-word associate sets were used in this experiment. The sets were divided to form two 90-word lists, each consisting of 6 associate sets. Each participant listened to the same 90-word list, with the words presented in the same order, a total of 5 times. All words of an associate set were presented together. Subjects either listened to lists associated to the false targets *chair, fruit, mountain, window, soft,* and *rough,* or to lists associated with the false targets *cold, needle, sleep, sweet, music,* and *thief.* These lists included the three associate sets used in the previous recall experiment; the three added sets were chosen from those that produced the highest rates of false recognition in a previous norming study (ranging from .69–.84 false recognition; see Stadler, Roediger, & McDermott, in press). Lists also were designed to avoid overlap in the themes of multiple associate sets (e.g the *doctor* set was not used because many of its words could also be associated with the words in the *needle* set).

Subjects in each age group were randomly assigned to the two 90-word lists. The 15-word associate sets within these 90-word lists were presented in 2 different orders. The words were presented at a rate of 1 word/2 seconds, as in

Experiment 1, in decreasing order of association (most- to least-highly associated).

Each 90-word list presentation was followed by a 36-word recognition test in which words were shown, in a different random order for each subject, on a computer screen (Chicago font; 48-point). This recognition test included 18 true targets (words #1, #8, and #10 from the 6 presented Roediger & McDermott 1995, associate sets), 6 false targets, and 12 unrelated lures consisting of 6 words from nonpresented associate sets (word #6 on each of 6 lists; true target controls) and 6 words that were false targets for the 6 nonpresented lists (false target controls). Results indicated slightly more false alarms to false target controls (.14) than to true target controls [.11; $F = 2.9$, $P = .087$], and no interactions between Type of Unrelated Lure and Age, Trial, or Age × Trial [Fs < 1]. Thus, for purposes of analysis we combined the true target controls and false target controls into a single unrelated lure category.

Each of the five recognition tests used a different set of unrelated lures; words were taken from unused Roediger and McDermott (1995) lists and from lists created by Stadler et al. (in press). The order of the recognition tests was counterbalanced across subjects.

Procedure

Subjects were tested individually. They were informed that they would be hearing a list of words a total of five times and that they would be asked to take a recognition test after each of these five presentations of the list. During study list presentation, words were presented auditorily at a rate of 1 word per 2 seconds, as in Experiment 1. Also as in Experiment 1, study list words were presented as a single list with no breaks between the various associate sets. Immediately following list presentation, subjects were given instructions for the recognition test. They were informed that some words might appear on multiple recognition tests and other words might appear on only one test. They were instructed to make their old/new recognition judgements based only on whether or not the word had been auditorily presented, not on whether or not it had appeared on a previous recognition test. There was no time limit for the recognition test; each word remained on the screen until the participant made his or her response, at which point the next word appeared on the screen.

Results

Figure 2 displays the proportions of "old" responses to true targets, false targets, and unrelated lures as a function of trials. Table 1 displays the results of signal detection analyses that we used to provide estimates of sensitivity and bias as a function of the main experimental manipulations. We consider the overall analyses of recognition first and then turn to the signal detection analyses.

Veridical Recognition

As shown in Fig. 2, younger adults correctly recognised a greater proportion of true targets on the first trial than did elderly adults, as confirmed by a focused contrast performed on Trial 1 hit rates in younger and older adults [$F(1,19) = 7.78$, MSe = 0.056, $P < .0.1$]. However, by the second trial, there were no significant differences between the hit rates of young and elderly adults, probably because performance in both groups increased to near-ceiling levels. An ANOVA revealed a significant effect of Trial [$F(4,152) = 34.43$, MSe = 0.009, $P < .0001$], no interaction effect of Age [$F(1,38) < 1$], and a nonsignificant Trial × Age interaction [$F(4,152) = 1.79$, $MSe = 0.009$, $P > .13$].

Analyses of corrected recognition scores that were obtained by subtracting false alarms rates to unrelated lures from hit rates to true targets reveal that elderly adults showed less accurate recognition than did young adults across trials, perhaps because ceiling effects in the hit rate data are now removed. An overall ANOVA indicates main effects of Age [$F(1,38) = 4.08$, $MSe = 0.155$, $P = .05$]. Trial [$F(4,152) = 17.57$, $MSe = 0.036$, $P < .0001$], and a nonsignificant Trial × Age interaction [$F(4,152) < 1$]. Separate ANOVAs indicate that both young and elderly adults significantly increased their corrected recognition scores across trials (for young, [$F(4,95) = 7.05$, $MSe = 0.054$, $P < .0001$; for elderly, $F(4,95) = 5.96$, $MSe = 0.066$, $P = .0003$],

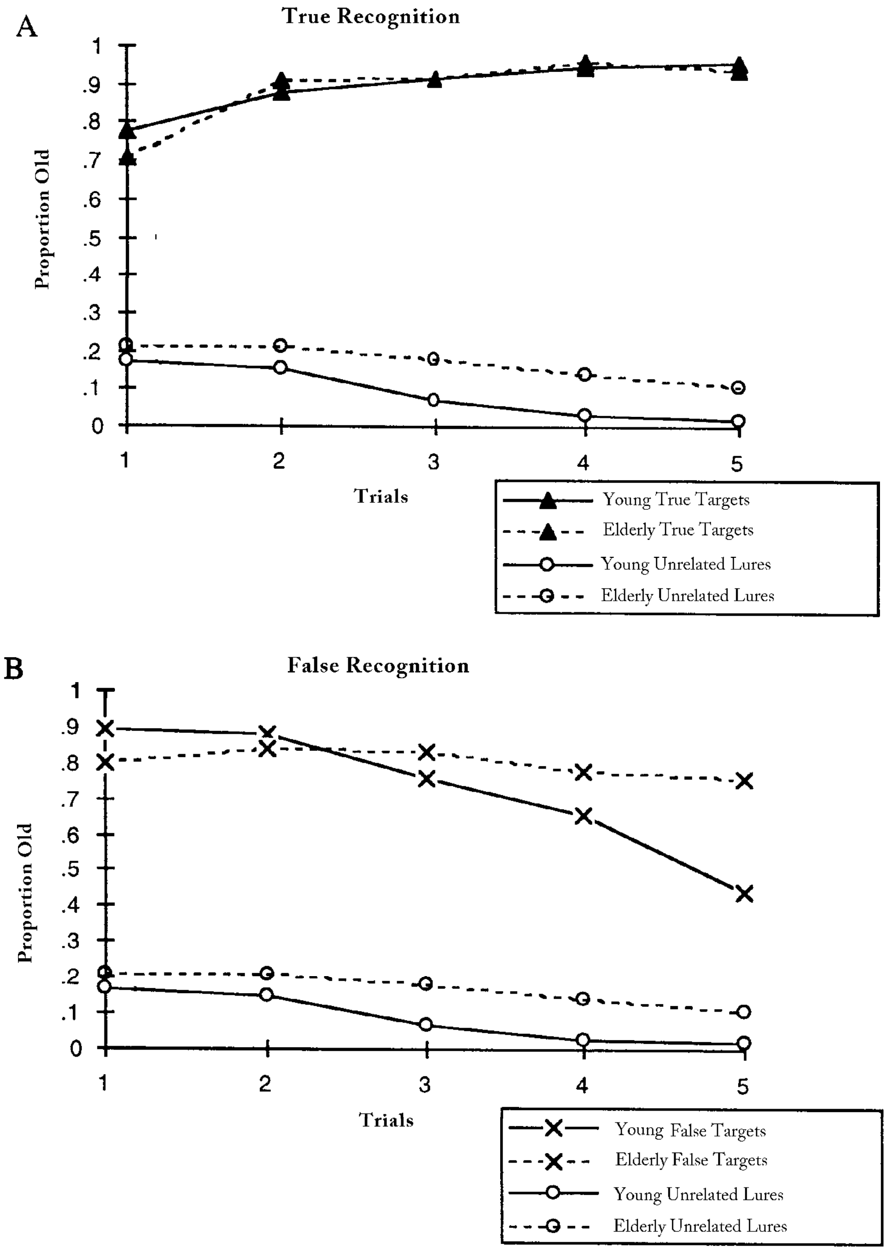

Fig. 2. *Proportions of old responses to true targets (Panel A), false targets (Panel B), and unrelated lures (Panels A and B) in young and elderly adults as a function of study/test trial in Experiment 2. Both the young and elderly adults showed an increase in true recognition across trials, whereas only the young adults demonstrated a reduction in false recognition across trials.*

Table 1. *Signal Detection Analyses of Sensitivity (A') and Bias (B''_D) as a Function of Study/Test Trials in Young and Elderly Adults*

Hits compared to Unrelated False Alarms (Item-specific Memory)				
	Young Adults		*Elderly Adults*	
Trial	*A'*	*B''_D*	*A'*	*B''_D*
1	.843	.215	.805	.213
2	.872	−.029	.886	−.082
3	.939	−.033	.903	−.178
4	.963	−.055	.93	−.118
5	.968	−.037	.941	−.065
Hits compared to Related False Alarms (Item-specific Memory)				
	Young Adults		*Elderly Adults*	
Trial	*A'*	*B''_D*	*A'*	*B''_D*
1	.529	−.81	.571	−.599
2	.623	−.895	.541	−.906
3	.679	−.911	.585	−.93
4	.751	−.912	.707	−.916
5	.836	−.795	.695	−.924
Related False Alarms compared to Novel False Alarms (Gist Memory)				
	Young Adults		*Elderly Adults*	
Trial	*A'*	*B''_D*	*A'*	*B''_D*
1	.898	.039	.815	.099
2	.886	.168	.821	.118
3	.885	.419	.849	.199
4	.878	.693	.842	.344
5	.808	.871	.885	.422

although young adults maintained higher corrected recognition rates than did elderly adults across all trials.

False recognition

On Trial 1, both groups of subjects made similar proportions of "old" responses to false targets, although there was a trend for fewer false recognition responses in the older adults. However, a focused contrast indicates no significant difference between the false recognition rates of the young and elderly adults [$F(1,19) = 1.23$, $MSe = 0.056$, $P > .28$].

However, although younger and older adults were reasonably well equated on Trial 1 with regard to their overall false recognition rates, young adults showed a significant decrease in false recognition rates across trials [$F(4,95) = 13.99$, $MSe = 0.048$, $P < .0001$], whereas elderly adults did not [$F(4,95) < 1$]. An overall ANOVA with Age as a between-subjects variable and Trial as a within-subjects variable indicates no effect of Age [$F(1,38) = 2.19$, $MSe = 0.158$, P > .14], a significant effect of Trial [$F(4,152) = 19.93$, $MSe = 0.02$, $P < .0001$], and most importantly, a significant Trial × Age interaction [$F(4,152) = 13.39$, $MSe = 0.02$, $P < .0001$].

When recognition scores were corrected for the general tendency to call an item "old" by subtracting "old" responses to unrelated lures from "old" responses to false targets, the same pattern was observed, with decreasing false recognition rates across trials for young adults [$F(4,95) = 4.12$, $MSe = 0.08$, $P < .005$], and no change across trials for elderly adults [$F < 1$]. An overall ANOVA performed on these corrected false recognition rates shows no effect of Age [$F(1,38) < 1$], or Trial [$F(4,152) = 1.90$, $MSe = 0.05$, P > .11]. along with a significant Trial × Age interaction [$F(4,152) = 5.63$, $MSe = 0.05$, $P < .0004$].

It should also be noted that both younger and older adults showed across-trial trends in false recognition of true and false target controls. Both age groups showed significant reductions in their false recognition responses to unrelated lures across the trials, and the degree of this decrease was approximately equal for the two age groups. An ANOVA performed on the combined data from true and false target controls showed no effect of Age [$F(1,38) < 1$], an effect of Trial [$F(4,152) = 6.58$, $MSe = 0.022$, $P < .0001$], and no Trial × Age interaction [$F(4,152) < 1$].

Signal Detection Analyses

To determine whether the patterns of effects described above are attributable to changes in sensitivity or response bias, signal detection analyses were conducted, following the procedures used by Koutstaal and Schacter (1997) and Schacter et al. (1998b). A' is used as an estimate of sensitivity and B''_D is used as an estimate of response bias (see Donaldson, 1993; Snodgrass & Corwin, 1988).

Values of A' can range between 0 and 1.00. Higher values indicate greater sensitivity, with .50 indicating chance performance. B''_D can range between − 1.00 and + 1.00, with − 1.00 signifying extremely liberal responding, and + 1.00 signifying extremely conservative responding. Because measures of A' and B''_D are undefined with hit rates of 0 or 1, the data were first transformed, as recommended by Snodgrass and Corwin, by setting $P(x) = (x + .5)/N + 1$ rather than $P(x) = x/N$. When subjects showed below-chance sensitivity (A' < .5, signifying that hits < false alarms), modified formulas given by Aaronsen and Watts (1987) were used. It should be noted that signal detection analysis is based on different underlying assumptions than is the foregoing corrected recognition analysis (for discussion, see Snodgrass & Corwin). Thus, the signal detection analyses reported next provide a different perspective on our data than do the corrected recognition analyses, rather than simply providing additional information.

Three different types of signal detection analyses were performed. The first analysis compares "old" responses to true targets (hits) and to true target controls (unrelated lure false alarms), providing measures of item-specific true recognition that we call A' unrelated and B''_D unrelated. The second analysis compares "old" responses to true targets with "old" responses to false targets (related false alarms), providing different measures of item-specific true recognition that assess participants' abilities to distinguish between true targets and false targets. We call these measures A' related and B''_D related. The third set of analyses compares "old" responses to false targets with "old" responses to false target controls. These measures provide an index of subjects' willingness to rely on gist information, despite any counterveiling influences of item-specific memory; we call them A' gist and B''_D gist. Table 1 displays A' and B''_D values for each of these three comparisons.

Hits Compared to Unrelated False Alarms (Item-specific Memory). As Table 1 shows, A' unrelated did not differ significantly between the elderly and young adult groups (perhaps because of ceiling effects), but did increase across trials. An ANOVA shows a nonsignificant effect of Age [$F(1,38) < 1$], a significant effect of Trial [$F(4,152) = 13.56$, $MSe = .01$, $P < .0001$], and no Trial × Age interaction, [$F(4,152) < 1$], B''_D also did not differ significantly between the two age groups. An ANOVA indicates no significant effect of Age [$F < 1$], along with a significant effect of Trial [$F(4,152) = 3.9$, $MSe = 0.18$, $P < .005$], and no Trial × Age interaction [$F < 1$]. Across trials, young and elderly adults appear to have been using similar criteria for their decisions, and both became modestly more liberal in their responding across the trials.

Hits Compared to Related False Alarms (Item-specific Memory). A' related values indicate that on the first trial, both young and elderly adults had little ability to distinguish studied words from related lures, with A' values hovering near the chance level of .50 (.53 for young adults and .57 for elderly adults; Table 1). A' related generally increased for both groups across trials, although somewhat more steeply in the young group, reaching .84 for the young adults and .70 for the elderly adults by the fifth trial. An overall ANOVA shows no effect of Age [$F(1,38) = 2.35$, $MSe = 0.06$, $P > .13$], an effect of Trial [$F(4,152) = 14.39$, $MSe = 0.02$, $P < .0001$], and a nonsignificant Trial × Age interaction [$F(4,152) = 1.87$, $MSe = 0.02$, $P > .11$.

Values of B''_D related show that when "old" responses to false targets are treated as false alarms, there is generally increasingly liberal responding across trials for both young and elderly adults. The elderly actually show a stronger trend of increasingly liberal responding; on Trial 1, they responded slightly more conservatively than the young but by Trial 5 were responding more liberally than the young. An ANOVA supports these observations, showing no significant effect of Age [$F(1,38) < 1$], along with a significant effect of Trial, [$F(4,152) = 7.69$, $MSe = 0.04$, $P < .0001$, and a significant Trial × Age interaction [$F(4,152) = 3.6$, $MSe = 0.04$, $P < .008$].

Related False Alarms Compared to Unrelated False Alarms (Gist Memory). In this analysis, we treat false alarms to related lures as a form of memory for the "gist" of previously studied items. A' gist values indicate that whereas young adults were more sensitive to gist influences on the first trial (.89) than were the elderly (.82), this trend reversed across trials, with the elderly showing higher levels of A' gist on the last trial (.89) than did the young (.81). An ANOVA supports this observation, showing no effect of Age [$F(1,38) < 1$] or Trial, [$F(4,152) < 1$] together with a significant Trial × Age interaction [$F(4,152) = 4.53$, $MSe = 0.01$, $P > .002$]. Thus, even though older adults were somewhat better able to distinguish between studied words and related lures with repetition (as indicated by the preceding analysis of A' related), they were nonetheless more willing than younger adults to rely on gist information as repetitions increased.

B''_D gist values increased across trials for both younger and older adults, indicating a trend for increasingly conservative responding, but the trend was more pronounced in younger than older adults, with the young showing much more conservative responding by the last trial (.87) than did the elderly (.42). Consistent with these observations, an overall ANOVA shows no effect for Age [$F(1,38) = 1.99$, $MSe = 1.02$, $P > .16$], along with a significant effect of Trial, [$F(4,152) = 16.55$, $MSe = 0.14$, $P < .0001$], and a significant Trial × Age interaction, [$F(4,152) = 4.03$, $MSe = 0.14$, $P < .02$]. Thus, across trials young adults tightened their retrieval criteria to a greater extent than did elderly adults.

Discussion

Experiment 2 extended the major results of Experiment 1 from recall to recognition. As expected, both older and younger adults showed significantly increased veridical recognition across trials. However, whereas in Experiment 1 young adults increased veridical recall to a greater extent than did elderly adult, Experiment 2 there were equivalent increases in veridical recognition for the two age groups (although the young adults had somewhat higher rates of correct recognition across all trials). This difference might indicate that item-specific memory is more beneficial for free recall than recognition: Access to general semantic information may not always be adequate for free recall of a word, so that readier access to item-specific information may result in a more rapid build-up of veridical recall across trials. By contrast, detailed item-specific information may be less important for recognition, where gist information may be sufficient for determining that a word on the recognition test had been presented at study.

Consistent with our major hypothesis, the trends for false recognition paralleled those in Experiment 1: Young adults reduced false recognition responses across trials whereas elderly adults did not. The young adults showed a decrease from an initial false recognition rate of .89 to a rate of .44 on the fifth trial; in contrast, elderly adults began with a rate of .80 and ended with a rate of .76. These trends remained when corrected false recognition scores were used, with young adults showing a decrease in corrected false recognition scores from .72 (Trial 1) to .42 (Trial 5), and the elderly showing a nonsignificant increase in corrected false recognition from .59 (Trial 1) to .65 (Trial 5).

The signal detection data suggest that a reduction in gist influences at least partially accounts for the observed suppression of false recognition in young adults. Across trials, the young adults showed decreasing influence of gist memory, as indicated by the gist A' measure, whereas the elderly actually show increased levels of gist A' across trials. Thus, younger adults were able to use increasing item specific information to counteract or oppose (Dywan & Jacoby, 1990) the corresponding build-up of gist influences, whereas elderly adults were largely unable to do so, instead responding mainly on the basis of gist information. The idea that older adults rely heavily on the increasing influence of gist representations also helps to explain why the elderly were able to decrease their false recognition responses to unrelated lures across trials to the same extent as the young adults. Whereas increasing gist information does not help older adults to rule out related lure words as presented items, it does help them to conclude that entirely unrelated items were not presented, thus leading to the decreases in false recognition to unrelated lure words.

In addition to increasing reliance on gist information, two of the three signal detection analyses (B_D'' related and B''_D gist) revealed that across trials, older adults used increasingly liberal response criteria compared to younger adults. Thus, changes in both sensitivity and bias are implicated in the pattern of across trials age differences we observed.

The results of Trial 1 in Experiment 2 were somewhat unexpected, with the elderly adults showing a trend for lower overall rates of false recognition than the young adults. Although these effects were not statistically significant, whereas Trial 1 analyses of true recognition did reveal significant age effects, this is probably because there were more observations in the true recognition data (18 items per subject) than in the false recognition data (6 items per subject). It is possible that the trend for reduced Trial 1 false recognition in older adults is attributable to the fact that there were no breaks between the study lists, in contrast to previous experiments that showed similar or greater levels of false recognition in older than younger adults (Norman & Schacter, 1997; Tun et al., 1998). Instead, all six associate sets were presented together to form one continuous 90-word list. With so many words presented at a rapid rate, elderly adults initially may have been less able to encode as much gist (or item-specific) information as the young adults, leading them to show trends for reduced false recognition and significantly reduced veridical recognition on the first trial. This analysis might also apply to some extent in Experiment 1, where older adults and younger adults showed similar levels of false recall, even though some previous evidence indicates higher levels of false recall in older than younger adults (Norman & Schacter, 1997; but see Tun et al., 1998, for data similar to ours).

GENERAL DISCUSSION

The results of our experiments support the hypothesis that elderly adults are more reliant on gist influences than are younger adults, and that elderly adults have more difficulty than younger adults using item-specific information to reduce false recognition. Both experiments showed clearly that elderly adults continued to make similar levels of false recall and false recognition responses across trials, whereas younger adults showed sharp reductions in both types of false memories. In Experiment 2, signal detection analyses suggested that the elderly adults' increased susceptibility to false memories stems from a combination of increased sensitivity to gist information and more lenient retrieval criteria.

The observation that repetition of target items has different effects on false memories in younger and older adults complements recent work by Jacoby (1999; see also, Jacoby, this issue) showing a related phenomenon. When instructed to respond "yes" to words they had heard earlier, and "no" to words they had seen earlier, false alarms to previously read words in younger adults decreased as a function of prior study list repetitions. By contrast, false alarms to previously read words increased as a function of study list repetitions in older adults. Thus, older adults fail to use recollection of item-specific information that accrues from repetition as a basis for rejecting previously studied lure words in Jacoby's (1999) procedure, and failed to use such information as a basis for rejecting nonstudied but related lure words in our paradigm.

Our results are also broadly similar to those reported previously by Schacter et al. (1998b), who used a similar multi-trial paradigm to examine false recognition suppression in amnesic patients and matched control subjects. Schacter et al. found that across repeated study/test trials, patients with amnesic syndromes resulting from damage to the medial temporal lobes (i.e, anoxia, encephalitis) showed flat or fluctuating levels of false recognition; Korsakoff amnesic patients actually showed increased false recognition across trials. While both types of patients also showed some across-trial increases in veridical recognition, Schacter et al. attributed those increases to strengthening gist representations rather than to a build-up of item-specific information. Schacter et al. suggested that both amnesic subgroups had difficulty remembering item-specific information, thus accounting for their failures to suppress false recognition, and that the Korsakoff patients in addition had problems with strategic monitoring and control processes that may result from frontal lobe damage (for review and discussion, see Schacter, 1987;

Shimamura, 1995). Therefore, as the Korsakoff patients strengthened gist representations across trials, but without a corresponding increase in item-specific information and with impaired retrieval monitoring processes, they showed significantly increased false recognition rates.

Previous studies of ageing memory have implicated both medial temporal and frontal regions in age-related memory changes (e.g., Glisky et al., 1995; Grady et al., 1995; Henkel, Johnson, & De Leonardis, 1998; Moscovitch & Winocur, 1992; Schacter, Savage, Alpert, Rauch, & Alpert, 1996a). Although we have no direct information concerning possible brain system correlates of the effects we observed, future studies using neuroimaging techniques, which have already proven helpful in the analysis of false recognition (e.g. Schacter, Buckner, Koutstaal, Dale, & Rosen, 1997a), could provide relevant information. Note also that when viewed in light of the performance of Korsakoff amnesics—who showed significant across-trial increases in false recognition—the fact that older adults are able to maintain constant levels of false recognition across trials, rather than showing increases, indicates that they are capable of some degree of false recognition suppression, although considerably less than that shown by younger adults.

Although we have emphasised that impaired suppression of false recognition reflects age-related increases in reliance on gist information (cf., Reyna & Brainerd, 1995), older adults' failures to reduce their false recall and recognition responses may also stem, at least in part, from a deficit in source memory. Source memory confusions may contribute to false recognition of semantic associates in either of two different ways. First, participants may generate a related lure word during study list presentation, and later have difficulty determining whether they actually heard the word or only thought about it. Second, because subjects were given multiple test trials as well as multiple study trials, false targets were that were produced on an earlier free recall test (Experiment 1), or that appeared on a prior recognition test (Experiment 2), may be misattributed to a study list. Given their difficulties on source memory tasks (e.g. Bartlett, Strater, & Fulton, 1991; Dywan & Jacoby, 1990; Henkel et al., 1998; McIntyre & Craik, 1987; Multhaup, 1995; Schacter et al. 1994; for review, see Spencer & Raz, 1995), elderly adults may be more susceptible to source confusions arising during study list presentation, or might be more susceptible to test-induced source confusions, having more difficulty than younger adults in determining whether a false target was written on a previous recall test, encountered visually on a previous recognition test, or actually heard during study list presentation (see Schacter et al., 1998b, for a discussion of similar issues with amnesic patients).

The first possibility (study list-induced source confusions) is difficult to address experimentally, although relevant evidence has been presented (cf. Koutstaal & Schacter, 1997; Mather, Henkel, & Johnson, 1997; McDermott, 1997; Norman & Schacter, 1997). The second possibility (test-induced source confusions) can be addressed by further experiments in which the number of study list presentations is varied without any intervening recall or recognition tests. If elderly adults are still unable to suppress their false responses under such conditions, then test-induced source memory confusion can be ruled out as a major contributor to the effects observed here. If, on the other hand, the elderly are able to suppress false recall or recognition under such conditions, then a role for test-induced source memory deficits would be implicated.

However, even if the latter outcome were obtained, and test-induced source confusions are a contributor to elderly adults' failure to reduce false recall and recognition across trials, such an outcome would still be broadly consistent with our hypothesis that elderly adults are relatively impaired in memory for item-specific as compared to gist information. If the elderly adults encode less item-specific information, and are more reliant on general features of the studied items, then presumably they are less able to determine whether a word was heard at study or seen at test (either on a computer screen or on their own recall sheet; cf. Schacter, Koutstaal, Johnson, Gross, & Angell, 1997b).

Our findings contrast sharply with two other recent sets of studies from our laboratory in which older adults have shown normal suppression of false recognition. Using the categorised pictures paradigm that previously produced large age-related increases in false recognition of novel pictures (Koutstaal & Schacter, 1997), Koutstaal, Schacter, Galluccio, and Stofer (in press) reported that false recognition was reduced significantly in both younger and older adults when subjects were given, at the time of study, distinctive verbal elaborators that emphasised unique aspects of each picture. Schacter, Israel, and Racine (1999) compared false recognition of Deese/Roediger-McDermott lists in an encoding condition where subjects hear and see study list words with an encoding condition in which subjects hear study list words and see a picture corresponding to each word. Both younger and older adults showed a significant reduction in false recognition of semantic associates after pictorial encoding compared to word encoding.

Why did older adults show normal suppression of false recognition in the studies of Koutstaal et al. (in press) and Schacter et al. (1999), and no suppression at all in our experiments? The source monitoring problems alluded to earlier may be relevant, because our paradigm allowed for a form of study/test source confusion that was not operative in the paradigms used by Koutstaal et al. and Schacter et al. Additional and possibly related clues are provided by a second experiment from Schacter et al. (1999). In the experiment that produced false recognition suppression after pictorial encoding in both younger and older adults, Schacter et al. manipulated picture versus word encoding on a between-groups basis. Likewise, in the Koutstaal et al. experiment with categorised pictures, the presence or absence of distinctive elaborators was manipulated between groups. By contrast, when Schacter et al. manipulated word versus picture encoding within-groups (i.e. for each participant, some word lists were studied with pictures and others as only words), neither younger nor older adults showed any suppression of false recognition after picture encoding compared to word encoding. Schacter et al. thus argued that false recognition suppression after picture encoding in the between-groups paradigm involves a global shift in responding produced by reliance on what they call a "distinctiveness heuristic": A mode of responding based on subjects' metamemorial awareness that recognition of studied items should be accompanied by recollection of distinctive details (i.e. pictorial information). After studying lists of words that are all accompanied by pictures, subjects require access to distinctive information before they are willing to call an item "old." The same sort of reasoning may apply to the between-groups suppression of false recognition observed by Koutstaal et al. (in press). By contrast, when some lists are studied with pictures and others with words, application of such a global heuristic cannot produce differential suppression of false recognition after picture encoding versus word encoding.

The foregoing observations raise the possibility that older adults can show normal suppression of false recognition when suppression is driven by a global shift in responding, such as the distinctiveness heuristic described by Schacter et al. (1999). Applying these ideas to the present experiments, false recognition suppression in our paradigm may involve mechanisms other than the distinctiveness heuristic or some similar global shift in responding. We have argued that across trial suppression of false recall and recognition depends on the build-up of item-specific information about studied lists: Younger subjects recollect more details of items that were presented with increasing repetitions, thereby allowing them to better determine which items did not appear on each study list; elderly adults are less able to do so. If this line of reasoning is correct, then it should be possible to demonstrate false recognition suppression in our paradigm, at least in younger adults, under conditions that are conceptually analogous to the within-group manipulation of picture vs. word encoding used by Schacter et al. (1999): Subjects study some lists five times, and other lists just once; after studying all lists, they are tested for true and false recognition. Under these conditions, false recognition suppression in the five repetition condition compared to the single repetition condition cannot be produced by a general shift in responding; it must involve access to specific items on specific lists. We would expect younger but not older adults to exhibit such effects.

On the other hand, it is logically possible that the suppression effect we observed in younger adults does reflect a general shift in responding, perhaps involving mechanisms analogous to a distinctiveness heuristic. But, in addition (as discussed earlier), the inclusion of false targets on recognition tests creates source monitoring problems that prevent older adults from usefully invoking the relevant heuristic. By this view, older adults might indeed show significant false recognition suppression under conditions in which one group of older adults receives a single exposure to the study lists prior to a recognition test and a separate group receives multiple study exposures before the recognition test. A global shift in responding could underlie whatever suppression effects occur under such conditions, and there would be no study/test source confusions that could prevent older adults from successfully using the relevant heuristic.

However, because the encoding conditions used in our experiments are rather impoverished, involving simple auditory presentation of word lists, any global suppression effects based on a distinctiveness heuristic are likely to be small. Unlike the picture encoding condition used by Schacter et al. (1999), repeated auditory presentation of word lists may not lead subjects to demand increasingly distinctive recollections before calling items “old”. Perhaps by enriching the study context (e.g. having distinct sources present study words), it would be possible to create a situation in which repeated presentation of study lists leads subjects to demand increasingly distinctive recollections and thereby produces a global suppression effect. If our analysis of the suppression effects exhibited by older adults in the Koutstaal et al. (in press) and Schacter et al. (1999) studies is correct, then we would expect to observe significant suppression effects in older adults under such conditions.

Because we have invoked the phrase “false recognition suppression” throughout this article, it is perhaps worth noting that the term can be used in at least two different ways: (1) a theoretically neutral sense that is roughly equivalent to “false recognition reduction”, simply describing the fact that false recognition rates are lower in one experimental condition than in another, and (2) a theoretically more loaded sense that refers to a process that actively counters or opposes gist-based false recognition influences that, if unchecked, would produce false recognition. Although we have used the term in both senses, we do not yet have direct evidence for the operation of an active suppression process. For instance, repetition of studied items might result in lower false recognition rates because repetition produces more differentiated representations of studied words, which in turn bear less similarity to nonstudied associates than do words that were studied only once (for discussion, see McClelland & Chappell, 1998; Schacter et al., 1998a). From this perspective, no active suppression may be necessary to produce reduced rates of false recall or recognition after repetition. Further experiments are needed to determine whether active suppression is involved in the repetition effects reported here.

In summary, we have found that older adults fail to exhibit suppression of false recall and recognition under conditions in which younger adults show robust suppression effects. Although the exact mechanisms underlying these age-related impairments remain to be elucidated, we believe that further exploration of the effects we have documented should provide useful insights into important but poorly understood aspects of cognitive ageing.

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