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Suppressing False Recognition in Younger and Older Adults: The Distinctiveness Heuristic

Daniel L. Schacter

Harvard University

Lana Israel

Oxford University

and

Carrie Racine

Harvard University

False recognition can occur at high levels after participants study lists of associated words and are tested with semantically related lures. Israel and Schacter (1997) reported that robust false recognition effects are reduced substantially when young adults also study pictures representing each associate. In Experiment 1, we found that older adults, who have previously shown increased susceptibility to false recognition of semantic associates, also exhibit substantial suppression of false recognition after pictorial encoding. In Experiment 2, we tested the hypothesis that suppression effects in Experiment 1 are attributable to the operation of what we call a *distinctiveness heuristic:* a response mode in which participants demand access to detailed recollections to support a positive recognition decision. Consistent with this hypothesis, we found that when encoding conditions were manipulated to render a distinctiveness heuristic ineffective, false recognition suppression after pictorial encoding was eliminated in younger and older adults. © 1999 Academic Press

False recognition—the mistaken claim that one has previously encountered a novel item—has been well-established experimentally (Roediger, McDermott, & Robinson, 1998) and analyzed from a variety of theoretical perspectives (cf., Hintzman, 1988; Hirshman & Arndt, 1997; Jacoby & Whitehouse, 1989; Johnson & Raye, in press; Reyna & Brainerd, 1995; Schacter, Norman, & Koutstaal, 1998; Wallace, Stewart, Shaffer, & Wilson, 1998). Early studies of false recognition used variants of a continuous recognition paradigm introduced by Underwood (1965), in which participants make old/new decisions about previously studied words, related lures (i.e., new words preceded by an associated word), and unrelated lures (i.e., new words that are not preceded by an associated word). False recognition in this paradigm is typically expressed as a small increase in false alarms to related lures compared to unrelated lures. However, more robust false recognition effects have been reported under conditions in which participants study large numbers of items that are conceptually or perceptually similar to a novel test item (Hintzman, 1988; Shiffrin, Huber, & Marinelli, 1995).

Roediger and McDermott (1995) recently provided a particularly striking demonstration of robust false recognition, using a modified version of a procedure introduced by Deese (1959; see also, Read, 1996). In the Roediger and McDermott paradigm, participants hear lists of 15 semantic associates and are then tested with previously presented words, semantically related lures that were not presented previously, and unrelated lure

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Address reprint requests to Daniel L. Schacter, Department of Psychology, Harvard University, 33 Kirkland Street, Cambridge, MA 02138. E-mail: dls@wjh.harvard.edu.

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words. Roediger and McDermott (1995) reported exceptionally high levels of false recognition (e.g., 80%) to related lures. These false recognition responses were accompanied by high confidence; moreover, when asked to make remember/know judgments (Gardiner & Java, 1993; Tulving, 1985) about test items, participants often claimed to "remember" the false targets. Subsequent studies have delineated characteristics of this powerful false recognition effect (e.g., Mather, Henkel, & Johnson, 1997; McDermott, 1997; Norman & Schacter, 1997; Payne, Elie, Blackwell, & Neuschatz, 1996; Robinson & Roediger, 1997; Seamon, Luo, & Gallo, 1998; Tussing & Greene, 1997), examined the phenomenon in such populations as amnesic patients (Schacter, Verfaellie, & Pradere, 1996) and elderly adults (Norman & Schacter, 1997; Tun, Wingfield, Rosen, & Blanchard, 1998), and explored the neural bases of robust false recognition using event-related potentials (Duzel, Yonelinas, Mangun, Heinze, & Tulving, 1997; Johnson, Nolde, Mather, Kounios, Schacter, & Curran, 1997) and such functional neuroimaging techniques as positron emission tomography (Schacter, Reiman, Curran, Yun, Bandy, McDermott, & Roediger, 1996) and functional magnetic resonance imaging (Schacter, Buckner, Koutstaal, Dale, & Rosen, 1997).

Schacter et al. (1998) argued that high levels of false recognition in the Deese/Roediger-McDermott paradigm are partly attributable to the fact that presentation of numerous strong associates during study emphasizes common semantic features of the studied words (i.e., gist [Reyna & Brainerd, 1995] or general similarity information [Hintzman & Curran, 1994]) more than distinctive details of particular items (other related factors, such as implicit associative responses and subsequent source memory confusions, likely also contribute to this false recognition effect [see Roediger et al., in press; Schacter et al., 1998]). Schacter et al. (1998) hypothesized that robust false recognition occurs when participants retain the common semantic features of presented words, but do not encode or retain distinctive details of individual items (for general discussion of similarity and distinctiveness effects in memory, see Hunt & McDaniel [1993]; for further discussion of possible neurobiological bases of similarity and distinctiveness, see Schacter et al. [1998] and also McClelland, McNaughton, & O'Reilley [1995]).

According to this analysis, false recognition should be reduced following study conditions that promote encoding of distinctive information about particular items. Israel and Schacter (1997) tested this idea experimentally. To increase encoding of distinctive information about individual items, Israel and Schacter presented one group of participants with lists of semantic associates in which each word was presented auditorily and was accompanied by a corresponding picture. A second group was exposed to the same words auditorily, accompanied by a visual presentation of the word. Israel and Schacter found that pictorial encoding yielded lower levels of false recognition to both semantically related and unrelated lures than did word encoding. In the picture encoding condition, there was a somewhat greater suppression effect when pictures rather than auditory words were presented on the recognition test.

Israel and Schacter argued that participants in the picture condition rejected new words because they lacked the distinctive qualities associated with remembered pictures. As suggested previously by Strack and Bless (1994), when studied stimuli are made so memorable that participants feel confident that they would remember them vividly, the absence of detailed recollections provide diagnostic evidence that an item is novel. After studying numerous semantic associates without any pictures, differences between the qualities of true and false memories are subtle (see Mather et al., 1997; Norman & Schacter, 1997). However, when semantic associates are studied with pictures, phenomenological differences between true and false memories are likely to be increased, thereby encouraging participants to demand access to distinctive details about a particular item before calling it "old." A similar interpretation has been offered by Smith and Hunt (in press), who reported reduced false recognition of related lures after visual study of words compared to the standard auditory study condition. They proposed that "visual presentation provides a better means for discriminating between studied items and the related critical items than does auditory presentation" (p. 4).[1]

In the present experiments, we explore further the nature and characteristics of false recognition after pictorial encoding. Experiment 1 examines the performance of older adults in the paradigm reported previously by Israel and Schacter (1997, Experiment 2). Compared to younger adults, older adults sometimes exhibit as much or more false recognition of related lures in the Deese/Roediger-McDermott paradigm, despite showing lower levels of true recognition (Norman & Schacter, 1997; Tun et al., 1998). Koutstaal and Schacter (1997) have uncovered large age-related increases in false recognition using a paradigm in which participants study varying numbers of pictures from different categories and later make false alarms to novel pictures from the studied categories (for review of these and previous findings on aging and false recognition, see Schacter, Koutstaal, and Norman [1997]).

Schacter et al. (1997) hypothesized that increased susceptibility to false recognition in elderly adults is in part attributable to an age-related tendency for generic or indistinct encoding of target information (Rabinowitz, Craik, & Ackerman, 1982). Indistinct encoding may produce selective impairments in remembering distinctive details of individual items (Spencer & Raz, 1995) that in turn increase susceptibility to various kinds of memory distortions (e.g., McIntyre & Craik, 1987; Schacter, Koutstaal, Johnson, Gross, & Angell, 1997). In experiments that used a modified version of the Deese/Roediger-McDermott paradigm and probed the qualitative characteristics of true and false memories, Norman and Schacter (1997) found that both types of memories were predominantly associated with access to semantic/associative information in older and younger adults, with both age groups showing relatively little access to perceptual/contextual information (see also Mather et al., 1997). While true memories were associated with greater access to perceptual/contextual information than were false memories, this difference was less pronounced in elderly adults than in younger adults. These results suggest that elderly adults are able to encode and retrieve the semantic similarities that drive false recognition, but are less likely than younger adults to encode or retrieve distinctive details about individual items that support true recognition.

If increased false recognition in elderly adults following encoding conditions that emphasize similarities among items (Koutstaal & Schacter, 1997; Norman & Schacter, 1997; Tun et al., 1998) reflects reliance on overly general encoding, then providing elderly participants with distinctive pictures should significantly reduce false recognition, just as Israel and Schacter (1997) found with younger adults. Indeed, if age-related increases in false recognition are exclusively produced by reliance on overly general encoding, then pictorial encoding could eliminate age effects in false recognition. Experiment 1 examines these possibilities.

In Experiment 2, we attempt to specify the locus of false recognition suppression after pictorial encoding in younger and older adults by evaluating the hypothesis that suppression is produced by reliance on what we call a *distinctiveness heuristic*—a mode of responding based on participants' metamemorial awareness that true recognition of studied items should include recollection of distinctive details. To test this hypothesis, we developed a variant of Israel and Schacter's paradigm in which reliance on a distinctiveness heuristic should not produce lower false recognition after pictorial encoding than after word encoding.

EXPERIMENT 1

In Experiment 1, older and younger adults studied auditorily presented lists of semantic associates that were each accompanied by either a picture or a visual word. Picture versus word

[1] As Smith and Hunt (in press) point out, their finding of reduced false recognition after study of visual versus auditory words contrasts with Israel and Schacter's (1997) finding that levels of false recognition did not differ after study of auditory words compared to visual words accompanied by auditory words. Smith and Hunt suggested that when visual and auditory words are presented simultaneously, as in Israel and Schacter's experiment (1997), visual processing of the studied words may be truncated.

encoding was manipulated as a between-groups variable. On the recognition test, participants made old/new recognition judgments about studied words, related lures, or unrelated lures; half of the test items from each encoding condition were presented as auditory words, and the other half were presented in a manner that reinstated initial encoding condition (auditory words plus pictures for the picture encoding condition, and auditory words plus visual words for the word encoding condition). In addition to old/new judgments, we explored qualitative characteristics of true and false recognition by requiring participants to make remember/know judgments (Gardiner & Java, 1993; Tulving, 1985) about each item.

Methods

Participants. Thirty-six younger adults and 36 older adults participated in the experiment. The younger adults were all Harvard University undergraduates, with a mean age of 19.8 years (range, 18–22 years), who were recruited via mailings to Harvard clubs, classes, and organizations; a partial analysis of their data has been provided separately by Israel and Schacter (1997, Experiment 2). The older adults were recruited via flyers and posters and were interviewed individually to exclude those with any of the following conditions: a history of alcoholism or substance abuse, cerebrovascular accident, recent myocardial infarction, present or previous treatment for psychiatric illness, current treatment with psychoactive medication, metabolic or drug toxicity, primary degenerative disorders (e.g., Alzheimer's disease, Parkinson's disease, or Huntington's disease), and brain damage from a known cause (e.g., hypoxia). Older participants' mean age was 67.9 years (range 61–74 years), and they had on average 15.8 years of formal education. Eighteen younger and 18 older participants were included in each of two main experimental conditions (word encoding and picture encoding). Participants were paid $8.

Materials and design. Twenty-one study lists, each composed of 12 items, were created using the Russell and Jenkins (1954) word association norms and adapting some of the lists used by Roediger and McDermott (1995). Study lists were constructed by selecting the 12 highest associates that could be represented pictorially. Words on each list were presented in order of decreasing associative strength to the nonpresented related lure (i.e., the most strongly associated word was presented first, the next most strongly associated word was presented second, and so forth). The 21 lists were divided into three sets for counterbalancing purposes; within each set, lists were presented in the same order to all participants. Participants studied 14 lists and were given a 63-item recognition test. The test consisted of 28 studied items or *true targets* (drawn from the first and seventh list positions of each of the 14 studied lists), 14 new unrelated lures or *true target controls* (drawn from the 1st and 7th list positions of each of the 7 nonstudied lists), 14 related lures or *false targets* (the related lure on which all studied items semantically converge for each of the 14 studied lists), and 7 new unrelated lures or *false target controls* (the related lure on which all studied items semantically converge for each of the seven nonstudied lists).

In the picture encoding condition, each list item was presented as an auditory word with a corresponding picture; in the word encoding condition, each list item was presented as an auditory word with its corresponding visual word. Items on the recognition test were randomly assigned to a test presentation mode, visual + auditory or auditory; no more than three items were presented consecutively in the same mode. In the picture encoding condition, the visual + auditory test mode involved simultaneous presentation of a picture and an auditory word, whereas in the word encoding condition the visual + auditory mode involved simultaneous presentation of a visual word and an auditory word. The recognition test was counterbalanced so that (1) each type of item (i.e., true target, true target control, false target, and false target control) was presented equally often in each of the two presentation modes and (2) each type of item appeared equally often in the first and second half of the test. Furthermore, items taken from the same study list were at least eight positions apart on the recognition test, and no more than two items of the same type appeared consecutively.

The pictorial stimuli were black and white line drawings of list items and varied in size (ranging from approximately 3 × 3 cm to 17 × 18 cm, with a modal size of approximately 10 × 11 cm). In general, the drawings contained similar amounts of detail, although this feature was not systematically controlled. Pictures were scanned on a PowerMacintosh 7600/132 using VistaScan and a UMAX Vista-S6E scanner. Auditory stimuli were recorded on a Macintosh Quadra 150 using SoundEdit Pro. Word stimuli were presented in uppercase in 55-point Geneva typefont. All stimuli were presented on a PowerComputing PowerCenter 132 using PsyScope 1.2b2. Participants heard auditory stimuli through headphones.

The main design consisted of two between-group variables, age (young vs old) and encoding condition (word vs picture), and two within-group variables, test presentation mode (visual + auditory vs auditory) and item type (true target, true target control, false target, and false target control).

Procedure. Participants were tested individually. They were told that 14 lists of 12 items each would be presented and that each item was composed of an auditory and a visual component. Participants were instructed to pay careful attention to both parts of the item because they would be tested on the items later. Additionally, participants were told that they would have 1 min to work on a puzzle after presentation of each study list, and that a beep would sound before presentation of the next study list (puzzles included a math subtraction task, a math addition task, and mazes). The visual component of each study item was displayed for 1.5 s; all auditory components were presented simultaneously in a female voice. Approximately 1.5 s elapsed between each study item. Presentation of each list took approximately 40 s. Following presentation of all 14 lists, participants received 3 min to work on mazes.

After this filler task, participants were given instructions for the recognition test. Participants were asked to indicate if each item was “old” (i.e., had appeared on one of the study lists) or “new” (i.e., had not appeared on the study lists) by pressing “o” or “n” on the keyboard. When given both visual and auditory cues, participants were told to consider both components when making recognition judgments. Participants in the picture condition were also assured that an old picture would never be presented with a new auditory label, nor a new picture presented with an old auditory label. Whenever they called a test item “old,” participants made remember/know judgments (Tulving, 1985) using instructions adapted from Rajaram (1993). After participants completed their judgments, they pressed the space bar for presentation of the next test item. When items were presented in auditory test mode, a cross-hair appeared in the center of the computer screen.

Results

Table 1 presents the proportion of “old” responses to true targets, true target controls, false targets, and false target controls as a function of test presentation mode in the word and picture encoding conditions for older and younger adults. Table 2 displays the results of signal detection analyses that provide estimates of sensitivity (A') and response bias (B''_D) in three critical comparisons. Table 3 presents the proportions of remember and know responses to each of the item types, together with corresponding estimates of recollection and familiarity that were obtained from remember and know responses, respectively, using procedures described by Yonelinas, Kroll, Dobbins, Lazzara, and Knight (1998). We first consider the overall data, next discuss the signal detection analyses, and conclude by considering the remember/know judgments.

Overall Data: True Recognition

Hit rates were generally higher for younger than older adults and were higher in the visual + auditory than auditory test mode, although this latter effect was much larger in the picture than the word encoding condition. Although hit rates were virtually identical in the picture and word encoding conditions, the discriminability of old and new items, as indicated by corrected recognition scores that were ob-

TABLE 1

Proportion of "Old" Responses on the Recognition Test as a Function of Item Type, Test Presentation Mode, Age, and Encoding Condition in Experiment 1

		Encoding condition			
		Young adults		Elderly adults	
Item type	Test presentation mode	Word	Picture	Word	Picture
True targets		.79	.78	.72	.71
	Auditory	.77	.71	.72	.62
	Visual + Auditory	.82	.85	.73	.81
True target controls		.21	.09	.18	.11
	Auditory	.18	.12	.17	.12
	Visual + Auditory	.23	.06	.20	.10
False targets		.66	.35	.72	.46
	Auditory	.64	.41	.68	.46
	Visual + Auditory	.68	.30	.76	.45
False target controls		.28	.08	.17	.16
	Auditory	.26	.08	.20	.18
	Visual + Auditory	.31	.07	.14	.14

tained by subtracting the proportion of "old" responses to true target controls from the proportion of "old" responses to true targets, was higher in the picture encoding condition than in the word encoding condition for both groups of participants, with younger adults showing somewhat higher levels of corrected recognition in both conditions.

An ANOVA on corrected hit rates revealed a significant main effects for Encoding Condition, $F(1,68) = 4.75$, $MS_e = .060$, $p = <.05$, and Test Mode, $F(1,68) = 12.35$, $MS_e = .029$, $p < .001$, and a trend for a main effect of Age, $F(1,68) = 2.87$, $MS_e = .060$, $p = .095$. The Encoding Condition × Test Mode interaction was significant, $F(1,68) = 14.91$, $MS_e = .029$, $p < .001$, and there were no further interactions with Age, Fs < 1. The interaction indicates that for both older and younger adults, recognition accuracy in the picture encoding condition was higher when pictures and their auditory labels were presented at test than when only auditory words were presented, whereas there were no differences between the visual + auditory and auditory test presentation modes in the word encoding condition.

Overall Data: False Recognition

The data in Table 1 indicate that within each encoding condition, older adults showed somewhat higher rates of false recognition to related lures than did younger adults, $F(1,68) = 2.97$, $MS_e = .086$, $p = .089$. However, the most striking finding is that older adults, like younger adults, showed a dramatic decrease in the proportion of "old" responses to false targets after studying pictures than words, $F(1,68) = 33.03$, $MS_e = .086$, $p < .0001$. Younger adults also showed similar reductions in the proportions of "old" responses to false target controls in the picture encoding condition compared to the word encoding condition, whereas elderly adults showed similarly low levels of false alarms to false target controls in both encoding conditions. Analysis of "old" responses to false target controls revealed a significant Age × Encoding Condition interaction, $F(1,68) = 5.62$, $MS_e = .056$, $p < .05$. Note, however, that both older and younger adults showed lower levels of false alarms to true target controls after picture encoding than word encoding, as indicated by a main effect of Encoding Condition,

TABLE 2

Signal Detection Analyses of Sensitivity (A') and Bias (B''_D) as a Function of Item Type, Test Presentation Mode, Age, and Encoding Condition in Experiment 1

Encoding condition/ Test presentation mode	Young adults A'	Young adults B''_D	Elderly adults A'	Elderly adults B''_D
	Item specific memory (true targets compared to true target controls)			
Word	.85	.05	.83	.25
Auditory	.85	.19	.83	.36
Visual + Auditory	.85	−.10	.83	.15
Picture	.90	.34	.87	.44
Auditory	.87	.39	.83	.53
Visual + Auditory	.93	.30	.90	.34
	Item specific memory (true targets compared to false targets)			
Word	.60	−.50	.50	−.44
Auditory	.57	−.39	.54	−.41
Visual + Auditory	.63	−.61	.47	−.47
Picture	.79	−.21	.68	−.23
Auditory	.72	−.07	.62	−.10
Visual + Auditory	.85	−.34	.74	−.36
	Gist memory (false targets compared to false target controls)			
Word	.70	.05	.79	.08
Auditory	.72	.10	.78	.13
Visual + Auditory	.68	−.03	.81	.03
Picture	.65	.56	.66	.36
Auditory	.65	.46	.67	.38
Visual + Auditory	.64	.67	.66	.33

$F(1,68) = 11.18$, $MS_e = .032$, $p < .005$, with no Age × Encoding Condition interaction, $F < 1$.

We also analyzed corrected recognition scores in which the proportion of "old" responses to false target controls was subtracted from the proportion of "old" responses to false targets. This analysis revealed a significant effect of Encoding Condition, $F(1,68) = 10.29$, $MS_e = .114$, $p < .005$, indicating lower false recognition rates following picture than word encoding, and a marginally significant effect of Age, $F(1,68) = 3.55$, $MS_e = .114$, $p = .064$, indicating higher false recognition rates in older than younger adults.

There were no main effects or interactions involving Test Mode for overall or corrected false recognition, Fs < 2.76, except for a marginally significant Age × Test Mode interaction, $F(1,68) = 3.65$, $MS_e = .078$, $p = .060$, indicating that younger adults showed slightly less corrected false recognition in the visual + auditory test mode than in the auditory test mode, whereas elderly adults showed the opposite trend.

Signal Detection Analyses

To determine whether the main findings discussed thus far can be attributed specifically to changes in sensitivity or response bias, we performed signal detection analyses based on procedures used and described by Koutstaal and Schacter (1997) and Schacter, Verfaellie, Anes, and Racine (in press; see also Tussing & Greene, 1997). We used A' as an estimate of sensitivity and B''_D as an estimate of response bias (Donaldson, 1992; Snodgrass & Corwin, 1988). Values of A' can vary between zero and 1.00; higher values indicate greater sensitivity, with .50 indicating chance performance. Values of the bias measure, B''_D, can vary between −1.00 (indicating extremely liberal responding) and +1.00 (indicating extremely conservative responding). Because these measures are undefined with hit rates of zero or one, the data were first transformed, as recommended by Snodgrass and Corwin (1988), by computing $p(x)$ as $(x + .5)/n + 1$ rather than x/n. In addition, when individual subjects showed below chance sensitivity (hits < false alarms, or $A' < .50$), modified formulas provided by Aaronson and Watts (1987) were used.

Following Koutstaal and Schacter (1997) and Schacter et al. (in press), we provide three different types of signal detection analyses, shown in the top, middle, and bottom panels of Table 2. The top panel of Table 2 shows estimates of sensitivity and bias comparing hits to true targets with false alarms to true target controls, which are measures of item-specific memory (referred to as A' unrelated and B''_D unrelated for sensitivity and bias, respectively). The mid-

TABLE 3

(A) Estimates of Recollection (*R*) and Familiarity (*F*(*d*′)) Based on a Dual Process Signal Detection Model (Yonelinas et al., in press); (B) Raw Proportions of Remember (*R*) and Know (*K*) Responses That Contribute to the Estimates of Recollection and Familiarity, Respectively, for Experiment 1

	A.							
	Encoding condition							
	Young adults				Elderly adults			
	Word		Picture		Word		Picture	
Item type/ Test presentation mode	*R*	*F*(d′)	*R*	*F*(d′)	*R*	*F*(d′)	*R*	*F*(d′)
True target	.58	1.21	.70	1.36	.49	.99	.54	1.00
Auditory	.61	.78	.62	1.04	.50	.82	.48	.54
Visual + Auditory	.54	1.64	.78	1.67	.48	1.15	.59	1.45
False target	.42	.64	.22	.14	.47	1.23	.31	.29
Auditory	.40	.84	.28	.24	.43	.95	.30	.34
Visual + Auditory	.43	.43	.16	.03	.50	1.56	.32	.24
	B.							
	R	*K*	*R*	*K*	*R*	*K*	*R*	*K*
True target	.62	.17	.71	.07	.55	.17	.58	.13
Auditory	.64	.13	.63	.08	.54	.18	.51	.10
Visual + Auditory	.60	.22	.78	.07	.56	.17	.65	.16
False target	.47	.19	.24	.11	.52	.20	.36	.10
Auditory	.45	.19	.31	.10	.48	.20	.34	.12
Visual + Auditory	.49	.19	.17	.13	.56	.20	.37	.09
True target controls	.08	.13	.04	.05	.12	.06	.08	.03
Auditory	.05	.13	.05	.07	.08	.09	.06	.06
Visual + Auditory	.10	.13	.02	.03	.16	.04	.10	.00
False target controls	.13	.15	.03	.05	.11	.06	.13	.03
Auditory	.12	.14	.03	.05	.11	.09	.15	.03
Visual + Auditory	.14	.17	.02	.05	.11	.03	.11	.03

dle panel compares hits with "old" responses to false targets, which provides a different measure of item-specific memory (A' related and B''_D related for sensitivity and bias, respectively). In the bottom panel of Table 2, false alarms to related lures are depicted as a form of memory for the "gist" of the study list (cf., Brainerd et al., 1995; Koutstaal & Schacter, 1997) and thus are treated in the same manner as hits in the previous two analyses. For this analysis, "old" responses to false targets are compared with "old" responses to false target controls; A' indicates the extent to which participants called false targets "old," compared to how often they called false target controls "old." In this comparison we call the measures of sensitivity and bias A' gist and B''_D gist, respectively.

True targets compared to true target controls (item-specific memory). Overall ANOVAs including Age and Encoding Condition as between-subjects variables and Test Mode as a within-subject variable were performed on the A' unrelated and B''_D unrelated values shown in the first panel of Table 2. Analysis of A' unrelated revealed main effects of Encoding Condition, $F(1,68) = 4.70$, $MS_e = .013$, $p < .05$, indicating greater discriminability between studied items and unrelated lures after picture than word encoding, and Test Mode, $F(1,68) = 8.08$, $MS_e = .006$, $p < .01$, indicating greater discriminability in the visual + auditory than auditory test mode. There was also a significant Encoding Condition × Test Mode interaction, $F(1,68) = 6.63$, $MS_e = .006$, $p < .05$, reflecting the fact that the advantage of picture over word encoding was greater in the visual + auditory than the auditory test mode.

Analyses of the criterion measure, B''_D unrelated, revealed significantly more conservative responding after picture than word encoding, $F(1,68) = 5.09$, $MS_e = .405$, $p < .05$, and in the auditory than in the visual + auditory test condition, $F(1,68) = 4.92$, $MS_e = .278$, $p < .05$. No other effects approached significance.

True targets compared to false targets (item-specific memory). As shown in the second panel of Table 2, discrimination between studied items and related lures was influenced by each of the main variables in the experiment. A' related was greater after picture than word encoding, as reflected by a main effect of Encoding Condition, $F(1,68) = 33.46$, $MS_e = .036$, $p < .0001$, was greater in the visual + auditory than the auditory test mode, as indicated by a main effect of Test Mode, $F(1,68) = 5.45$, $MS_e = .024$, $p < .05$, and was higher in younger than older adults, as indicated by a main effect of Age, $F(1,68) = 10.18$, $MS_e = .026$, $p < .001$. There was also an Encoding Condition × Test Mode interaction, $F(1,68) = 6.69$, $MS_e = .024$, $p < .05$, indicating that the greater discriminability between studied items and related lures in the picture encoding condition compared to the word encoding condition was increased in the visual + auditory test mode compared to the auditory test mode.

Analyses of B''_D indicate more conservative responding after picture than word encoding, $F(1,68) = 6.27$, $MS_e = .359$, $p < .05$, and in the auditory test mode compared to the visual + auditory test mode, $F(1,68) = 9.43$, $MS_e = .153$, $p < .01$. No other effects approached significance.

False targets compared to false target controls (gist memory). A' gist indicates the degree to which participants are willing to rely on gist or general similarity information when making recognition responses. As indicated by the third panel in Table 2, values of A' gist were higher after word than after picture encoding for both younger and older adults, although the difference between conditions was more pronounced in the older group. In addition, elderly adults were characterized by higher A' gist values than younger adults, particularly after word encoding. However, an overall ANOVA revealed only a main effect of Encoding Condition, $F(1,68) = 7.43$, $MS_e = .041$, $p < .01$, with a trend for an effect of Age, $F(1,68) = 2.68$, $MS_e = .041$, $p = .106$. Although the Encoding Condition × Age interaction did not approach significance, $F(1,68) = 1.38$, $MS_e = .041$, it should be noted that (a) the main effect of Encoding Condition on A' gist values was significant in elderly adults, $F(1,34) = 7.93$, $MS_e = .039$, $p < .01$, but not in younger adults, $F < 1$, and (b) whereas there was no difference between A' gist values for old and young after picture encoding, $F < 1$, A' gist was significantly higher in older than younger adults after word encoding, $F(1,34) = 4.45$, $MS_e = .036$, $p = <.05$.

B''_D values in the lower panel of Table 2 indicate consistently more conservative responding after picture than word encoding, as shown by a significant main effect of Encoding Condition, $F(1,68) = 20.24$, $MS_e = .286$, $p < .0001$. No other effects were significant, Fs < 1.92.

Recollection and Familiarity: Remember/Know Responses

The proportions of remember and know responses in the various experimental conditions are presented in Table 3, together with estimates of recollection and familiarity derived using the procedures of Yonelinas et al. (1998). Yonelinas et al. have noted several problems that can arise when analyzing the raw proportions of remember and know responses as a function of experimental manipulations, as had been done frequently in previous remember/know studies (see also Donaldson, 1996; Gardiner & Gregg, 1997; Hirshman & Master, 1997). Most notably, estimates of know responses may be skewed in conventional analyses by failing to take into account that when remember responses change as a function of an experimental manipulation, so do the number of opportunities to make know responses. Yonelinas et al. have developed a model that addresses this issue. More specifically, they have described a dual process account in which remember responses are used to model recollection as a high-threshold process, and know responses are used to model familiarity as a signal detection (d') process.

We analyzed our data both in the conventional manner and using the procedures of Yonelinas et al., and generally found similar patterns of results. We will report the results of statistical analyses that were performed on the estimates derived from the Yonelinas et al. procedures. Specifically, we estimated recollection by dividing the proportion of remember responses to true or false targets by the proportion of remember responses to true or false target controls [$R = (\text{‘}R\text{’}_{old} - \text{‘}R\text{’}_{new})/(1 - \text{‘}R\text{’}_{new})$]. We estimated familiarity by computing, separately for old and new know responses, the probability that an item is familiar and also not recollected [($F_{old} = \text{‘}K\text{’}_{old}/1 - \text{‘}R\text{’}_{old}$); ($F_{new} = \text{‘}K\text{’}_{new}/1 - \text{‘}R\text{’}_{new}$)]. We then obtained estimates of d' from standard tables.[2]

True recognition. Analysis of remember responses indicates that recollection was considerably higher in younger than in older adults, $F(1,68) = 6.18$, $MS_e = .087$, $p < .05$. There was also a significant Encoding Condition × Test Mode interaction, $F(1,68) = 15.00$, $MS_e = .020$, $p < .0005$, reflecting higher levels of recollection after pictorial than word encoding in the visual + auditory test mode but not in the auditory test mode.

Estimates of familiarity were considerably higher in the visual + auditory test mode than in the auditory test mode, $F(1,68) = 24.31$, $MS_e = .694$, $p < .0001$. No other effects were significant, Fs < 2.14.

[2] We used A′ (see Tables 2 and 5) rather than d' for our basic signal detection analyses because A′ makes less stringent assumptions than does d' (see Snodgrass & Corwin, 1988) and thus is useful in providing estimates of sensitivity and bias that are relatively free of theoretical assumptions. In using the d' analysis described by Yonelinas et al. (1998) to estimate familiarity (see Tables 3 and 6), we are accepting the fundamental assumptions of their theoretical model.

False recognition. False recollection was much lower after picture than word encoding, $F(1,68) = 11.06$, $MS_e = .098$, $p < .005$. False familiarity was also considerably lower after picture than word encoding, $F(1,68) = 14.13$, $MS_e = 1.37$, $p < .0005$, and was higher in older than in younger adults, $F(1,68) = 4.01$, $MS_e = 1.37$, $p < .05$. No other effects were significant, Fs < 3.12.

Discussion

Israel and Schacter (1997) reported that studying semantic associates as pictures produced lower levels of false recognition to related lure words than did a standard encoding condition in which only words were studied. Experiment 1 has extended this finding to older adults by showing that, just as in younger adults, false recognition to related lures is reduced after picture encoding compared to word encoding. In line with previous results (Norman & Schacter, 1997; Tun et al., 1998), we found some evidence that older adults are relatively more susceptible to false recognition of semantic associates than are younger adults. Overall analyses of recognition performance showed marginally lower levels of true recognition and marginally higher levels of false recognition in older than younger adults. Analyses of recollection and familiarity based on remember and know responses provided stronger evidence of age differences. Consistent with earlier studies (e.g., Parkin & Walter, 1992), elderly adults showed lower levels of true recollection than did younger adults, with no significant differences in familiarity.

The overall pattern of results is in line with our suggestion that if age-related increases in false recognition following encoding conditions that emphasize similarities among items reflect the influence of overly general encoding, then providing elderly participants with distinctive pictures should significantly reduce false recognition. We also noted earlier that if increased false recognition in elderly adults is entirely attributable to overly general encoding, then pictorial encoding might eliminate age differences. Although we did not obtain conclusive support for this suggestion, we obtained some positive evidence: signal detection analyses revealed significant age differences in A' gist—the tendency to rely on general similarity or gist information—after word encoding but not after picture encoding.

Signal detection analyses also revealed that reduced false recognition after picture encoding was reflected both in lower levels of A' gist, indicating reduced influence of general similarity or gist information, and in higher levels of B''_D gist, indicating more conservative responding. Indeed, the clearest result from the signal detection analyses was that both younger and older adults consistently responded more conservatively after picture encoding than after word encoding. This result was obtained in each of the three types of signal detection analyses we performed, with values of B''_D unrelated, B''_D related, and B''_D gist all significantly higher in the picture encoding condition than in the word encoding condition. The only exception to this general pattern was that older adults did not show reduced false alarms to false target controls after pictorial encoding, but in view of the generally low levels of false alarms to these items by the older adults, this result may be attributable to a floor effect.

The signal detection analyses also revealed that in the picture encoding condition, participants were better able than in the word encoding condition to distinguish between studied items and either related lures or unrelated lures, as indicated by significant effects of encoding condition on A' unrelated and A' related. These effects were especially pronounced in the visual + auditory test condition, as shown by significant Encoding Condition × Test Mode interactions for both A' unrelated and A' related. The interactions indicate that reinstating encoding conditions increased participants' abilities to distinguish between studied and nonstudied items following picture encoding, but not following word encoding.

The foregoing analyses provide evidence relevant to understanding the observed suppression of false recognition following picture encoding. We suggest that the consistently more conservative bias we observed after picture encoding than after word encoding may depend on a general shift in responding based on participants' metamemorial assessments of the kinds of information they feel they *should* remember (Strack & Bless, 1994). Having encountered pictures with each of the presented words, participants in the picture encoding condition may employ a general rule of thumb whereby they demand access to detailed pictorial information in order to support a positive recognition decision; failure to gain access to such distinctive information when tested with related lures will tend to result in a negative recognition decision. Importantly, suppression based on metamemorial assessments can function without access to *list-specific distinctive information* about studied items. For instance, when presented with the related lure item "bread" on the recognition test, either as an auditory word or auditory word + picture, participants in the picture encoding condition may have recalled seeing pictures of such presented associates as "milk," "butter," "flour," or "dough"; because they could remember pictures of these presented words, but failed to recall a corresponding picture for "bread," participants may have used their recollections of particular list items to suppress false recognition responses. Consistent with the idea that suppression based on a distinctiveness heuristic need not involve access to such list-specific information, hit rates were virtually identical in the word and picture encoding groups, yet we still observed a significant reduction in false recognition in the picture encoding group. Thus, we hypothesize that suppression relies on a general expectation that a test item should elicit a vivid perceptual recollection if, indeed, it had been presented previously. Participants in the word encoding condition, by contrast, do not expect to retrieve distinctive representations of previously studied items and, hence, are much less likely to demand access to detailed recollections.

We refer to the hypothesized "rule of thumb" in the picture encoding condition as a *distinctiveness heuristic*. We use the term *heuristic* (e.g., Kahneman, Slovic, & Tversky, 1982) in order to emphasize aspects of heuristic processing that have been delineated previously by Chaiken, Lieberman, and Eagly (1989) in the context of persuasion research, and by Johnson, Hashtroudi, and Lindsay (1993) in the context of memory research. Chaiken et al. (1989, p. 212) observed that "When processing heuristically, people focus on that subset of available information that enables them to use simple inferential rules, schemata, or cognitive heuristics to formulate their judgments and decisions." Johnson et al. (1993; see also Jacoby, Kelley, & Dywan, 1989) have argued that heuristic processes play an important role in source monitoring, noting that "…heuristic judgments involve criteria such as 'if the familiarity level is above X, the event probably happened', or 'if the amount of perceptual detail exceeds X, the event was probably perceived.'" We suggest that when using a distinctiveness heuristic, participants are especially attuned to whether they recollect distinctive details about an item and use criteria such as "if I do not remember seeing a picture of an item, it is probably new."

In Experiment 2, we attempt to test the idea that false recognition suppression after pictorial encoding relies on a distinctiveness heuristic by altering a critical feature of the encoding conditions from Experiment 1.

EXPERIMENT 2

To evaluate the distinctiveness heuristic hypothesis, we attempted to create conditions in which reliance on a distinctiveness heuristic alone could not produce suppression of false recognition after picture encoding compared to word encoding. In Experiment 1, picture versus word encoding was manipulated on a between-groups basis, thereby allowing participants in the picture encoding condition to invoke a distinctiveness heuristic and respond more conservatively to false targets than participants in the word encoding condition. In Experiment 2, we manipulated picture versus word encoding on a within-groups basis. Having studied some lists with pictures and others with words only, reliance on a distinctiveness heuristic alone would not produce differential suppression of false recognition for lists studied with pictures compared to those studied with words alone. Instead, access to list-specific information would be necessary in order to achieve lower levels of false recognition following picture than word encoding. Accordingly, if false recognition suppression after pictorial encoding is entirely attributable to reliance on a distinctiveness heuristic, then the suppression effect should be eliminated in Experiment 2. By contrast, if the suppression effect also involves access to list-specific distinctive information, then false recognition should be lower after picture encoding than after word encoding in Experiment 2.

Method

Participants. Participants were 24 younger adults and 24 older adults recruited according to the same criteria as in Experiment 1. Mean age of younger adults was 20.2 years (range, 17–27 years), and they had on average 13.2 years of education. Mean age of older adults was 68.8 years (range, 63–75 years), and they had on average 15.8 years of education.

Material and design. Study and test stimuli were identical to those used in Experiment 1, but the manner in which they were presented differed between experiments. As in Experiment 1, twenty-one 12-item study lists were divided into three sets for counterbalancing purposes. Participants studied 14 lists and were given a 63-item recognition test. However, for each participant in Experiment 2, half of the study lists were presented in pictorial form and the other half were presented in word form (i.e., 7 of the 14 study lists were presented as pictures with their corresponding auditory labels, and 7 study lists were presented as words with their corresponding auditory labels). Across participants, each list appeared equally often in picture or word form. Within participants, no more than two lists appeared consecutively in the same presentation mode. All items on the recognition test were presented as either picture and auditory word or as a visual word and auditory word.

The main design consisted of two between-group variables, age (young vs old) and test presentation mode (picture vs word), and two within-group variables, encoding condition (picture vs word) and item type (true target, true target control, false target, and false target control).

TABLE 4

Proportion of "Old" Responses on the Recognition Test as a Function of Item Type, Test Presentation Mode, Age, and Encoding Condition in Experiment 2

Item type/ Test presentation mode	Young adults			Elderly adults		
	WE	PE	TC[a]	WE	PE	TC[a]
True targets	.75	.83	.17	.60	.77	.22
Word	.79	.77	.16	.71	.71	.26
Picture	.70	.88	.18	.49	.82	.18
False targets	.49	.47	.25	.66	.63	.26
Word	.54	.55	.24	.76	.68	.25
Picture	.44	.39	.26	.56	.58	.27

Note. WE, word encoding condition; PE, picture encoding condition; TC, target controls.
[a] Because encoding condition was manipulated within-groups, the same true target controls (upper three rows) and false target controls (lower three rows) were used in the word and picture encoding conditions.

Procedure. The procedure was in most respects identical to that of Experiment 1. Participants were presented with 14 study lists of 12 items each. They were instructed to pay careful attention to the visual and auditory component of each item because they would be tested on the items later. After presentation of each list, participants had 1 min to work on a puzzle. Once all lists were presented, participants received 3 min to work on mazes before performing the remember/know recognition test.

Results. Table 4 presents the proportion of "old" responses to true targets, true target controls, false targets, and false target controls as a function of experimental conditions for younger and older adults. Table 5 displays the results of the signal detection analyses, and Table 6 presents the remember/know data and recollection/familiarity estimates.

Overall Data: True Recognition

Hit rates were higher in younger than older adults, and for both younger and older adults hit rates were higher following picture than word encoding in the picture test mode, but not in the word test mode. A similar pattern was observed with corrected recognition scores that were obtained by subtracting the proportion of "old" responses to true target controls from the proportion of "old" responses to true targets. An ANOVA on corrected hit rates revealed significant main effects of Age, $F(1,44) = 8.88$, $MS_e = .065$, $p < .005$, and Encoding Condition, $F(1,44) = 24.54$, $MS_e = .015$, $p = <.0001$, and an Encoding Condition × Test Mode interaction, $F(1,44) = 27.05$, $MS_e = .015$, $p < .0001$, with no other significant effects.

Overall Data: False Recognition

In sharp contrast to Experiment 1, the proportions of false alarms to related lures in both younger and older adults were unaffected by picture versus word encoding (Table 4). Older adults showed higher levels of false alarms to related lures than did younger adults in all conditions, $F(1,44) = 7.51$, $MS_e = .088$, $p < .01$, and both younger and older adults showed less false recognition in the picture test mode than in the word test mode, $F(1,44) = 5.09$, $MS_e = .088$, $p < .05$. A similar pattern was evident for corrected false recognition, with near significant main effects for Age, $F(1,44) = 3.74$, $MS_e = .153$, $p = .059$, and Test Condition, $F(1,44) = 4.06$, $MS_e = .153$, $p = .051$. There were no other significant effects, Fs < 1.20.

Signal Detection Analyses

As in Experiment 1, we provide three different types of signal detection analyses, shown in the upper, middle, and lower panels of Table 5.

True targets compared to true target controls (item-specific memory). An ANOVA on A' un-

TABLE 5

Signal Detection Analyses of Sensitivity (A') and Bias (B''_D) as a Function of Item Type, Test Presentation Mode, Age, and Encoding Condition in Experiment 2

Encoding condition/ Test presentation mode	Young adults A'	Young adults B''_D	Elderly adults A'	Elderly adults B''_D
	Item-specific memory (true targets compared to true target controls)			
Word	.85	.23	.75	.29
Word	.87	.14	.79	.03
Picture	.82	.31	.72	.56
Picture	.88	.03	.84	.08
Word	.87	.13	.80	.07
Picture	.89	−.08	.87	.10
	Item-specific memory (true targets compare to false targets)			
Word	.67	−.29	.47	−.28
Word	.68	−.43	.47	−.48
Picture	.66	−.15	.46	−.08
Picture	.74	−.49	.60	−.45
Word	.68	−.44	.52	−.36
Picture	.80	−.54	.68	−.54
	Gist memory (false targets compare to false target controls)			
Word	.65	.34	.75	.08
Word	.68	.35	.81	−.08
Picture	.61	.33	.70	.23
Picture	.65	.39	.72	.15
Word	.71	.35	.75	.10
Picture	.59	.44	.68	.20

related values revealed main effects of Encoding Condition, $F(1,44) = 25.33$, $MS_e = .003$, $p < .0001$, indicating greater discriminability between studied items and unrelated lures after picture than word encoding, and Age, $F(1,44) = 10.85$, $MS_e = .011$, $p < .005$, indicating greater discriminability in younger than older adults. The effect of encoding was modified by an Encoding Condition × Test Mode interaction, $F(1,44) = 22.76$, $MS_e = .003$, $p < .0001$, showing that heightened discriminability after pictorial encoding was observed in the picture test condition but not in the word test condition. Age differences were larger after word than picture encoding, as reflected by an Encoding Condition × Age interaction, $F(1,44) = 5.22$, $MS_e = .003$, $p < .05$.

Analyses of the criterion measure, B''_D unrelated, revealed more conservative responding in the word encoding condition compared to the picture encoding condition, $F(1,44) = 12.40$, $MS_e = .082$, $p = .001$. However, this effect was observed only in the picture test condition, as documented by an Encoding Condition × Test Mode interaction, $F(1,44) = 13.96$, $MS_e = .082$, $p < .00l$. No other effects approached significance, Fs < 1.

True targets compared to false targets (item-specific memory). As shown in the second panel of Table 5, discrimination between studied items and related lures (A' related) was higher in younger than older adults, $F(1,44) = 22.19$, $MS_e = .033$, $p < .0001$ and was higher after picture than word encoding, $F(1,44) = 10.19$, $MS_e = .024$, $p < .005$. There was also an Encoding Condition × Test Mode interaction, $F(1,44) = 6.33$, $MS_e = .024$, $p < .05$, indicating that the increased discriminability between true and false targets after picture encoding was larger in the picture test mode than in the word test mode.

Analyses of B''_D indicate more conservative responding after word than picture encoding, $F(1,44) = 6.51$, $MS_e = .125$, $p < .05$. As in the previous analysis, this effect was found only in the picture test condition, as documented by a significant Encoding Condition × Test Mode interaction, $F(1,44) = 11.16$, $MS_e = .125$, $p < .005$. No other effects were significant, $F < 3.16$.

False targets compared to false target controls (gist memory). In contrast to Experiment 1, the bottom panel in Table 5 indicates that levels of A' gist (which indicate the degree to which participants are willing to rely on gist or general similarity information when making recognition responses) were unaffected by Encoding Condition, $F < 1$. Elderly adults were characterized by somewhat higher A' gist values than were younger adults after both picture and word encoding, as indicated by a trend for a main effect of Age, $F(1,44) = 3.20$, $MS_e = .057$, $p = .081$.

TABLE 6

(A) Estimates of Recollection (*R*) and Familiarity (*F*(*d*′)) Based on a Dual Process Signal Detection Model (Yonelinas et al., in press); (B) Raw Proportions of Remember (*R*) and Know (*K*) Responses That Contribute to the Estimates of Recollection and Familiarity, Respectively, for Experiment 2

A.

Item type/Test presentation mode	Young adults: Word *R*	Young adults: Word *F*(d′)	Young adults: Picture *R*	Young adults: Picture *F*(d′)	Elderly adults: Word *R*	Elderly adults: Word *F*(d′)	Elderly adults: Picture *R*	Elderly adults: Picture *F*(d′)
True target	.53	1.06	.69	1.21	.41	.63	.56	1.10
Word	.56	1.22	.60	1.16	.54	.75	.46	.78
Picture	.49	.91	.77	1.25	.28	.51	.65	1.42
False target	.19	.59	.20	.31	.43	1.01	.38	.73
Word	.12	.80	.15	.73	.59	1.38	.41	1.02
Picture	.26	.22	.24	−.09	.28	.64	.35	.44

B.

	Word *R*	Word *K*	Picture *R*	Picture *K*	TC[a] *R*	TC[a] *K*	Word *R*	Word *K*	Picture *R*	Picture *K*	TC[a] *R*	TC[a] *K*
True target	.55	.19	.70	.13	.05	.12	.51	.09	.62	.14	.15	.07
Word	.57	.22	.60	.17	.03	.13	.61	.10	.54	.17	.16	.10
Picture	.53	.17	.79	.09	.07	.11	.41	.08	.70	.11	.14	.04
False target	.27	.21	.27	.20	.08	.17	.55	.11	.53	.10	.21	.06
Word	.24	.30	.25	.30	.10	.14	.64	.12	.54	.14	.19	.06
Picture	.31	.13	.29	.10	.06	.20	.46	.10	.51	.07	.23	.05

Note. TC, target controls.
[a] Because encoding condition was manipulated within-groups, the same true target controls (upper three rows of B) and false target controls (lower three rows of B) were used in the word and picture encoding conditions.

There was also a marginally significant effect of Test Mode, $F(1,44) = 3.78$, $MS_e = .057$, $p = .058$, indicating generally higher levels of A' gist in the word test mode compared to the picture test mode.

B''_D values in the lower panel of Table 5 indicate a near-significant trend for more conservative responding in younger than older adults, $F(1,44) = 3.57$, $MS_e = .440$, $p = .066$. No other effects approached significance, $Fs < 1.83$.

Recollection and Familiarity: Remember/Know Responses

True recognition. As in Experiment 1, true recollection was higher in younger than in older adults, $F(1,44) = 5.89$, $MS_e = .060$, $p < .05$. Recollection was also considerably higher after picture than word encoding, $F(1,44) = 21.13$, $MS_e = .026$, $p < .0001$. However, recollection was higher following picture encoding than word encoding in the picture test condition, but not in the word test condition, as shown by a significant Encoding Condition × Test Mode interaction, $F(1,44) = 27.30$, $MS_e = .026$, $p < .0001$.

Estimates of familiarity were also higher after picture than word encoding, $F(1,44) = 4.72$, $MS_e = .475$, $p < .05$. As with recollection, however, this effect was observed only in the picture test condition, as confirmed by an Encoding Condition × Test Mode interaction, $F(1,44) = 5.25$, $MS_e = .475$, $p < .05$. No other effects were significant, Fs < 2.45.

False Recognition. In contrast to Experiment 1, estimates of false recollection were virtually identical after picture and word encoding, $F < 1$. Older adults showed higher levels of false recollection than did younger adults, $F(1,44) = 8.18$, $MS_e = .134$, $p < .01$. This main effect of Age was modified by an Age × Test Mode interaction, $F(1,44) = 4.08$, $MS_e = .134$, $p < .05$, reflecting that the age-related increase in false recollection was more pronounced in the word test mode than in the picture test mode.

As in Experiment 1, false familiarity was higher in older than in younger adults, $F(1,44) = 4.07$, $MS_e = 1.22$, $p < .05$, but in contrast to Experiment 1, there was no effect of Encoding Condition on false familiarity, $F(1,44) = 1.58$, $MS_e = .842$. False familiarity was also higher in the word than picture test mode, $F(1,44) = 9.13$, $MS_e = 1.22$, $p < .005$. No other effects approached significance, Fs < 1.29.

Discussion

In Experiment 2 there were no differences in false recognition after picture and word encoding in either the picture or the word test modes, thereby supporting the idea that suppression of false recognition depends on the use of a distinctiveness heuristic without access to list-specific information. The picture encoding condition was associated with higher levels of both true recollection and familiarity than was the word encoding in Experiment 2, although beneficial effects of pictorial encoding on recognition accuracy were observed only when pictures were presented at test. These findings suggest that pictorial encoding provided participants with access to more distinctive recollections than did word encoding, at least in the picture test condition. In Experiment 2, however, demanding access to distinctive recollections in order to make a positive recognition response was not sufficient to produce differential suppression of false recognition following picture and word encoding: all participants had encoded some lists as pictures and others as words, so access to list-specific information was necessary for differential suppression of false recognition. By contrast, because encoding condition was manipulated between-groups in Experiment 1, a generalized shift in responding based on a distinctiveness heuristic was sufficient to produce differential suppression of false recognition after picture encoding compared to word encoding.

Signal detection analyses are consistent with these conclusions. In Experiment 1, each of the three signal detection analyses revealed evidence of more conservative responding in the picture encoding condition than in the word encoding condition. In Experiment 2, by contrast, there was no evidence of more conservative responding after pictorial encoding. Levels of B''_D gist were indistinguishable in the picture and word encoding conditions, and levels of B''_D unrelated and B''_D related indicated more conservative responding after word than picture encoding. Note, however, that these latter differences were observed only in the picture test mode and might reflect the fact that participants in this condition were sometimes given new pictures at test for items they had studied as words, perhaps eliciting conservative response biases (the finding of higher B''_D unrelated after word than picture encoding might simply reflect the fact that, because a single unrelated lure false alarm rate was used for the two encoding conditions, the condition that produces a lower hit rate also necessarily produces more conservative responding). Yet even in the word test mode, there was no evidence of more conservative responding in the picture encoding condition than in the word encoding condition. Thus, the important point for our purposes is that the consistently conservative responding observed in the picture encoding condition compared to the word encoding condition in Experiment 1—which we attribute to the use of a distinctiveness heuristic—was not observed in Experiment 2.

Consistent with the foregoing points, we found that participants in the picture test mode showed less false recognition of related lures than did participants in the word test mode. Because type of test was manipulated between groups, this effect likely reflects the operation of a distinctiveness heuristic: participants in the picture test mode, who were provided with more distinctive cues than participants in the word test mode, may have demanded more detailed recollections to support a positive recognition decision than did participants in the word mode. Although signal detection analyses did not demonstrate significantly more conservative responding in the picture than word test mode, there were numerical trends in this direction for each of the three analyses.

As noted earlier, analysis of the true recognition data indicated that in the picture test mode, participants showed levels of recognition higher for items studied as pictures than for those studied as words, whereas no such effect was present in the word test mode. Analysis of remember/know responses indicated that in the picture test mode, there were much higher levels of recollection for old items studied as pictures than for old items studied as words only; there were no such differences in recollection in the word test conditions.

These findings indicate that participants who were shown pictures at test had some basis for demanding more specific recollections than did participants who were shown words at test. Because false targets did not provide access to representations with these distinctive properties, participants in the picture test mode responded "old" less often to false targets than did participants in the word test mode. However, participants in both test modes were unable to use related lures to gain access to list-specific information about whether associated items were studied as pictures or words; accordingly making fewer "old" responses to false targets in the picture test mode did not provide a basis for differentially suppressing false recognition according to whether the relevant lists of associates had been studied with pictures or words only.

As in Experiment 1, elderly adults in Experiment 2 showed higher levels of false recognition than did younger adults. However, whereas in Experiment 1 there was some evidence that age-related increases in susceptibility to false recognition were reduced after picture encoding compared to word encoding, there was no such evidence in Experiment 2. These observations suggest that elderly adults may be able to use a distinctiveness heuristic based on prior encoding of pictures to partially or entirely overcome their increased tendency (compared to younger adults) to respond positively to semantically related false targets (Experiment 1). However, when a distinctiveness heuristic does not produce differential suppression for picture encoding compared to word encoding (Experiment 2), age-related increases in false recognition are comparable after encoding of pictures and words.

GENERAL DISCUSSION

The two experiments reported here extend the Israel and Schacter (1997) finding of false recognition suppression after pictorial encoding to elderly adults and also provide evidence implicating a specific mechanism of suppression, which we have called the distinctiveness heuristic. In Experiment 1, where a between-groups manipulation of picture and word encoding allowed for the effective operation of a distinctiveness heuristic, younger and older adults each exhibited 30–40% reductions in overall levels of false alarms to related lures after picture encoding compared to word encoding. However, in Experiment 2, where a within-groups manipulation of picture versus word encoding rendered the distinctiveness heuristic ineffective for differentially suppressing false alarms after pictorial encoding relative to word encoding, there was no evidence of significant suppression. These contrasting patterns of results are shown together in Fig. 1.

Our findings support and extend previous work by Strack and Bless (1994), who discussed the operation of a metamemorial strategy similar to the distinctiveness heuristic in a different experimental context (see also Hirshman and Arndt [1997] for a related distinction between decision-based and memory-based modulation of false alarms). In the experiments by Strack and Bless, participants studied pictures, most of which came from a single large category (i.e., tools); the study list also contained a few pictures from outside the category. On a subsequent recognition test, participants made

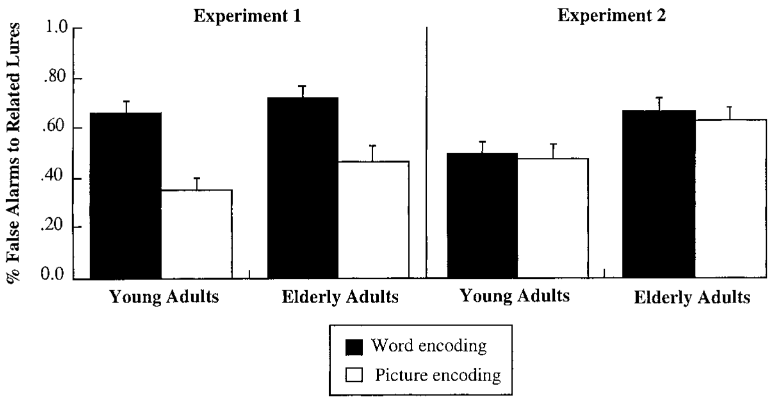

FIG. 1. Proportions of false alarms to related lures words by younger and older adults as a function of word encoding and picture encoding in Experiment 1 (left) and Experiment 2 (right). Results are collapsed across test presentation mode. Both age groups showed marked reductions in false recognition after picture encoding in Experiment 1, where a distinctiveness heuristic could be used to suppress false alarms after picture encoding relative to word encoding, but not in Experiment 2, where a distinctiveness heuristic could not be used to suppress false alarms after picture encoding relative to word encoding.

significant numbers of false alarms (e.g., 25–30%) to lure items from within the dominant category (i.e., nonstudied tools), but never made false alarms to lures from outside the dominant category. Strack and Bless argued that because the few studied items from outside the dominant category were highly salient, participants reasoned that they would have possessed a detailed recollection of such items had those items been presented on the study list—in our terms, these participants may have invoked a distinctiveness heuristic. Note, however, that there is no reason to assume that participants in these experiments would have made high levels of false alarms to items from outside the dominant category even if these items had been presented in the context of other unrelated items. Thus, our findings indicate that the kinds of metamemorial processes discussed by Strack and Bless can be invoked to suppress, at least partially, powerful false recognition effects of the kind typically observed with procedures described by Roediger and McDermott (1995) and others. In so doing, our findings also support the claims of Johnson and colleagues (e.g., Johnson et al., 1993; Johnson & Raye, in press) that heuristic processes can play an important role in memory and source monitoring decisions. Our data also add to other demonstrations that false recognition of semantic associates can be reduced by inducing participants to adopt more stringent response criteria. For instance, Gallo, Roberts, and Seamon (1997) and McDermott and Roediger (in press) have found that warning participants about the presence of related lure items reduces (but does not eliminate) the false recognition effect. Although such warning effects do not depend specifically on a distinctiveness heuristic (no distinctive information is presented at the time of encoding), they do involve general shifts toward more conservative responding that also characterize the operation of the distinctiveness heuristic.

Our findings also highlight the limits of a distinctiveness heuristic as a means of suppressing robust false recognition effects. When access to list-specific information is required to show reduced false recognition after pictorial encoding, as in Experiment 2, reliance on a distinctiveness heuristic cannot produce differential false recognition suppression after pictorial encoding compared to word encoding. Of course, the fact that we failed to observe evidence of differential suppression in Experiment 2 need not mean that access to list-specific information can never be used to suppress false recognition in our paradigm; it is entirely conceivable that experimental conditions could be created in which participants are able to suppress false recognition of related lures based on access to list-specific information. Note also that accessing list-specific information and relying on a distinctiveness heuristic need not be mutually exclusive modes of suppressing false recognition. For example, if experimental conditions can be created that allow participants to use list- or item-specific information to suppress false recognition of related lures, this list-specific suppression may operate in conjunction with, rather than in the place of, a distinctiveness heuristic.

Moreover, related research on false recognition has already provided evidence of suppression based on mechanisms that likely involve more than reliance on a distinctiveness heuristic. Brainerd, Reyna, and Kneer (1995) reported that false recognition of a related lure word that had been preceded earlier in a list by a single semantic associate could be suppressed below baseline levels of false alarms to unrelated words by presenting the studied word again immediately prior to the related lure. According to Brainerd et al. (1995), this phenomenon of false recognition reversal occurs because presenting the target word immediately prior to the related lure permits participants to gain access to a specific recollection of their initial encounter with the target, which in turns allows them to note that the immediately following lure item is not identical to the studied target. However, the magnitude of the false recognition effect observed by Brainerd et al. when the lure was *not* preceded immediately by a target word was considerably smaller than the false recognition effects observed after word encoding in our experiments and in similar studies using the Roediger and McDermott (1995) procedures. Thus, it is not known whether item-specific retrieval processes of the kind studied by Brainerd et al. can be used to suppress the large false recognition effects observed in our experiments and in related studies (see Brainerd & Reyna, in press) or whether suppression of robust false recognition depends mainly—or perhaps exclusively—on the distinctiveness heuristic and related means of inducing global shifts in response criteria (Gallo et al., 1997; McDermott & Roediger, in press).

Nonetheless, the possibility that some false recognition suppression effects are attributable to reliance on a distinctiveness heuristic, whereas others may involve access to list-specific or item-specific information, has possibly important implications for other findings concerning false recognition. As noted earlier, Smith and Hunt (in press) reported reduced false recognition in the Deese/Roediger-McDermott paradigm after visual study compared to auditory study, and argued that visual processing is more readily discriminable from the amodal processing that contributes to false recognition than is auditory processing. Viewed from the perspective developed here, it is possible that reduced false recognition in the Smith and Hunt paradigm is attributable to the use of a distinctiveness heuristic: after visual study of target words, participants may demand access to visually based recollections before endorsing items as old. Alternatively, when making recognition decisions about a false target, participants might recall seeing associated words during study and reject the false target based on their access to this list-specific information. Because Smith and Hunt manipulated visual versus auditory encoding between groups (as in our Experiment 1), a distinctiveness heuristic could be the source of the effects that they observed. If so, then these effects should disappear when visual versus auditory encoding is manipulated within groups (as in our Experiment 2). By contrast, if access to list-specific information is involved, then false recognition should be lower after visual than auditory study even when study conditions are manipulated within groups.

Similar considerations arise when considering false recognition in older adults. As we have noted, our data extend previous findings from similar paradigms showing relatively increased susceptibility to false recognition of semantic associates (Norman & Schacter, 1997; Tun et al., 1998) and categorized pictures (Koutstaal and Schacter, 1997) in older adults. The Koutstaal and Schacter findings are particularly striking, with older adults showing false alarm rates of 60–70%—twice that of younger adults—to within-category lures after studying 18 pictures of objects from a particular category. In more recent studies, Koutstaal, Schacter, Galluccio, and Stofer (in press) examined whether providing participants with distinctive elaborators for each studied picture would reduce false recognition and contribute to narrowing or even eliminating previously observed age differences. Thus, for example, whereas in the control condition participants studied 18 pictures of various cars, shoes, and objects from other categories, in the experimental condition participants studied these same pictures, but accompanied by brief verbal descriptions designed to highlight the distinctive properties of each picture relative to all the others within the category. Koutstaal et al. found that false recognition was reduced sharply in the experimental condition compared to the control condition and that the reduction was greater for older than for younger adults (however, even in the experimental condition older adults still made significantly more false alarms to within-category lures than did younger adults).

As with the Smith and Hunt (in press) study, when viewed from the theoretical perspective developed here, false recognition suppression in the Koutstaal et al. experiments could be attributable to the operation of a distinctiveness heuristic: participants in the experimental condition, knowing they had been given distinctive elaborators for each picture, may have demanded access to detailed recollections of the distinctive information before responding "old" to similar but novel pictures. Alternatively, participants in the experimental condition, when confronted with a novel item from a studied category, may have recalled category-specific distinctive information that allowed them to determine that the lure item had not been studied previously. For instance, when confronted with a novel picture of a car, participants may have recalled some of the distinctive elaborators associated with previously studied cars; based on their failure to recall any such information for the novel car, they called the item "new."

Because the presence or absence of distinctive elaborators was manipulated between groups in the Koutstaal et al. experiments, it is not possible to distinguish between these two alternative interpretations of the Koutstaal et al. data. To do so, the presence or absence of distinctive elaborators could be manipulated within groups, which would render a distinctiveness heuristic ineffective in producing differential suppression of false recognition for categorized pictures studied with distinctive elaborators compared to those studied without elaborators. Under these conditions, access to category-specific information would be required to produce differential suppression of false recognition in the experimental condition compared to the control condition.

Recent data from another type of false recognition suppression paradigm raise the possibility that whereas older adults show normal false recognition suppression when suppression is produced by a distinctiveness heuristic, they may fail to show normal suppression when other mechanisms are involved. Schacter et al. (in press) reported that when lists of semantic associates similar to those used here are repeatedly studied and tested, healthy volunteers showed significant suppression of false alarms to related lures across trials: true recognition increased significantly from the first to the fifth trial, whereas false recognition decreased significantly from the first to the fifth trial (see McDermott [1996] for a similar finding with false recall). Schacter et al. also reported that amnesic patients failed to demonstrate significant suppression and even showed evidence of increasing false recognition across trials. Recent work in our laboratory has extended the false recognition suppression paradigm used by Schacter et al. (in press) to the study of cognitive aging and found little or no evidence of false recognition suppression across trials in older adults, even though younger adults showed robust suppression effects and both older and younger adults showed increased hits across trials (Kensinger & Schacter, 1998). Similar patterns of results have been obtained in experiments using categorized word lists (A. Wagner, D. L. Schacter, & C. Racine, unpublished observations).

These failures to observe suppression of false recognition across trials in older adults provide a striking contrast to the normal suppression of false recognition in elderly adults observed in our experiments and by Koutstaal et al. (1998). Although the exact reasons for the contrasting patterns remain to be elucidated, Schacter et al. (in press) argued that across-trial suppression of false recognition in healthy volunteers is based on the increasing accessibility of item-specific recollections of studied items: with repetition, participants recall more accurately the exact items that were presented on a particular list, which in turns allows them to note that a related lure word had not been presented previously. According to Schacter et al., amnesic patients do not build up such item-specific recollections across trials and thus are unable to suppress the strengthening influence of the semantic similarity or gist information that does build across trials.

A similar interpretation could be applied to older adults: if across-trial suppression of false recognition depends on developing detailed item-specific recollections, and elderly adults do not build up sufficient item-specific information across trials, then older individuals will exhibit impaired suppression compared to younger adults. By this view, fundamentally different mechanisms are involved in the suppression effects observed after pictorial encoding in our paradigm (distinctiveness heuristic) and suppression effects observed across trials in the Schacter et al. (in press) paradigm (access to list- or item-specific information).

However, one important link is missing in this argument. It is logically possible that the suppression effects observed in the Schacter et al. (in press) repetition paradigm could be attributed to the operation of processes similar to the distinctiveness heuristic described here: as true recognition increases across trials, participants may demand increasingly strong or detailed representations in order to make a positive recognition response—that is, because their veridical recollections are more accurate and compelling after repetition, participants may respond in a generally more cautious manner to false targets. If so, then the observed failures of older adults to show significant suppression of false recognition across trials could reflect their failure to invoke an appropriate heuristic-based shift in responding.

To determine whether suppression in the Schacter et al. (in press) repetition paradigm is attributable to increasing access to item/list-specific information on the one hand or a heuristic-based shift in responding on the other, it will be necessary to manipulate repetitions on a within-groups basis (e.g., participants study some lists once and others five times prior to testing). Under these conditions, reliance on a distinctiveness or similar heuristic would not produce differential suppression of false recognition for lists studied five times compared to lists studied only once (for the same reason picture encoding did not produce false recognition suppression compared to word encoding in our Experiment 2). Thus, if suppression effects were observed under these conditions, they could be confidently attributed to the use of item/list-specific information about the repeated items. If elderly adults failed to show suppression effects under these conditions, impaired access to item/list specific information would be strongly implicated.

Whatever the outcome of such research, the present results indicate that older adults can show normal suppression of false recognition under conditions in which suppression is attributable to the operation of a distinctiveness heuristic. We suggested at the outset that providing pictures during study would encourage participants to focus on the distinctive features of otherwise highly similar lists of associates. We also hypothesized that if age-related increases in false recognition depend, at least in part, on indistinct encoding of target information, increased focus on distinctive properties of items during study would be especially helpful to older adults. Consistent with these suggestions, in Experiment 1 there was some evidence that significant age differences in false recognition following word encoding were eliminated after picture encoding.

The overall pattern of results, however, indicates that conditions that promote distinctive encoding provide a basis for older (and younger) participants to set a more stringent criterion for responding "old" to test items.

When increasing distinctive encoding does not provide a basis for suppressing false recognition with more conservative responding (Experiment 2), neither group exhibits encoding-based suppression effects. These observations suggest that age differences in retrieval mechanisms, as well as encoding, are implicated in false recognition effects. As Schacter et al. (1997) suggested, it may be most fruitful to focus on interactions between encoding and retrieval when theorizing about age differences in false recognition. Indistinct encoding processes may promote the use of excessively liberal criteria during retrieval in older adults; increasing distinctive encoding at study allows older individuals to set more appropriate criteria at test. While theories of veridical memory have long recognized the importance of interactions between encoding and retrieval (e.g., Tulving & Thompson, 1973), it is also useful to focus on encoding/retrieval interactions in thinking about false memory phenomena.

Although we have invoked the concept of a distinctiveness heuristic to explain the contrasting patterns of false recognition suppression in Experiments 1 and 2, it is important to emphasize that our only evidence for this claim has been provided by pictorial encoding. Thus, in contrast to general conclusions about the operation of a "distinctiveness heuristic," our data may speak only to the operation of a "picture heuristic"—that is, the effects we observed may be specific to the use of pictures. One reason to believe that our conclusions apply more generally to the domain of "distinctive information" is that picture superiority effects on memory have been attributed to more distinctive encoding of pictures than words (e.g., Dewhurst and Conway, 1994). Nonetheless, to assess the generality of our conclusions it will be necessary to obtain evidence using other manipulations that increase the distinctiveness of studied materials (see, for example, Hunt & McDaniel, 1993; Hunt & Smith, 1996; Schmidt, 1991). The experiments by Koutstaal et al. (1998), noted earlier, represent one step in this direction.

Further insight into the necessary conditions for using the distinctiveness heuristic could also be obtained by examining its operation in patients with severe memory disorders. We have assumed that in order to employ a distinctiveness heuristic in our experiments, participants must be able to recollect during the recognition test that they saw pictures earlier. There is no reason to assume that older adults would have any difficulty recalling such general information, and the results of Experiment 1 support this assumption. However, patients with severe amnesic syndromes might have serious difficulties remembering on the recognition test whether they saw any pictures earlier and, hence, might fail to show suppression effects that are based on a distinctiveness heuristic. Schacter et al. (in press) have already provided evidence of impaired suppression of false recognition in amnesic patients, but the mechanisms underlying this deficit remain to be specified. Further neuropsychological investigations of false recognition suppression could provide insights into the brain mechanisms that are necessary to support the operation of the distinctiveness heuristic.

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