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## CHAPTER 3

# Proactive and Retroactive Effects in Memory Performance: Dissociating Recollection and Accessibility Bias

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Several years ago at a conference, in discussing a problem for some people of easily becoming lost in new surroundings, Robert Crowder shared his strategy of stopping frequently to look back at the route he had just traversed, saying that doing so serves the important function of allowing one to see the route as it will appear when one returns. Stopping to look back is a generally useful strategy even when one cannot truly return. Looking back at his accomplishments, Bob has good reason to feel a great deal of pride. Among his greatest accomplishments are the students that he mentored, many who have gone on to become leading researchers and journal editors. Here, using Bob's strategy of looking back, we argue that much of the current research on memory has unknowingly returned to problems that have been investigated, specifically proactive and retroactive interference.

As described in Crowder's (1976) influential book, the interference theory of forgetting was seen as "the most comprehensive theoretical system in the field of human learning and memory" (p. 217). McGeoch (1932) argued that forgetting is the result of interference rather than decay with the passage of time or disuse. The prototype design used to investigate retroactive interference is owed to Müller and Pilzecker (1900, cited in Crowder, 1976). For that design, there are two conditions, both of which learn a first list of verbal items and later are tested for memory of that list (Table 3.1A). The control group is allowed to rest during the interval between the study and the test, whereas the experimental group learns another list of items, an interpolated list, during that interval. The advantage in retention performance

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TABLE 3.1

*Example sequence of events in retroactive interference and misinformation effect*

CONDITION	TIME 1	TIME 2	TIME 3
A. Retroactive interference			
Experimental	Learn A-B	Learn A-D	Test A-B
Control	Learn A-B	Rest	Test A-B
B. Misinformation effect			
Experimental	Mother-weekend	Mother-2 weeks	Test
Control	Mother-weekend	Rest	Test

of the control condition over the experimental condition defines retroactive interference. The standard procedure for such experiments became paired-associate learning with the experimental condition conforming to an A-B, A-D paradigm: Two different responses, B and D, are learned in association to the same stimulus. By McGeoch's (1942) response competition theory, retrieval failures occur because some unwanted information is retrieved rather than the sought-after information. In the case of retroactive interference, the response learned in the second list (D) "blocks" retrieval of the first-list response (B). The basic idea is that forgetting results from blockage of retrieval (accessibility) caused by competing information rather than from actual loss of information from memory.

Crowder (1976) referred to McGeoch's (1942) theory as an independence hypothesis and contrasted that hypothesis with the unlearning hypothesis that later dominated theorizing about retroactive interference. The independence in question is between the learning of first- and second-list responses in the A-B, A-D paradigm. By McGeoch's theory, learning of a second association (A-D) does not influence the association of an earlier response (A-B) but, rather, has its effect on retention performance by providing a competitor for the earlier response. In contrast, the theory of unlearning holds that learning of a second association weakens the earlier association, a dependence hypothesis. The unlearning hypothesis originated from experiments by Melton and Irwin (1940) whose results show that the forgetting of paired associations from a first list could not be fully accounted for by interlist intrusions. Such intrusions, responses from the interpolated list that were mistakenly given in place of the first-list response, would be expected to account for all effects of retroactive interference if forgetting is caused by second-list learning competing with earlier learning. To explain the discrepancy, it was argued that learning of a response to a stimulus in an interpolated list requires unlearning or weakening of the earlier learned response. Retroactive interference was said to reflect both response competition and unlearning.

Postman and Underwood (1973) combined the notions of response competition and unlearning by proposing a two-factor theory of forgetting to account for proactive

and retroactive interference. For proactive interference, it is the influence of prior learning that is of interest (Table 3.2A). The experimental group for proactive interference is the same as for retroactive interference except it is memory for the interpolated list that is tested. The control group "rests" rather than engaging in the prior learning. Proactive interference is measured as the retention advantage of the control over the experimental group and is said to result from response competition. Effects of unlearning are restricted to retroactive interference.

There was a great deal of controversy surrounding the question of whether unlearning or independence best describes the relation between responses paired with the same stimulus. Against the unlearning hypothesis, Martin (1971) showed that recall of a first-list response was stochastically independent of recall of a second-list response rather than the two being inversely related. An inverse relationship would be predicted if learning of the second-list response entailed unlearning of the first-list response. However, Hintzman (1972) argued that such conditionalized results cannot be used to establish independence. Some of the arguments against the independence hypothesis were later used against other claims of independence—the independence assumption in the process dissociation procedure (see the exchange between Jacoby, Begg, & Toth, 1997; Jacoby & ShROUT, 1997; and Curran & Hintzman, 1997; Hintzman & Curran, 1997) and the proposed independence between recognition and recall put forth by Flexser and Tulving (1978; also see 1993; Hintzman, 1992, 1993; and Tulving & Flexser, 1992). The controversy surrounding the independence versus unlearning hypotheses was never really resolved. Rather, interests of memory researchers shifted to topics highlighted by the "cognitive revolution." Investigations of retroactive and proactive interference became unpopular, largely because of their having been couched in theorizing about

TABLE 3.2  
*Memory effect of primes*

BETWEEN-PARTICIPANT TEST CONDITIONS	PROBABILITY OF CORRECT RECALL		
	WITHIN-PARTICIPANT TEST CONDITIONS		
	VALID	BASELINE	INVALID
Mostly valid	.81	.67	.51
Mostly invalid	.77	.69	.60
BETWEEN-PARTICIPANT TEST CONDITIONS	ESTIMATES OF RECOLLECTION (R) AND ACCESSIBILITY BIAS (A)		
	R	A	
Mostly valid	.32	.74	
Mostly invalid	.38	.61	

associations and identified with "verbal learning," a tradition viewed as no longer fashionable.

At approximately the same time as interest in interference theory was declining in North America, it was used by British psychologists to describe exciting, new findings about the memory performance of people with amnesia. Warrington and Weiskrantz (1970) tested memory by presenting a fragmented version of earlier studied words as cues for their retrieval and found that memory performance of people with amnesia was nearly equal to that of people with normally functioning memory. They described their results by saying

it may not be too far-fetched to suggest that effective normal day-to-day memory demands that previous events be forgotten or suppressed and the inability to do so in the amnesic subject produces responses analogous to prior-list intrusions recorded in formal verbal learning experiments. (p. 630)

The notion is that people with amnesia are more vulnerable to interference than are normal people. Providing fragments as cues for retrieval was seen as having its effect by limiting interference in a way that allowed people with amnesia to eliminate incorrect, alternative responses just as people with normal memories. The type of test used by Warrington and Weiskrantz later became known as an indirect or implicit test of memory, and there is now a great deal of evidence to show dissociations between performance on indirect and direct tests for people with normal memory (e.g., Roediger & McDermott, 1993) and for special populations such as people with amnesia (Shimamura, 1989) and older adults (Light & La Voie, 1993). Similar to the account of amnesia forwarded by Warrington and Weiskrantz, age-related differences in memory have been explained as resulting from the older adults being more susceptible to interference effects than are younger people (Hasher & Zacks, 1988; Winocur, 1982).

The "misinformation effect" (for a review, see Ayers & Reder, 1998) can be seen as an example of retroactive interference gained by using materials that are more interesting than are paired associates. In her classic experiments, Loftus (1975) showed that later presented, misleading information can influence memory reports about an earlier event in ways that are important for eyewitness testimony. Participants in her experiment viewed a scene that included a stop sign and were later asked a misleading question that implied that a yield sign, rather than a stop sign, appeared in the earlier scene. Participants in this experimental condition were much more likely to mistakenly report the presence of a yield sign in the earlier scene than were those in a control condition who were not asked the misleading question. The paradigm conforms to an investigation of retroactive interference with the stop sign corresponding to A-B and the misleading question about the yield sign corresponding to A-D learning. The misinformation effect refers to the worsened memory performance of the experimental as compared with the control condition just as does "retroactive interference."

Theoretical accounts of the misinformation effect have also been similar to those given for retroactive interference. Loftus (1975) claimed that the misleading question had its effect by altering the memory trace of the earlier event, a notion that is similar to unlearning. In contrast, McCloskey and Zaragoza (1985) suggested that misinformation effects are not reflective of memory change but, rather, are due to task demands and strategies that are similar to those accompanying response competition. The misleading information is seen to provide a competitor for response in the same way that a second-list response competes with a first-list response. Just as is found for retroactive interference, the misinformation effect is larger for older in comparison with younger adults (Cohen & Faulkner, 1989).

As described above, increased susceptibility of older adults to interference or misinformation effects means only that they are more likely to use incorrect or misleading information in tests of memory. Our goal is to better understand the basis for that difference. We forward a dual-process account of retroactive and proactive interference that differs in important ways from the traditional account that appeals to unlearning and response competition. Our approach distinguishes between recollection and automatic influences of memory (e.g., Jacoby, 1991) and seeks to measure the contributions of the two types of processes. Recollection refers to a consciously controlled use of memory where impairment is largely responsible for amnesia and age-related differences in memory. Recollection is assumed to be independent of more automatic forms of memory that are largely preserved in people with amnesia and older adults and are, to some extent, revealed by performance on indirect tests. We argue that in contrast to alternative approaches, the greater susceptibility to interference shown by the older adults is a consequence rather than a cause of age-related differences in memory. We show that retroactive and proactive interference sometimes result from an effect on an automatic influence of memory that we term "accessibility bias" without changing ability to recollect.

### **"I Told You . . .": Analysis of a Misinformation Effect**

Suppose that a wife tells her husband that her mother is going to visit for a weekend. After a delay of several days, she attempts to create a false memory by saying, "As I told you, my mother will arrive this weekend for a 2-week visit." The husband might accept the misinformation conveyed by the false "I told you . . ." claim, mistakenly concluding that he was earlier informed of the impending lengthy visit, whereas he would have correctly remembered the earlier conversation had it not been for the false claim (Table 3.1B). If the husband had challenged the "I told you . . ." claim, the wife might respond by accusing him of not paying full attention to their earlier conversation, suggesting that lack of attention has effects that are the same as those of misinformation. Although lack of attention can undoubtedly result in misinformation, we show that effects of the two are sometimes very different.

We suspect that scenarios of the above sort are common and that the potential power of a false "I told you . . ." claim is widely known. As described later, false "I told you . . ." claims are a common ploy used to defraud older adults.

Our experiments investigating the "I told you . . ." effect used materials that are much less interesting than a visiting mother-in-law and, at most, no more interesting than the paired associates used in investigations of retroactive interference. Pairs of related words (e.g., knee bone) were presented for study. In one condition, participants devoted full attention to study. In a second condition, divided attention, participants studied the word pairs while simultaneously engaged in a listening task that involved monitoring for sequences of three consecutive odd numbers. Memory was tested by providing the lefthand member of each pair along with a fragment of the righthand member (knee b\_n\_) as cues for its recall. Immediately prior to the presentation of the recall test, a prime word was presented. The prime was the same as the target word (a valid prime), an alternative to the target word (an invalid prime), or a neutral nonword stimulus (a baseline prime). The design of the experiment is outlined in Table 3.3.

For now, consider only the invalid prime and baseline conditions, which correspond to the experimental and control conditions in a standard investigation of retroactive interference. The invalid prime condition was meant to correspond to a false "I told you . . ." claim. For that condition, a plausible alternative to the target word was used as the prime. The alternative was plausible in that, like the target, it was related to the context word and would complete the fragment. As expected, presentation of this invalid prime produced a misinformation effect, or retroactive interference, compared with the baseline condition in which a prime word was not presented (Table 3.4). That is, presentation of an invalid prime decreased the probability of correct recall and increased the probability of the prime being mistakenly reported as earlier studied. Dividing attention reduced the probability of correct recall and increased false recall for both the invalid prime and baseline conditions. The probabilities of correct and false recall add up to approximately 1.0 because materials were selected to allow only two possible responses to each test item, with

TABLE 3.3  
*Basic procedure used for valid and invalid prime experiments*

STUDY PHASE CUE WORD AND TARGET	TEST PHASE		TEST CONDITION
	PRIME	WORD FRAGMENT	
bed sheet	sleep	bed s_ee_	Invalid prime
eagle bird	✂✂✂✂	eagle b__d	Baseline (no prime)
knee bone	bone	knee b_n_	Valid prime

TABLE 3.4

*Probability of correct recall for prime conditions*

STUDY CONDITION	PROBABILITY OF CORRECT RECALL		
	TEST CONDITIONS		
	VALID	BASELINE	INVALID
Full attention	.81 (.19)	.71 (.28)	.59 (.41)
Divided attention	.65 (.34)	.53 (.44)	.38 (.62)

ESTIMATES OF RECOLLECTION (R) AND ACCESSIBILITY BIAS (A)		
STUDY CONDITION	R	A
Full attention	.41	.67
Divided attention	.04	.65

Note. Numbers in parentheses are the probabilities of false recall.

those responses being ones that would come to mind for most people. Also participants were instructed to respond to each test item, guessing if necessary.

How did the invalid prime have its effect? One possibility is that the invalid prime replaced or altered memory for the earlier studied response (cf. Loftus, 1975). On this hypothesis, the reduction in correct recall produced by the invalid prime is not different in kind from the poorer recall produced by divided compared with full attention during the study. For both, the difference is because of poorer memory for the earlier studied list. However, there is another possibility: Perhaps the participant giving the invalid prime as a response was a consequence rather than a cause of poor memory. That is, perhaps participants gave the prime as a response only when they could not remember the earlier studied, target word. This account holds that the effect of an invalid prime is very different from that of dividing attention during the study. Rather than reducing memory for the earlier studied list, the invalid prime has its effect by means of accessibility bias: Presenting a word as a prime makes it more accessible as a response to be used when one is unable to recollect the studied word. By this view, dividing attention caused poor memory for the original list, whereas an invalid prime had its effect only after memory for the original list had failed.

If the prime exerts a simple bias effect that is based on accessibility, then the debilitating effect of an invalid prime should be mirrored by a facilitative effect of a valid prime. If the prime causes memory replacement, symmetry of this sort would not be predicted. Choosing between the two accounts, therefore, requires a third test condition, one for which a valid, rather than an invalid, prime is presented (Table 3.3). Results from the three test conditions can be combined to separate effects of the prime on accessibility bias from differences in recollection.

If presentation of a prime only influences accessibility bias, then, compared with the baseline condition, the increase in false recall produced by presentation of an invalid prime should be offset by an increase in correct recall produced by presentation of a valid prime. That is, the probabilities of correct recall for the valid and invalid prime conditions should be symmetrical around the baseline condition (Table 3.4). To separate the contributions of recollection and accessibility bias, assume that for each of the test conditions, participants can sometimes recollect the studied word, with probability  $R$ . After a valid prime, when recollection fails ( $1 - R$ ), participants correctly give the prime as a response with a probability ( $A$ ) that reflects accessibility bias influenced by the prime. For the valid prime condition then, the probability of a correct response is the sum of the probability of recollection of the correct word and the probability that accessibility bias results in the correct word when recollection fails:  $P(\text{Correct Recall Valid Prime}) = R + A(1 - R)$ . The influence of the prime on accessibility bias is assumed to be the same for the valid and invalid prime conditions. Consequently, in the invalid prime condition, the prime is falsely reported only when recollection fails and the prime word is favored by accessibility bias:  $P(\text{False Recall Invalid Prime}) = A(1 - R)$ .

With the use of these equations, the probability of recollection can be estimated by subtracting the probability of false recall (FR) in the invalid prime condition from the probability of correct recall (CR) in the valid prime condition,  $R = P(\text{CR} | \text{Valid Prime}) - P(\text{FR} | \text{Invalid Prime})$ . This measure rests on a rationale that is similar to that for subtracting false alarms from hits to measure "true" memory (see Snodgrass & Corwin, 1988, for a discussion of measures of recognition memory performance). Given an estimate of true memory (recollection), accessibility bias can be estimated using the probability of false recall in the invalid prime condition:  $A = P(\text{FR} | \text{Invalid Prime}) / (1 - R)$ . Accessibility bias reflects use of the prime, a form of memory that is assumed to be independent of recollection of the target word.

Gaining estimates of  $R$  and  $A$  by means of the above equations shows that divided, compared with full, attention during study influenced recollection but left estimated accessibility bias unchanged (Table 3.4). Did presentation of a prime influence the probability of recollection? If it did not, one should be able to use the estimate of recollection gained from the valid and invalid prime conditions to predict performance in the baseline (no prime) condition. Because materials were balanced across replications, accessibility bias in the baseline condition should be equal for the two alternative responses ( $A = .5$ ). Combining estimates of  $R$  with this estimate of accessibility bias results in a predicted baseline performance equal to  $R + (1 - R)(.50)$ . This equation almost perfectly predicts observed baseline performance for both the full-attention (.70 predicted vs. .71 observed) and divided-attention (.52 predicted vs. .53 observed) conditions, showing that presentation of a prime did not influence recollection.



The misinformation effect, or retroactive interference, observed in our experiment reflected only an influence on accessibility bias; ability to recollect was unchanged by presentation of a prime. In contrast, the manipulation of full versus divided attention produced an opposite dissociation by influencing recollection and leaving accessibility bias unchanged. Fitting a multinomial model to the results provides another means of gaining support for the same conclusions. The results are fit well by a multinomial model in which recollection and accessibility bias served as independent bases for responding. In the model, estimates of recollection were constrained to be the same across test conditions and estimates of accessibility bias were constrained to be the same across full- versus divided-attention conditions. Accessibility bias was set at .50 for baseline conditions.

### **Manipulating Accessibility Bias**

Returning to the earlier example, the memory influence of an "I told you . . ." claim would be expected to depend on the validity of past claims from the same source. If the source were an unreliable one, having been often caught making erroneous claims, the "I told you . . ." claim might be ignored or, at least, might do much less to influence accessibility bias than it would if it had come from a credible source. At the extreme, an "I told you . . ." claim from an unreliable source might be treated as reason to reject the content of the claim and might show reactance by producing a response different from that dictated by the claim. In our situation, participants might strategically avoid giving a prime word as a response if the prime word is seldom valid.

An experiment done by Kara Hrubí, a graduate student at New York University, varied the probability of the prime being valid. In our earlier experiment, the prime was as likely to be valid as invalid whereas in a "mostly valid" condition in Hrubí's experiment the prime was valid on two thirds of the trials and invalid on only one third of the trials. Those probabilities were reversed in a "mostly invalid" condition. We expected accessibility bias to be larger when the prime was mostly valid.

The results are consistent with our expectations (Table 3.5). Probabilities of correct recall after valid and invalid primes were almost perfectly symmetrical around performance in the baseline condition in which a prime was not presented. This symmetry shows that presentation of a prime did not influence recollection but, rather, had its effect by means of an influence on accessibility bias. Estimates of recollection and accessibility bias were gained by the same means as in the earlier experiment. Comparisons of those estimates show that recollection did not differ for the mostly valid and mostly invalid conditions. However, accessibility bias did differ such that participants in the mostly valid condition were more likely to produce the prime as a response. The results are well fit by a multinomial model that constrained recollection to be equal across all conditions but allowed accessibility bias to differ between the mostly valid and mostly invalid conditions. Again, accessibility bias was set at .50 for baseline conditions.

TABLE 3.5

*Example sequence of events in proactive interference and action slip*

CONDITION	TIME 1	TIME 2	TIME 3
A. Proactive interference			
Experimental	Learn A-B	Learn A-D	Test A-D
Control	Rest	Learn A-D	Test A-D
B. Action slip			
Experimental	Fly	Drive	Test
Control	Rest	Drive	Test

Although not significant, there was a tendency for recollection to be higher in the mostly invalid than in the mostly valid condition. People might be more likely to attempt recollection when dealing with a low-credibility source of influence. Further analyses compared performance in the mostly valid and mostly invalid conditions during the last half of the experiment. Results from that analysis are the same as from the experiment as a whole except differences in accessibility bias were larger. This is to be expected because it takes time for participants to catch on that the prime is mostly valid or mostly invalid. However, a surprising result is that participants continued to favor the prime as a response even late in the experiment in the condition in which the prime was usually invalid. That is, participants never avoided the prime to the extent required for accessibility bias to drop to .50, let alone consistently avoiding the prime which would produce a value below .50. Perhaps effects of a prime on accessibility bias are automatic in the sense of being extremely difficult to avoid. Preliminary data collected by one of the present authors, Sandra Hessels, suggest that this is the case. In her experiment, participants heard the prime shortly before being presented with a recall test item. Telling participants to ignore the prime did not eliminate its effect. We suspect that in future experiments, we will be able to find conditions that allow participants to fully ignore the prime and conditions that result in reactance, that is, consistent avoidance of the prime as a response. Finding such conditions is important for applied purposes and for theory.

### Misleading the Elderly Population

Our interest in misinformation effects that result from a false "I told you . . ." statement comes from our concern about fraudulent practices aimed at older adults. Older adults are a favorite target for scams and some of those scams involve a false "I told you . . ." statement (Jacoby, 1999). One example comes from home repairs. An older person may be approached by a dishonest salesperson with an offer of, for example, fixing pavement on a driveway for a very reasonable price. Later, when the job is completed, the amount demanded as payment is much higher than the

price that was originally quoted. If the person complains, the dishonest salesperson responds, "I told you before that this was what it would cost." Out of uncertainty for what was originally agreed on, it is likely that the person will accept the false information and pay the increased price. Such scams take advantage of the impaired recollection of older adults by providing a response alternative that is in the scammer's best interest.

Jacoby (1999) compared the performance of younger and older participants using the procedures described above. A deficit in ability to recollect for older adults would give reason to expect them to show a larger effect of an invalid prime. Perhaps older adults are less often able to remember what was said earlier and, so, are more often open to the effects of accessibility bias. Jacoby attempted to equate recollection for one group of younger participants with that of older participants to see whether there were effects of aging beyond those on recollection. Younger participants in that group divided their attention during the study, the same manipulation that was found to reduce recollection in the first experiment described here. There were three groups of participants: older, young full attention, and young divided attention. The procedure was the same as outlined in Table 3.3. The probability of a prime being valid was .50.

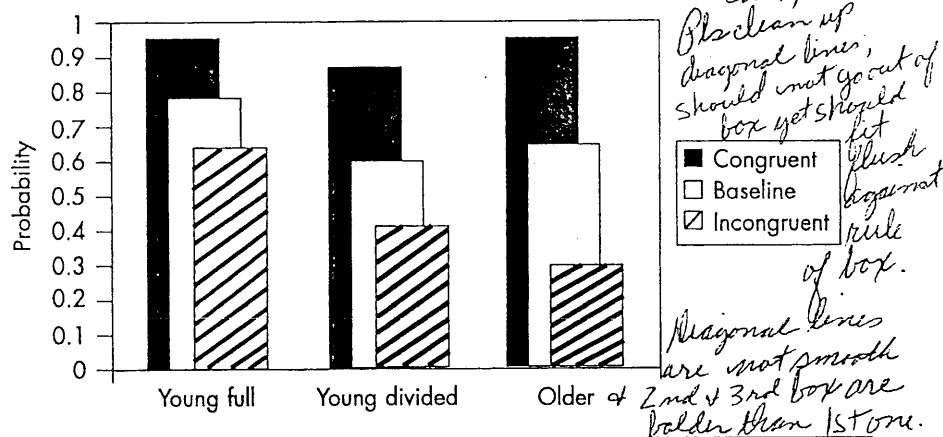
Results reveal that for all groups, presentation of an invalid prime had its effect by means of an influence on accessibility bias. Compared with performance in the baseline condition, the decrease in correct responding produced by an invalid prime was approximately equal to the increase in correct responding produced by a valid prime (see Figure 3.1). Older participants were more susceptible to interference from an invalid prime than were young full-attention participants. However, they also show a larger positive priming effect. This pattern of results can be explained as produced by older participants' lessened ability to recollect. That is, older adults are more susceptible to a false "I told you . . ." claim than are the young full-attention participants because of a deficit in recollection. Greater susceptibility of young people can be produced by dividing attention during the study to reduce recollection. Dividing young participants' attention during the study produced results that were very similar to those found for older participants. Performance on baseline trials was nearly identical for older and younger divided-attention participants, suggesting that their ability to recollect was equated. The small difference in performance for the two groups after an invalid prime reflects a difference in accessibility bias. Young divided-attention participants were more likely to avoid using the prime as a response when they were unable to recollect than were older participants. This strategic avoidance of the prime increased accuracy after an invalid prime but produced an offsetting decrease in accuracy after a valid prime.

### Summary and Implications for Theory

Our "I told you . . ." experiments show the advantages of arranging conditions to examine retroactive effects on facilitation in combination with effects on interference.

FIGURE 3.1

The probability of correct recall for young divided-attention, young full-attention, and elderly population groups. From "Deceiving the Elderly: Effects of Accessibility Bias in Cued-Recall Performance," by L. L. Jacoby, 1999, *Journal of Cognitive Neuroscience*, 16, p. xxx. Copyright 1999 by Psychological Press Ltd. Adapted with permission.



Traditional investigations of retroactive interference have included only a baseline and an interference condition (Table 3.1), and effects have been explained as due to response competition or unlearning. In contrast, we added a third condition to examine retroactive facilitation (valid prime) and retroactive interference (invalid prime). Doing so provides advantages that are the same as gained by examining hits and false alarms, rather than false alarms alone, in a standard investigation of recognition memory. Just as examining hits and false alarms allows one to separate effects on bias from those on memory, the addition of valid primes allows effects of accessibility bias to be separated from differences in recollection. Using that strategy shows that presentation of a prime did not influence memory in ways implied by the notion of unlearning. Instead, retroactive effects of the prime reflected only an influence on accessibility bias. Retroactive interference produced by an invalid prime was fully offset by retroactive facilitation produced by a valid prime. This symmetry of retroactive effects is expected if they reflect an influence of the prime on accessibility bias but would not be expected if presentation of a prime altered memory for the target. Had we examined performance only in the baseline and interference conditions, as is standard, we would have been unable to separate effects on bias from those on recollection of the earlier studied list. Similarly, Doshier, McElree, Hood, and Rosedale (1989) showed that priming in a recognition task reflects an influence on bias rather than increased discriminability. Presentation of semantically related primes improved performance on recognition judgments for

target (old) items but worsened performance on recognition judgments for nontarget (new) items. As with our valid and invalid primes, semantic primes did not affect memory, but instead produced the symmetry characteristic of bias effects.

The effects of priming show that accessibility bias is dissociable from differences in recollection. Presentation of a prime and manipulating prime validity had an effect on accessibility bias but left recollection unchanged. Dividing attention during the study produced an opposite dissociation by reducing recollection and leaving accessibility bias unchanged. Age-related differences in susceptibility to interference were largely because of a deficit in recollection. Older participants were less likely to be able to recollect and, so, were more often open to effects of accessibility bias. That is, greater susceptibility to interference was a consequence rather than a cause of the older adult's poorer ability to remember the target word. Accessibility bias reflects a form or use of memory that is independent of recollection and is largely uninfluenced by aging. As described in the next section, using our approach to analyze proactive effects produced results that further support these conclusions.

### **Proactive Effects: Separating Habit and Recollection**

Hay and Jacoby (1999) related the story of an aging math professor at the University of Manitoba who went to a conference in Chicago. When ready to return home, he was unable to find his airline ticket. After much searching, he bought another ticket and, arriving home, called his wife to pick him up at the airport. She replied that she would be unable to do so because he had driven their only car to Chicago. Such action slips demonstrate the influence of previously established habit on memory performance. If the professor did not usually travel to conferences by airplane, he would be unlikely to make such a mistake. Action slips are nothing more than instantiations of proactive interference (Table 3.2B).

Classic interference theory has explained proactive interference as due to response competition. An item comes to mind and, because of a loss of list differentiation, is mistakenly given as a response although it was appropriate for a prior list. According to this view, interference can be avoided only by retrieving list membership for each item that comes to mind and inhibiting response if the item is a member of the inappropriate list. Greater susceptibility to interference of people with amnesia (Warrington & Weiskrantz, 1970) and the elderly population (Hasher & Zacks, 1988) is said to be because of a lessened ability to suppress or inhibit inappropriate responses. In contrast to an inhibition account, greater susceptibility to interference might result from a deficit in recollection. When recollection of the target item fails, a guess is generated that is based on the first item that comes to mind. In the absence of recollection, habit determines item production. The argument is the same used to explain retroactive effects.

Hay and Jacoby (1996) separated the contributions of habit and recollection using materials that were the same used in our "I told you . . ." experiments. The

procedures and underlying rationale were also similar except a manipulation of habit replaced the manipulation of priming. The first phase of their experiments was a training phase meant to develop a habit of a particular probability. Context words were presented along with a fragment of the target word and participants were asked to guess how the fragment would be completed. In Experiment 1, some fragments were completed with one word 75% of the time (e.g., knee b\_n\_ ; bone) and with the alternative word 25% of the time (knee b\_n\_ ; bend), whereas for other fragments the two alternatives were presented equally often (50/50). In a second phase of the experiment, participants saw short lists of the word pairs and were told to remember the pairs for a test that would immediately follow. During the test, the context words were presented with the fragments and were to be used as cues for recall of the target word in the short list. Incongruent test items were those in which the target was the nondominant response (the item presented 25% of the time during the training phase). Test items for which the target was presented 75% of the time were considered congruent. Items from the 50/50 condition served as a baseline against which effects of differential habit were evaluated.

The role served by congruent test items corresponds to that of valid primes in the "I told you . . ." experiments. Habit from prior training, a form of accessibility bias, would lead to the same response as recollection just as would a valid prime. For incongruent test items, in contrast, habit is opposed by recollection in the same way as are the effects of an invalid prime. By our view, then, effects of habit come about in the same way as those of priming with the obvious difference that habit produces proactive effects whereas priming effects are retroactive. The equations used by Hay and Jacoby (1996) to separate the contributions of habit and recollection are the same as described earlier for separating accessibility bias and recollection in our "I told you . . ." experiments.

Hay and Jacoby (1996) found that the probabilities of a correct response for congruent and incongruent test items were symmetrical around that for the baseline provided by items from the 50/50 training condition (.82, .63, and .72, respectively), a pattern of results that is the same as for valid and invalid primes in the "I told you . . ." experiments. The disadvantage for incongruent test items, compared with baseline, reflects proactive interference and was fully offset by proactive facilitation, the advantage for congruent items over baseline. Computing estimates revealed that estimated habit was higher for items from the 75/25 condition than for those from the 50/50 condition (.67 vs. .48), but estimated recollection was near identical for the two conditions (.45 vs. .43). Note that estimated habit shows probability matching—the estimate of habit was near the training probability (e.g., .67 vs. .75). Such probability matching is also found in other experiments reported by Hay and Jacoby and serves as converging evidence of the validity of assumptions underlying the estimation procedure (see Hay & Jacoby, 1996, for a discussion of this point along with a description of other converging evidence). A manipulation of response deadline produced a dissociation that was opposite to that produced by the manipula-

tion of prior training (Experiment 3). Requiring participants to respond rapidly, rather than slowly, at the time of test reduced recollection but left habit unchanged. The effect on recollection was expected because recollection is generally assumed to be a slower process than is responding on the basis of habit. In a recent experiment, Jacoby, Debner, and Hay (in press) found that dividing attention during the study of the short lists reduced recollection but left estimated habit unchanged. That dissociation is the same as produced by dividing attention in their "I told you . . ." experiments.

Hay and Jacoby (1999) examined the effects of aging on recollection and habit. The results from their Experiment 1 (see the first two rows of Table 3.6) show that for incongruent test items, older adults were more likely than were the young to mistakenly give the response made dominant by prior training. That is, older adults were more susceptible to proactive interference or, stated differently, more likely to be influenced by a "bad" habit, or more likely to produce a "memory slip" akin to the action slip described at the beginning of this section. The result might be interpreted as evidence that older adults were less able to inhibit a habitual response (cf. Hasher & Zacks, 1988). A weakness in the inhibition account, however, is that it focuses only on the incongruent test items, a condition in which habit and recollection are in opposition. To gain a more complete account, one also needs to examine the situation where habit and recollection act in concert: congruent test items. The older adults were less likely to correctly respond to congruent test items. This disadvantage for older participants in a situation where habit is a source of correct responding would not be expected if they are impaired in their ability to inhibit habit-based responses. The effects can be better explained by a dual-process account in which recollection serves as an alternative to habit as a basis for responding. Estimates gained from our dual-process model show that the older adults were less able to recollect but did not differ from younger adults in their reliance on habit when recollection fails.

Can older participants be inoculated against effects of interference? An inhibition account would recommend teaching older adults to be cautious to carefully examine

TABLE 3.6

*Probability of dominant response and estimates*

GROUP	TRIAL TYPE		ESTIMATES	
	CONGRUENT	INCONGRUENT	RECOLLECTION	HABIT
Young participants	.88	.29	.60	.70
Elderly participants	.80	.50	.30	.74
Elderly participants <sup>a</sup>	.89	.31	.58	.73

Note. Data from Experiment 1 of Hay and Jacoby (1999). <sup>a</sup>This group were given elaborated instructions and had a longer response deadlines. Data are from Experiment 3, distinctive condition only, of Hay and Jacoby (1999).

the origin of a response before making it overt to avoid being misled. The goal of this strategy is to enhance the editing function of consciousness (Jacoby, Kelley, & McElree, 1999). In contrast, we would seek to rehabilitate performance by finding conditions that encourage recollection. Hay and Jacoby (1999, Experiment 3) showed that when older people were provided with extra time at encoding and a longer retrieval deadline and explicit instructions to elaborate and integrate the pairs presented for study, their memory performance improved dramatically (bottom row, Table 3.6). These more supportive conditions made the older adults less susceptible to interference as shown by their better performance on incongruent test items and also improved their performance on congruent test items. Computing estimates show that the more supportive conditions served to enhance recollection for the older participants to a level that was as high as that of younger participants. Habit was unchanged. Thus, an effective way of reducing susceptibility to interference is to enhance an alternative basis for responding—recollection—rather than focus on interference alone.

## Conclusion

Retroactive and proactive interference sometimes reflect only an influence on accessibility bias. This conclusion could not have been reached if we had relied on the experimental designs that have traditionally been used to investigate retroactive and proactive interference. Rather, it was necessary to examine performance in facilitation and interference conditions. Doing so allowed us to use a dual-process model to separate the contributions of recollection and accessibility bias. Support for the assumptions underlying that model is provided by findings of dissociations. As an example, contrary to an unlearning account of retroactive interference (Loftus, 1975; Postman & Underwood, 1973), presentation of an invalid prime did not alter memory for an earlier studied list but, rather, only influenced accessibility bias. In contrast, aging and dividing attention had their effects by reducing recollection and generally leaving accessibility bias unchanged. The greater susceptibility to interference shown by older adults was because of a deficit in recollection rather than a lessened ability to inhibit or suppress inappropriate responses (cf. Hasher & Zacks, 1988). Interference effects did not arise from a competitor that “blocked” retrieval of a correct response (cf. McGeoch, 1942). An account of that sort does not explain the symmetrical effects of valid and invalid primes or congruent and incongruent training. Such symmetry is expected if the effects arose from accessibility bias.

Our means of gaining estimates rests on the assumption that recollection and accessibility bias are independent contributors to overall performance. This approach to analyzing retroactive and proactive effects is the same as the process dissociation procedure (Jacoby, 1991) but creates conditions required to gain estimates in ways



different than were originally used (for discussions of advantages of this change in means of creating conditions, see Hay & Jacoby, 1999; and Jacoby, 1998). The independence assumption underlying the process dissociation procedure has been its most controversial aspect (e.g., see Curran & Hintzman, 1997, and the reply by Jacoby et al., 1997). Findings of dissociations, of the sort described here, provide support for the independence assumption. However, dissociations should not always be expected. Differences in retroactive interference, as an example, might often reflect both differences in accessibility bias and a change in recollection. When primes were mostly invalid, rather than mostly valid, accessibility bias was reduced, and there was also a tendency toward an increase in recollection. The greater susceptibility of the older adults to interference produced by an invalid prime was largely because of their lessened ability to recollect. However, there was also a difference between young and old in accessibility bias. When unable to recollect, the older participants were more likely to rely on the prime than were younger participants. For these cases, it seems reasonable that differences in both recollection and accessibility bias were involved. It remains to be seen what effects are produced by manipulations that have been standard in investigations of retroactive and proactive interference, such as a manipulation of the retention interval between the study and the test.

The advance that we hope to gain from our approach is improved means of analyzing deficits in memory performance. Identifying older participants who are most vulnerable to a false "I told you . . ." claim is important to protect those individuals from attempted scams that plague older adults. Once identified as being vulnerable, it is necessary to diagnose the cause of that greater vulnerability. A deficit in recollection would be treated much differently than would an inappropriate accessibility bias. The latter might take the form of unwarranted trust or "gullibility" and be treated by warning older adults to be cautious and to strategically avoid being influenced by the memory reports of others. However, such caution is optimal only if one is in a generally hostile environment. Reducing accessibility bias has the benefit of reducing the probability of being misled by invalid claims but has the potentially large cost of also reducing the facilitation gained from valid claims. Similarly, reduced habit avoids action slips at the cost of facilitation that comes from an appropriate habit. The best defense against a false "I told you . . ." claim is to recollect what was truly said just as our forgetful university professor's best defense against the action slip of flying home would have been to have recollected that he drove to the conference. Measurement of recollection is the first step toward devising procedures that allow for its rehabilitation. The results from our preliminary attempts to rehabilitate recollection are encouraging (Hay & Jacoby, 1999; Jacoby, Jennings, & Hay, 1998).

The basis for forgetting can best be understood by looking at it not in isolation but in conjunction with instances of improved memory performance. This affords the use of a dual-process model that separates estimates of recollection from estimates

of bias or habit. Separation of the two processes demonstrates that bias reflects a form or use of memory (implicit memory) that is largely uninfluenced by aging and even preserved by people with amnesia and that is independent of recollection. A dual-process model can easily be applied to more historical memory research concerned with the effects of interference. Crowder (1976) stated that "learning is not so much a matter of acquiring new behavior as it is a matter of organizing previously acquired behavior into new sequences" (p. 411). Looking back, it seems that our investigations aimed at explaining "I told you . . ." effects, habit effects and, in turn, the effects of aging are not unlike rearranging methods and principles that were investigated in great detail many years ago.

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