14

Recollection and Familiarity

Process-Dissociation

COLLEEN M. KELLEY & LARRY L. JACOBY

Alan Baddeley (1982) recounted the following story to illustrate the active processes involved in recollection. He was traveling to London by train when he noticed a familiar face. As the person did not recognize him, he assumed it was someone he had seen on the train before or around Cambridge. When he got off the train he noticed the man again, and because he had been thinking about memory and retrieval, he resolved to attempt to remember who the person was. Two associations came to mind: the name Sebastian, and something to do with children. "Sebastian" conjured up several further associations, including one friend named Sebastian from a different city, another friend whose school-age son was named Sebastian, and the teddy bear in Evelyn Waugh's *Brideshead Revisited.* All of these he rejected as irrelevant. Later, the idea of "baby-sitting" popped to mind, followed by the immediate recollection that Alan and Sebastian were members of the same baby-sitting group, with a clear image of Sebastian's sitting room with many finely printed books, a printing machine in another room, and the knowledge that Sebastian was a printer. Those details produced a strong experience of confidence in recall, as they were far more diagnostic than if he had remembered simply a room with books and a desk, which as Baddeley notes would be true of all his acquaintances.

Baddeley's anecdote beautifully illustrates the different subjective experiences of familiarity and recollection. It is a distinction that was noted by Aristotle, by William James, as well as by more contemporary psychologists (Atkinson & Juola, 1974; Mandler, 1980; Jacoby & Dallas, 1981). This chapter focuses on whether the different subjective experiences of familiarity and recollection indicate the need for two distinct processes in models of memory, or whether they simply reflect a quantitative difference in a single dimension or single process such as "trace strength." If recollection and familiarity are separate memory processes, what is the nature of those processes, and what is the relationship between the processes in the performance of a task such as a recognition memory test?

Functional Differences between Familiarity and Recollection

As indicated in Baddeley's anecdote, there are clear functional differences between familiarity and recollection. When a person looks familiar, the source of that familiarity is ambiguous: Is it a long-lost friend, someone we've seen in passing, somebody famous? Or just a person who resembles someone we know well? In contrast, recollection involves a flood of details that allows us to clearly pin down a previous encounter with the person. We took advantage of those functional differences in familiarity and recollection to demonstrate that there are two separate memory processes in a set of experiments we call the "false fame" experiments (e.g., Jacoby, Woloshyn, & Kelley, 1989). Participants in these experiments read a list of nonfamous names (e.g., Sebastian Weisdorf, no relation to Baddeley's Sebastian, as far as we know), under conditions of either full or divided attention. Our participants' attention was divided by requiring them to monitor an auditory list of random digits and to signal whenever they heard three consecutive odd digits. In the second phase of the experiment, participants were given a "fame judgment test": they were to judge whether names on a list were famous or not, and the list included famous names, some new nonfamous names, and nonfamous names that had just been read in the earlier list. Participants were informed that if they recognized any of the names as ones they had just read, they should respond "nonfamous," as all names on the earlier list were nonfamous.

Normally, recognition can be based on either familiarity or recollection. However, if the familiarity that accrues to a name because one has just read it is similar to the familiarity of the only mildly famous people's names we used on the test, our participants couldn't use familiarity as a basis for recognition, and so exclude the name from those judged "famous." To do so would lead to many misses of actual famous names that could only be judged famous because they were familiar. Instead, participants could only be sure that they recognized a name from the earlier list if they could recollect reading it. If they failed to recollect reading a nonfamous name, and yet it became familiar because of its presentation on the list, they would err and call the name "famous." That is exactly what happened when the probability of recollection was low because participants had read the names under conditions of divided attention: old nonfamous names were more likely to be judged "famous" than were new nonfamous names. In contrast, if the names had been read with full attention, participants successfully used recollection to correctly judge the name "nonfamous." Old nonfamous names were less likely to be judged "famous" than were new nonfamous names.

Dividing participants' attention with the digit monitoring task prevented participants from elaborating on or reflecting upon the nonfamous names as they read them, and so led to a very low rate of recollection. However, the rather minimal processing allowed under conditions of divided attention (which included reading the names aloud) was enough to enhance the familiarity of those nonfamous names. What does this effect tell us about the underlying process that gives rise to familiarity? Mandler (1980) suggested that recollection is supported by elaboration and inter-item organizational processing whereas familiarity is a function of processing that increases the integration of representations of items. Jacoby and Dallas (1981) suggested that familiarity is generated by changes in perceptual processing of the kind that is revealed by indirect memory tests such as perceptual identification. In a visual perceptual identification test, a word or picture is presented briefly and followed by a pattern mask. Words or pictures that have been read or viewed recently show a higher probability of being identified under those degraded conditions. The subjective experience of old items on the perceptual identification test is that they "pop out" at the viewer, and in fact appear to be presented for a longer duration than the new items (Jacoby & Witherspoon, 1982). Jacoby and Dallas speculated that the subjective experience of familiarity might be based on those changes in the perceptual experience of old items, in much the same way that Tversky and Kahneman (1973) suggested that subjective probability could be based on the ease of generating examples of a class, the "availability heuristic." People could attribute their experience of perceptual fluency to having viewed a word or picture previously, and so experience a feeling of familiarity, via a "fluency heuristic." Some variables such as number of repetitions and spacing of repetitions showed parallel effects on perceptual identification test performance and recognition memory test performance, but other variables such as levels of processing affected recognition but not perceptual identification. This combination of parallel effects and dissociative effects could be accounted for by the two bases for recognition memory.

If familiarity is an interpretation of changes in processing due to prior experience, then it should be possible to bring about those changes in processing in other ways, and so create illusions of familiarity. Jacoby and Whitehouse (1989) tested that hypothesis by flashing brief previews of words prior to those words being presented in full view during a recognition test. The notion was that when the preview word matched the word presented during the recognition test, processing of the recognition test word would be more fluent, and so it would seem more familiar. However, that misattribution of the fluent processing of the test word to having studied it earlier would occur only if participants did not realize that the preview word was the source of the more fluent processing. Therefore, the illusion of familiarity was expected only when the preview word was presented so briefly that participants were unaware of it, and that is what happened. Both old test words and new test words were more likely to be judged "old" on the recognition test when preceded by a very briefly presented matching preview word, compared to control items with no preview word. In contrast, when the matching preview word was presented for a longer duration, such that participants were fully aware of it, participants were less likely to judge the test word "old." Rajaram (1993) found that the illusion of memory created by the very brief preview words acted to make words more familiar as indicated by "know" judgments, but did not affect the likelihood of recollection as indicated by "remember" judgments (see Gardiner, chapter 15).

Recognition test words read in predictive sentence contexts also can be mistakenly experienced as familiar owing to prior study as shown in a series of experiments by Whittlesea (1993). People were more likely to respond "old" to recognition test words at the end of a predictive sentence context such as, "The stormy seas tossed the *boat*," compared to test words presented in an unpredictable context, "She saved up her money and bought a *boat*." Words read in the predictable context were pronounced more quickly, which may indicate that the false familiarity is mediated by perceptual processing or speeded lexical access (Weldon, 1991), or perhaps a postpronunciation assessment of "goodness of fit" with the rest of the sentence, or even lack of novelty (Poldrack & Logan, 1998).

Past experience affects later experience in a multitude of ways, often without people's knowledge or appreciation of those effects. The false fame phenomenon is an example of such implicit memory effects in that the likelihood that a name is judged famous is increased by recent experience reading the name, in the absence of conscious recollection. The consequences of prior processing can shape a wide variety of experiences: it can make visual duration seem extended (Witherspoon & Allan, 1985), lower judgments of background noise (Jacoby, Allan, Collins, & Larwill, 1988), increase the judged validity of statements (Begg & Armour, 1991), lower the judged difficulty of anagrams (Kelley & Jacoby, 1996), and increase the comprehensibility of sentences (Kelley, 1999). These effects are misattributions of the increased fluency of perceptual and conceptual processing owing to prior experience. Any of the component processes that give rise to these misattributions could be a candidate component of familiarity. Specifying the component processes of familiarity is an important task for future research. The fluency heuristic and other potential bases for familiarity are the focus of papers in a special issue of *Acta Psychologica* (Wolters, & Logan, 1998).

Separating Familiarity and Recollection: Ironic Effects

The false fame effects described earlier are an ironic effect of prior experience similar to the effects explored by Wegner (1994): Having read a list of names that one is told were all nonfamous ironically increases the probability of an error on the fame test, similar to the automatic effect of trying *not* to think about something that perversely increases the likelihood that one will think exactly that thought. Elderly adults, amnesiacs, and patients who have sustained a closed-head injury are all more susceptible to an ironic effect of past experience, in that they show a large false fame effect even after reading the nonfamous names with full attention (Bartlett, Strater, & Fulton, 1991; Cermak, Verfaellie, Butler, & Jacoby, 1993; Dywan & Jacoby, 1990; Dywan, Segalowitz, Henderson, & Jacoby, 1993; Jennings & Jacoby, 1993; Squire & McKee, 1992). This pattern of results suggests that recollection is more affected by aging and amnesia than is familiarity, although familiarity could also be affected. The method of placing recollection and familiarity in opposition does not allow one to specify precisely the degree to which either process is affected.

Repetition of events can increase ironic effects of recent exposure when increases in familiarity go unopposed by parallel increases in recollection. To place recollection and familiarity in opposition, Jacoby (1991, 1999) used a procedure logically related to the false fame studies. In the first phase, young and older adults read a list of words, with instructions to study them for a later memory test. Some of the "read" words were presented only once, and others were presented either two or three times. In the second phase, participants listened to a second list of words presented via a tape recording, and also tried to memorize those words. On the memory test, participants were given a list of words and told to respond "yes" if they *heard* the word in the second phase. However, they were warned that words read in the first phase would appear on the test, as well as new words. Therefore, if they could recollect that the word was read, they could be sure it was not heard and therefore they should say "no" on the test. However, if the word was simply familiar, they couldn't be certain that it was not heard, and so should respond "yes." Given these instructions, words that are recollected as having been read are excluded from positive responses, but words that are familiar, because they were either read or heard, will be included in the positive responses, along with words that are recollected as having been heard. Thus, recollection can be used to exclude read words, much as recollection could be used to exclude nonfamous studied names on the fame test.

If one simply focuses on recognition performance on heard items for the young versus older adults, there is a moderate deficit for the older adults (.52 for "hits" by older adults, compared to .63 for younger adults). It is not clear whether this represents problems with recollection, familiarity, or both. However, if one focuses on the failures to exclude "read" items, there is a clear problem in older adults' ability to recollect. For young adults, repetition decreased failures to exclude read items: the probabilities of saying "yes" to read items decreased for items read three times compared to items read once. Exactly the opposite pattern occurred for older adults: repetition increased failures to exclude read items (see table 14.1). Younger adults could oppose any effects of repetition on familiarity by their increased ability to recollect that an item was on the read list. Older adults were unable to keep the rising familiarity owing to repetition in check with corresponding increases in recollection.

This crossover interaction effect of repetition cannot be the result of a single process (cf. Donaldson, 1996). If one adopted a signal detection analysis by assuming, for example,

Table 14.1 Probability of responding "Yes" item was heard.

	False Alarms				
	Read				Hits
Group	1x	2x	3x	New	Heard
Young	.35	.31	.21	.22	.63
Elderly	.43	.53	.59	.19	.52

an ordered distribution of familiarity values corresponding to the number of presentations, such that the familiarity distribution for new items is lower than that for once-read items, which is in turn lower than the distribution for repeatedly read items—there is no placement of response criteria that could produce the pattern of results such that the probability of FA (repeatedly read) > FA (once-read) > FA (new) for elderly adults and also produce FA (repeatedly read) < FA (once-read) < FA (new) for younger adults. This pattern of results requires a form or use of memory in addition to familiarity that is different for elderly and young adults. (For similar patterns of results along with discussions of relevance to single-process models of memory, see Jacoby, Jones, & Dolan, 1998, as well as McElree, Dolan, & Jacoby, 1999.)

Estimating Recollection and Familiarity: The Process-Dissociation Procedure

Does familiarity as well as recollection diminish with aging? The method of placing familiarity and recollection in opposition does not allow one to detect such a pattern of effects, nor can it distinguish complex effects of a variable that simultaneously lowers familiarity and increases recollection from a simple increase in recollection. What is needed is some means of estimating the contributions of familiarity and recollection to performance.

An early approach to the problem of obtaining estimates of familiarity and recollection was to use performance on recall tests as a measure of recollection. Mandler (1980) took that approach in studies of recognition memory for paired associates, when he used cued-recall performance (of A given B, and of B given A) as an estimate of recollection, and solved for estimates of the familiarity of the A item, the B item, and AB pair given levels of recognition of the single items versus the pair. Given much previous work that found variables that affected recall performance and recognition performance in different ways, he assumed that recollection and familiarity make independent contributions to recognition. The equation describing such independence is recognition performance (Rg) equals Familiarity (F) plus Recollection or retrieval (R), minus the overlap of the two processes, or $Rg = F + R - FR$. He then demonstrated that when items had been presented the same number of times, estimates of F were constant across conditions with widely varying levels of recall and recognition.

Using other tasks such as recall to estimate the probability of recollection within recognition or using perceptual identification to estimate the probability of familiarity within recognition is at best a rough guide to what actually happens within the recognition task. Even if the nominal external cue were the same, the participant's goals and orientation would be different in the two tasks, and so the effective cues would differ (for a related discussion, see Kelley & Jacoby, 1998). Further, it is not necessarily the case that recall performance is a pure measure of recollection. People might produce the studied B member of an AB pair when cued with the A member, but not have an experience of recollecting the AB study episode. This production of B would be experienced as a guess, but would be a guess informed by prior experience, in much the same way that prior experience increases the production rates of items above baseline in an indirect memory test. This informed guessing process may be operating in Baddeley's anecdote, when he thought "Sebastian" when he first attempted to recall where he had previously seen that person. Ideally, estimates of recollection and familiarity should be derived from performance on the recognition memory test.

Jacoby (1991) developed a procedure to measure recollection and familiarity within a task. The method, called the Process-Dissociation Procedure, hinges on assessing recollection in terms of the control over responding it affords. Recollection is measured as the difference in responding when people are directed to *not* use responses from a particular study episode (the exclusion condition outlined earlier in the ironic effects of repetition study) compared to when they are directed *to* use responses from that study episode (the inclusion condition). So, in addition to the exclusion condition outlined earlier, participants would be directed to respond to some items on the recognition memory test by responding "yes" to all studied words, both read and heard items. In the inclusion condition, participants are told to use the test item to attempt to recollect the prior presentation of the item on either the read or heard list, but also to say "yes" if they fail to recollect the item but it is nonetheless familiar.

Assuming independence of recollection and familiarity, the probability of responding "yes" to a read item under inclusion instructions is equal to $R + F - RF$. In contrast, mistakenly responding "yes" to read items under the exclusion instructions represents failures of recollection and the operation of familiarity, or $(1 - R)F$. By subtracting the probability of "yes" to read items under exclusion instructions from the probability of "yes" to read items under inclusion instructions, one can obtain an estimate of R, which can then be used to solve for an estimate of F.

The independence assumption underlying the equations implies that there are variables that produce dissociative effects on the estimates of familiarity versus recollection. And that is indeed the case. Elderly participants show lower contributions of recollection to their recognition memory test performance compared to younger participants, but show just as much familiarity (Jennings & Jacoby, 1993, 1997; Jacoby, 1999). Returning to the ironic effects of repetition, Jacoby (1999, experiment 4) used the process-dissociation procedure to show that repeatedly reading a word served to increase both recollection and familiarity. For young adults, the probability of recollection for words read once was .38 and increased to .67 when words were read three times. The corresponding probabilities of recollection for elderly adults were much lower: .20 and .49. Estimated familiarity was lower for words read once rather than three times but did not differ for young (.45 vs. .57) and elderly (.44 vs. .58) adults.

A similar pattern of lower recollection but invariant familiarity appears for dysphoric compared to nondysphoric participants (Hertel & Milan, 1994). Forcing participants to respond quickly rather than more slowly reduces the estimates of recollection but does not affect estimates of familiarity (Yonelinas & Jacoby, 1994). Presenting longer lists of words at study reduces estimates of recollection but leaves familiarity intact. These invariances do not indicate that familiarity is unresponsive to variations in study conditions: Solving an anagram at study produces higher estimates of familiarity and recollection compared to simply reading the word (Jacoby, 1991); engaging in semantic compared to shallow processing (Toth, 1996); studying items in the form of pictures rather than words (Wagner, Gabrieli, & Verfaellie, 1997); and reinstating study context words at test (Jacoby, 1996). (For further examples see table 14.2.) These results suggest that recollection relies on the products of elaboration and reflection, but familiarity relies on the products of more minimal perceptual and conceptual processing.

The process-dissociation procedure can be cast in the form of a multinomial model. Multinomial modeling is a statistical technique used to estimate parameters that correspond to the probabilities of hypothetical events that are discrete cognitive states. Once the cognitive events are specified that produce behavior in various categories (such as responding "old" on a recognition test), tree diagrams can be written to specify the model

Table 14.2 Estimates of recollection and automaticity as a function of aging, level of attention, study duration, habit strength, and response deadline.

Dissociating Variable	Recollection	Automaticity
Aging[a]		
Items studied once		
Young	.38	.45
Elderly	.20	.44
Items studied three times		
Young	.67	.57
Elderly	.49	.58
Attention[b]		
Full	.25	.47
Divided	.00	.46
Attention[c]		
Full	.29	.54
Divided	.14	.55
Study Duration[c]		
10 s	.44	.59
1 s	.22	.58
Habit Strength[d]		
Strong	.45	.67
Weak	.43	.48
Study Duration[d]		
1 s	.47	.62
300 ms	.27	.65
Response Deadline[d]		
3 s	.41	.62
1 s	.26	.61
Aging[e]		
Distinctive Items		
Young	.60	.70
Elderly	.30	.72
Non-distinctive Items		
Young	.44	.72
Elderly	.29	.72

Note. [a]From Jacoby (1999); [b]from Jacoby, Toth and Yonelinas (1993); [c]from Jacoby (1998); [d]from Hay and Jacoby (1996); [e]from Hay and Jacoby (1999). Estimates of "automaticity" reflect influences of familiarity, habit, bias depending on the particular paradigm.

(Rieder & Batchelder, 1988). In the case of attempting to estimate the parameters for processes underlying recognition, in addition to estimating F and R, separate parameters are included for guessing. Thus the multinomial model can handle differences in guessing (e.g., Buchner, Erdfelder, & Vaterrodt-Plünnecke, 1995; Erdfelder & Buchner, 1998). Doing so will not change the pattern of results from that obtained using the original process-dissociation procedure as long as false-alarm rates for new words, used to estimate guessing, do not differ across types of test (inclusion vs. exclusion) or groups (Jacoby, 1998; Yonelinas & Jacoby, 1996).

Yonelinas (1994) developed a dual-process model of recognition that assumes that familiarity is a continuous dimension, much as is assumed in single-process models of recognition memory, which use signal detection measures to separate memory from decision processes or response biases. However, recollection is a second process underlying recognition, and unlike familiarity, it operates as a discrete threshold process. Continuous strength processes and discrete-threshold (or high-threshold) processes produce very different relations between hits and false alarms as confidence varies. Such plots of hits versus false alarms across levels of confidence are known as receiver operating characteristics, or ROCs (see Murdock, 1974). Accordingly, familiarity alone would produce an ROC that is curvilinear and symmetrical around the negative diagonal. Recollection alone would produce a straight-line ROC that would begin at the lowest level of the hit rate and increase to 1,1. In combination, recollection and familiarity would produce ROC curves that are curvilinear but asymmetrical (see also Yonelinas, 1997).

Yonelinas, Kroll, Dobbins, Lazzara, and Knight (1998) provided evidence to support the assumption that recollection and familiarity serve as independent bases for recognition memory and found that amnesiacs suffer a deficit in familiarity as well as recollection. Re-analysis of results from published studies, as well as results from a new experiment, supported the conclusion that amnesia was associated with deficits in both recollection and familiarity but with a much greater deficit in recollection. Further, the ROCs in amnesiacs versus control participants differed in ways that supported their model with its underlying assumption of the independence of familiarity and recollection.

Extensions of the Process-Dissociation Procedure

The process-dissociation procedure has been generalized to other problems where multiple processes can contribute to performance in a single task, most importantly to the study of conscious memory (e.g., recollection and familiarity) versus unconscious or implicit memory (thought to be tapped by indirect tests such as stem completion; for reviews, see Kelley & Lindsay, 1996, and Roediger & McDermott, 1993). The procedure involves study of a single list of items, such as words. At test, cues such as word stems (e.g., *mot*_ _) are presented, with a signal to use the cue to produce a word studied on the list, but to guess if recollection fails (the inclusion condition), or with a signal to use the cue to produce a word not on the studied list (the exclusion condition). Again assuming independence of conscious and unconscious memory, the difference in producing a studied word under inclusion instructions $(C + U - CU)$ versus exclusion instructions $(1 - C)U$ is the estimate of conscious recollection. Using this procedure revealed that recollection is lowered dramatically by divided attention at study, whereas unconscious memory is unaffected, which has led to calling the unconscious memory "automatic" (Jacoby, Toth, & Yonelinas, 1993).

Hay and Jacoby (1996) applied a variant of the process-dissociation procedure in their studies that attempted to separate the contribution of experimentally established habits from the effects of recollection. Experimental habits were established in a training phase, where stimulus words were paired with a typical response on 75% of the occasions (e.g., knee-bend) and an atypical response on 25% of the occasions (e.g., knee-bone). After the habits were established, the second phase involved study of particular lists of word pairs, which included some word pairs where the right-hand member of the pair was a typical response, and some word pairs where the right-hand member of the pair was an atypical response. After studying each list, recall was cued with the left-hand member of the pair and a fragment of the right-hand member of the pair (e.g., *knee-b _ n _*). With this arrangement, correct recall of typical pairs could be based either on memory for the list (R) or on the habitual response (H). Assuming independence of the two sources for correct responding, the probability of correct recall for typical pairs can be represented as: Prob (typical) = R + H(1 – R).

When people make memory slips—that is, when they mistakenly respond with the habitual response after having studied an atypical pair—memory has failed and habit is determining their response. The probability of such errors after study of atypical pairs is represented by: Prob (typical) = H (1 – R).

By using these two equations, Hay and Jacoby were able to solve for estimates of the contributions of habit (H) and memory (R) to cued-recall performance. They found that manipulating the strength of the habit established in the first phase did not affect the estimates of R in later cued recall, but did affect the estimates of H. The estimates of H matched the probabilities established in the training phase. Manipulations of the presentation rate of the list and response time in cued recall affected the estimates of R, but did not affect the estimates of H. These dissociations support the assumption that habit and memory make independent contributions to memory performance, and converge with results from the inclusion/exclusion procedure. Hay and Jacoby (1999) showed that cued recall performance of elderly and young participants differed only because elderly participants were less able to recollect; the contribution of habit was age invariant. Again, the pattern of results is the same as found with the inclusion/exclusion procedure.

The finding that estimates of habit show probability matching suggests that habit is a form of implicit learning. Reber (e.g., 1989) has argued that probability matching reflects implicit learning of an event sequence that is acquired independently of a conscious effort to learn and without intentional strategies. Knowlton, Squire, and Gluck (1994) described probability learning as a task that relies primarily on the form of memory preserved by amnesiacs. They found that amnesiacs show evidence of probability learning but perform more poorly than people with normally functioning memory. They suggested that the poorer probability learning of amnesiacs is a result of their inability to recollect (declarative memory), a type of memory used by people with normal memory to supplement the more automatic, unintentional form of memory (procedural memory) that is fully relied on by those with amnesia for performance in probability learning tasks. The process-dissociation procedure offers the advantage of separating the contributions of different forms or uses of memory within a task, rather than identifying processes with different tasks. Just as recall does not serve as a pure measure of recollection in recognition memory performance, performance in probability learning tasks is unlikely to serve as a pure measure of more automatic bases of responding (e.g., implicit learning or habit) in cued-recall performance.

Ratcliff and McKoon (1995, 1997) argued that many implicit memory effects are actually bias effects and proposed a counter model of such effects. We (Jacoby et. al., 1993) agree that automatic influences of memory (implicit memory) can be expressed as bias. However, we see the term "bias" as synonymous with the claim that an automatic influence of memory, such as familiarity in a test of recognition memory, can serve as an alternative to recollection as a basis for responding. Jacoby, McElree, and Trainham (1999) have shown that results reported as support for their counter model by Ratcliff and McKoon (1997) when reanalyzed, reveal striking dissociations that are the same as found by Hay and Jacoby (1996). That is, the experiments supporting the counter model reveal striking dissociations betweeen bias effects and memory, suggesting the same independence between processes as found using the process-dissociation procedure.

Controversy Surrounding the Process-Dissociation Procedure: Alternative Approaches

The assumptions underlying the process-dissociation approach have been controversial (e.g., Buchner et al., 1995; Curran & Hintzman, 1995, 1997; Graf & Komatsu, 1994; Mulligan & Hirshman, 1997; Ratcliff, Van Zandt, & McKoon, 1995). Most controversial has been the assumption that recollection and familiarity *independently* contribute to performance. Curran and Hintzman (1995) found correlations between R and A and so argued that the two bases for responding are not independent. However, through subsequent exchanges (see Curran & Hintzman, 1997, and Hintzman & Curran, 1997, along with responses by Jacoby, Begg, & Toth, 1997, and Jacoby & Shrout, 1997) agreement was reached that correlations between R and A calculated by aggregating over participants or over items cannot legitimately be used to test the independence of underlying processes. Jacoby (1998) showed that instructions can be manipulated in a way that results in violation of assumptions underlying the process-dissociation procedure, and also described other boundary conditions for those assumptions. "Paradoxical" dissociations that result from violating underlying assumptions (Curran & Hintzman, 1995) can be replicated when participants are instructed to use a particular strategy, but those dissociations were not related to correlations between R and A. Although the independence assumption underlying the process-dissociation procedure can be violated, correlations between R and A are not useful for detecting such violations.

An alternative to the independence assumption is that recollection and familiarity are in a redundant relationship—that is, recollection cannot occur unless familiarity first occurs, so recollected items are a subset of familiar items (Buchner et al., 1995; Joordens & Merikle, 1993). By this account, recollection is a late stage of processing that relies on the prior stage of computing familiarity. One way to think about the difference between independence and redundancy is with the example of generate/recognize models of recall versus models of direct retrieval. If recall is cued by a stem of the studied word, e.g., *mot- -*, people can be instructed to use that cue to generate the first word that comes to mind, and then do a recognition check of whether the generated item was on the list. With that strategy, recognition is a later stage of processing that occurs only if a studied word has been generated and, so, clearly the two cannot be independent. Generation of studied items would be above baseline because of effects of automatic or unconscious memory (Jacoby & Hollingshead, 1990). It was such generate/recognize instructions that Jacoby (1998) used to violate the independence assumption underlying the process-dissociation procedure and to establish boundary conditions for the procedure.

In contrast, the instructions in the process-dissociation procedure are to use the stem as a cue for retrieval, and so start a process of recollection. People might find also that the studied item comes automatically to mind, but in this case, recollection of the studied item does not depend on waiting for the automatic retrieval to occur—the two processes occur independently. In the case of recollection and familiarity, if recollection depended upon familiarity, the equations used to generate estimates with the process-dissociation procedure would be in error, and it becomes quite amazing that so many manipulations would have produced invariance in estimates of F across wide variations in R (e.g., divided attention, elderly vs. young participants, short-deadlines to respond vs. long-deadlines to respond.) Those experiments all used instructions designed to encourage direct retrieval.

Age-related deficits in recollection are closely related to age-related deficits in source monitoring (Spencer & Raz, 1995). Source monitoring paradigms assess memory for source by examining overt source attributions (Johnson, Hashtroudi, & Lindsay, 1993; Mitchell & Johnson, chapter 12). Participants choose one of *n*-alternatives denoting whether and in what context the test item was studied. For example, participants might hear some words and read other words during study and then later judge for each test word whether it was read, heard, or not studied earlier. Those judgments are used to compute both a measure of recognition memory and a measure of source memory, often with the intention of studying possible impairments in certain types of source discrimination (e.g., Foley & Johnson, 1985; Harvey, 1985). Results from standard tests of source memory have shown that older, as compared to younger, adults are less able to remember whether information was presented visually or aurally (e.g., Light, La Voie, Valencia-Laver, Albertson-Owens, & Mead, 1992; McIntyre & Craik, 1987).

To adequately measure source memory (recollection), one must take response biases into account and make an assumption about the relation between recognition and source memory, which, in turn, requires that one adopt a model of recognition-memory performance. The treatment of source information as a late achievement is implicit in the multinomial model most often used to measure source monitoring (e.g., Buchner, Erdfelder, Steffens, & Martensen, 1997; Johnson, Kounios, & Reeder, 1994). The model that is most commonly used (Batchelder & Riefer, 1990, Model 5b) treats the probability of retrieving source information as conditional on having recognized or detected an item as "old." However, this model does not specify the processes involved in the detection parameter, D—that is, it does not specify a particular model of recognition memory. One could interpret D or recognition of old items as dependent only on familiarity, and interpret the source memory parameter as recollection. In contrast, the independence model is a dual-process model of recognition memory (see Clark & Gronlund, 1996, for a discussion of evidence for a dual-process model of recognition). McElree et al. (1999) describe how an independence assumption of the sort used to interpret ironic effects of repetition can be accommodated in the framework of global-memory models (e.g., MINERVA2, Hintzman, 1988; SAM, Gillund & Shiffrin, 1984; TODAM, Murdock, 1982). Jacoby (1999) showed that a multinomial model based on an independence assumption could account for results from his experiment using fewer parameters than required by a model based on a redundancy assumption.

The remember/know procedure (see Gardiner, chapter 15) focuses on differences in subjective experience whereas investigations of source memory and use of the process-dissociation procedure have emphasized differences in objective performance and sought to specify underlying processes. However, we agree regarding the importance of subjective experience. Estimates of recollection gained by the process-dissociation procedure are sometimes the same as the probability of a "remember" response, which is used as an index of the subjective experience of recollection. That is, subjective and objective measures of recollection often coincide. A point of controversy is how "know" responses should be interpreted. Participants are told to respond "know" on a test of recognition memory, for example, if an item seems familiar but they cannot remember encountering the item during study—a situation similar to that experienced by Baddeley in the anecdote used to begin this chapter. We have identified "know" responses with familiarity and argued that one must make an assumption about the relation between recollection and familiarity (e.g., an independence assumption) to interpret those responses in terms of the underlying processes. (For further discussion of the relation between remember/know and process dissociation, see Jacoby, Yonelinas, & Jennings, 1997; Kelley & Jacoby, 1998; Richardson-Klavehn, Gardiner, & Java, 1996).

Concluding Comments

Placing processes in opposition as in the "fame" and the "ironic effects" experiments produces results that show the necessity of a dual-process model for recognition. There is a growing consensus that contributions of different forms or uses of memory must be separated within a task rather than identified with different tasks, although there is little agreement about how that should be done.

It is important to devise means to measure deficits in recollection or source memory as part of diagnosis and treatment. As an example, older adults' greater susceptibility to false memory (e.g., Schacter, Kagan, & Leichtman, 1995) can be seen as a failure to use recollection as a basis for excluding test items that are familiar for a wrong reason. An exclusion test is not equivalent to asking people to report on memory for source. People sometimes make exclusion errors even though if directly asked they could report the source information that would allow those errors to be avoided, and this is likely to be particularly true for older adults (e.g., Dywan & Jacoby, 1990; Multhaup, 1995). Also, understanding exclusion errors requires that one consider the possibility of differences in familiarity as well as differences in recollection (Yonelinas et al., 1998). Older adults and other special populations are more prone to errors that reflect an over-reliance on habit (Hay & Jacoby, 1999).

To measure the separate contributions of the different processes to overall performance, one must adopt an assumption about the relationship between recollection and more automatic influences of memory, such as familiarity. It seems likely that an independence assumption is appropriate in some situations whereas a redundancy assumption is appropriate in other situations. That is, we expect any model to have boundary conditions. An important goal for research is to specify such boundary conditions and so reveal factors that determine the relation between underlying processes. The question about the relation between processes underlying memory performance has a parallel in the relation between the automatic versus consciously controlled processes underlying social behavior (see Chaiken & Trope, 1999). There, too, it is important to distinguish between early-selection (independence) and late-correction (redundancy) models to specify better the nature of deficits in social monitoring and to design treatments aimed at escaping the effects of such automatic processes as stereotyping (Jacoby, Kelley, & McElree, 1999).

Although recollection and automatic influences of memory are not *always* independent, there are advantages to be gained by arranging situations such that independence holds. Our proposal of independence between memory processes is consistent with the proposal by McClellend, McNaughton, and O'Reilly (1995) of independent learning systems in the hippocampus and neocortex. Aggleton and Brown (1999) describe evidence to support their claim that recollection and familiarity have different anatomical bases, and discuss the importance of techniques for separately measuring the two bases for recognition memory. Dissociations such as those presented in table 14.2 encourage us to believe that assumptions underlying the process-dissociation procedure can be met.

Acknowledgment This research was supported by grants to Larry L. Jacoby from the National Institute on Aging (NIA) #AG13845-02 and National Science Foundation (NSF) #SBR-9596209.

References

Aggleton, J. P., & Brown, M. W. (1999). Episodic memory, amnesia, and hippocampal-anterior thalamic axis. *Behavioral and Brain Sciences, 22*, 425–490.

Atkinson, R. C., & Juola, J. F. (1974). Search and decision processes in recognition memory. In D. H. Krantz, R. C. Atkinson, R. D. Luce, & P. Suppes (Eds.), *Contemporary developments in mathematical psychology, Vol.1, Learning, memory and thinking* (pp. 243–293). San Francisco, CA: Freeman.

Baddeley, A. (1982). Amnesia: A minimal model and an interpretation. In L. S. Cermak (Ed.), *Human memory and amnesia* (pp. 305–336). Hillsdale, NJ: Erlbaum.

Bartlett, J. C., Strater, L., & Fulton, A. (1991). False recency and false fame of faces in young adulthood and old age. *Memory & Cognition, 19*, 177–188.

Batchelder, W. H., & Riefer, D. M. (1990). Multinomial processing models of source monitoring. *Psychological Review, 97*, 548–564.

Begg, I., & Armour, V. (1991). Repetition and the ring of truth: Biasing comments. *Canadian Journal of Behavioral Science, 23*(2), 195–213.

Buchner, A., Erdfelder, E., Steffens, M. C., & Martensen, H. (1997). The nature of memory processes underlying recognition judgments in the Process Dissociation procedure. *Memory & Cognition, 25*, 508–517.

Buchner, A., Erdfelder, E., & Vaterrodt-Plünnecke, B. (1995). Toward unbiased measurement of conscious and unconscious memory processes within the process dissociation framework. *Journal of Experimental Psychology: General, 124*, 137–160.

Cermak, L. S., Verfaellie, M., Butler, T., & Jacoby, L. L. (1993). Attributions of familiarity in amnesia: Evidence from a fame judgment task. *Neuropsychology, 7*, 510–518.

Chaiken, S., & Trope, Y. (Eds.) (1999). *Dual process theories in social psychology*. New York: Guildford.

Clark, S. E., & Gronlund, S. D. (1996). Global matching models of recognition memory. How the models match the data. *Psychonomic Bulletin & Review, 3*(1), 37–60.

Curran, T., & Hintzman, D. L. (1995). Violations of the independence assumption in process dissociation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 531–547.

Curran, T., & Hintzman, D. L. (1997). Consequences and causes of correlations in process dissociation. *Journal of Experimental Psychology: Learning, Memory and Cognition, 23*, 496–504.

Donaldson, W. (1996). The role of decision processes in remembering and knowing. *Memory & Cognition, 24*, 523–533.

Dywan, J., & Jacoby, L. L. (1990). Effects of aging on source monitoring: Differences in susceptibility to false fame. *Psychology and Aging, 5*, 379–387.

Dywan, J., Segalowitz, S. J., Henderson, D., & Jacoby, L. L. (1993). Memory for source after traumatic brain injury. *Brain & Cognition, 21*, 20–43.

Erdfelder, E., & Buchner, A. (1998). Process-dissociation measurement models: Threshold theory or detection theory? *Journal of Experimental Psychology: General, 127*, 83–96.

Foley, M. A., & Johnson, M. K. (1985). Confusions between memories for performed and imagined actions: A developmental comparison. *Child Development, 56*, 1145–1155.

Gillund, G., & Shiffrin, R. M. (1984). A retrieval model for both recognition and recall. *Psychological Review, 91*, 1–67.

Graf, P., & Komatsu, S. (1994). Process dissociation procedure: Handle with caution! *European Journal of Cognitive Psychology, 6*, 113–129.

Harvey, P. D. (1985). Reality monitoring in mania and schizophrenia: The association of thought disorder and performance. *Journal of Nervous and Mental Disease, 173*, 67–73.

Hay, J. F., & Jacoby, L. L. (1996). Separating habit and recollection: Memory slips, process dissociations and probability matching. *Journal of Experimental Psychology: Learning, Memory and Cognition, 22*, 1323–1335.

Hay, J. F., & Jacoby, L. L. (1999). Separating habit and recollection in young and elderly adults. Effects of elaborative processing and distinctiveness. *Psychology and Aging, 14*, 122–134.

Hertel, P. T., & Milan, S. (1994). Depressive deficits in recognition: Dissociation of recollection and familiarity. *Journal of Abnormal Psychology, 103*, 736–742.

Hintzman, D. L. (1988). Judgments of frequency and recognition memory in a multiple-trace memory model. *Psychological Review, 95*, 528–551.

Hintzman, D. L., & Curran, T. (1997). More than one way to violate independence: Reply to Jacoby and Shrout (1997). *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 511–513.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30*, 513–541.

Jacoby, L. L. (1996). Dissociating automatic and consciously-controlled effects of study/test compatability. *Journal of Memory and Language, 35*, 32–52.

Jacoby, L. L. (1998). Invariance in automatic influences of memory: Toward a user's guide for the process-dissociation procedure. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*, 3–26.

Jacoby, L. L. (1999). Ironic effects of repetition: Measuring age-related differences in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*, 3–22.

Jacoby, L. L., Allan, L. G., Collins, J. C., & Larwill, L. K. (1988). Memory influences subjective experience: Noise judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14*, 240–247.

Jacoby, L. L., Begg, I. M., & Toth, J. P. (1997). In defense of functional independence: Violations of assumptions underlying the process-dissociation procedure? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 484–495.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General, 3*, 306–340.

Jacoby, L. L., & Hollingshead, A. (1990). Toward a generate/recognize model of performance on direct and indirect tests of memory. *Journal of Memory, and Language, 29*, 433–454.

Jacoby, L. L., Jones, T. J., & Dolan, P. O. (1998). Two effects of repetition: Support for a dual-process model of know judgments and exclusion errors. *Psychonomic Bulletin and Review, 5*, 705–709.

Jacoby, L. L., Kelley, C. M., & McElree, B. (1999). The role of cognitive control: Early selection vs. late correction. In S. Chaiken & Y. Trope (Eds.), *Dual process theories in social psychology* (pp. 383–400). New York: Guilford.

Jacoby, L. L., McElree, B., & Trainham, T. N. (1999). Automatic influences as accessibility bias in memory and Stroop-like tasks: Toward a formal model. In A. Koriat & D. Gopher (Eds.), *Attention and Performance XVII* (pp. 461–486). Cambridge, MA: MIT Press.

Jacoby, L. L., & Shrout, P. E. (1997). Toward a psychometric analysis of violations of the independence assumption in process dissociation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 505–510.

Jacoby, L. L., Toth, J. P., & Yonelinas, A. P. (1993). Separating conscious and unconscious influences of memory: Measuring recollection. *Journal of Experimental Psychology: General, 122*, 139–154.

Jacoby, L. L., & Whitehouse, K. (1989). An illusion of memory: False recognition influenced by unconscious perception. *Journal of Experimental Psychology: General, 118*, 126–135.

Jacoby, L. L., & Witherspoon, D. (1982). Remembering without awareness. *Canadian Journal of Psychology, 36*, 300–324.

Jacoby, L. L., Woloshyn, V., & Kelley, C. M. (1989). Becoming famous without being recognized: Unconscious influences of memory produced by dividing attention. *Journal of Experimental Psychology: General, 118*, 115–125.

Jacoby, L. L., Yonelinas, A. P., & Jennings, J. M. (1997). The relation between conscious and unconscious (automatic) influences: A declaration of independence. In J. D. Cohen & J. W. Schooler (Eds.), *Scientific approaches to consciousness* (pp. 13–47). Mahwah, NJ: Erlbaum.

Jennings, J. M., & Jacoby, L. L. (1993). Automatic versus intentional uses of memory: Aging, attention, and control. *Psychology & Aging, 8*, 283–293.

Jennings, J. M., & Jacoby, L. L. (1997). An opposition procedure for detecting age-related deficits in recollection: Telling effects of repetition. *Psychology and Aging, 12*, 352–361.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin, 114*, 3–28.

Johnson, M. K., Kounios, J., & Reeder, J. A. (1994). Time-course studies of reality monitoring and recogntion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 1409–1419.

Joordens, S., & Merikle, P. M. (1993). Independence or redundancy? Two models of conscious and unconscious influences. *Journal of Experimental Psychology: General, 122*, 462–467.

Kelley, C. M. (1999). Subjective experience as a basis for "objective judgments": Effects of past experience on judgments of difficulty. In D. Gopher & A. Koriat (Eds.), *Attention and Performance XVII* (pp. 515–536). Cambridge, MA: MIT Press.

Kelley, C. M., & Jacoby, L. L. (1996). Adult egocentrism: Subjective experience versus analytic bases for judgment. *Journal of Memory and Language, 35*, 157–175.

Kelley, C. M., & Jacoby, L. L. (1998). Subjective reports and process dissociation: Fluency, knowing, and feeling. *Acta Psychologica, 98*, 127–140.

Kelley, C. M., & Lindsay, D. S. (1996). Conscious and unconscious forms of memory. In E. L. Bjork & R. A. Bjork (Eds.), *Handbook of perception and cognition: Memory* (2nd ed.; pp. 31–63). San Diego, CA: Academic Press.

Knowlton, B. J., Squire, L. R., & Gluck, M. A. (1994). Probabilistic classification learning in amnesia. *Learning and Memory, 1*, 106–120.

Light, L. L., La Voie, D., Valencia-Laver, D., Albertson-Owens, S. A., & Mead, G. (1992). Direct and indirect measures of memory for modality in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 1284–1297.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review, 87*, 252–271.

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

McElree, B., Dolan, P. O., & Jacoby, L. L. (1999). Isolating the contributions of familiarity and source information to item recognition: A time-course analysis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*, 563–582.

McIntyre, J. S., & Craik, F. I. M. (1987). Age differences in memory for item and source information. *Canadian Journal of Psychology, 41*, 175–192.

Mulligan, N. W., & Hirshman, E. (1997). Measuring the bases of recognition memory: An investigation of the process-dissociation framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 280–304.

Multhaup, K. S. (1995). Aging, source, and decision criteria: When false fame errors do and do not occur. *Psychology and Aging, 10*, 492–497.

Murdock, B. B., Jr. (1974). *Human memory: Theory and data*. New York: Erlbaum.

Murdock, B. B., Jr. (1982). A theory for the storage and retrieval of item and associative information. *Psychological Review, 89*, 609–626.

Poldrack, R. A., & Logan, G. D. (1998). What is the mechanism for fluency in successive recognition? *Acta Psychologica, 98*, 167–181.

Rajaram, S. (1993). Remembering and knowing: Two means of access to the personal past. *Memory and Cognition, 21*, 89–102.

Ratcliff, R., & McKoon, G. (1995). Bias in the priming of object decisions. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 754–767.

Ratcliff, R., & McKoon, G. (1997). A counter model for implicit priming in perceptual word identification. *Psychological Review, 104*, 319–343.

Ratcliff, R., Van Zandt, T., & McKoon, G. (1995). Process dissociation, single-process theories, and recognition memory. *Journal of Experimental Psychology: General, 124*(4), 352–374.

Reber, A. S. (1989). Implicit learning and tacit knowledge. *Journal of Experimental Psychology: General, 118*, 219–235.

Reider, D. M., & Batchelder, W. H. (1988). Multinomial modeling and the measurement of cognitive processes. *Psychological Review, 95*(3), 318–339.

Richardson-Klavehn, A., Gardiner, J. M., & Java, R. I. (1996). Memory: Task dissociations, process dissociations and dissociations of consciousness. In G. Underwood (Ed.), *Implicit cognition* (pp. 85–158). Oxford: Oxford University Press.

Roediger, H. L., & McDermott, K. B. (1993). Implicit memory in normal human subjects. In H. Spinnler & F. Boller (Eds.), *Handbook of neuropsychology* (Vol. 8; pp. 63–131). Amsterdam: Elsevier.

Schacter, D. L., Kagan, J., & Leichtman, M. D. (1995). True and false memories in children and adults: A cognitive neuroscience perspective. *Psychology, Public Policy, and Law, 1*, 411–428.

Spencer, W. D., & Raz, N. (1995). Differencial effects of aging on memory for content and context: A meta-analysis. *Psychology and Aging, 10*, 527–539.

Squire, L. R., & McKee, R. (1992). Influence of prior events on cognitive judgments in amnesia. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 106–115.

Toth, J. P. (1996). Conceptual automaticity in recognition memory: Levels-of-processing effects on familiarity. *Canadian Journal of Experimental Psychology, 50*, 123–138.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology, 5*, 207–232.

Wagner, A. D., Gabrieli, J. D. E., & Verfaellie, M. (1997). Dissociations between familiarity processes in explicit-recognition and implicit-perceptual memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 305–323.

Wegner, D. M. (1994). Ironic processes of mental control. *Psychological Review, 101*, 34–52.

Weldon, M. S. (1991) Mechanisms underlying priming on perceptual tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17*, 526–541.

Whittlesea, B. W. A. (1993). Illusions of famil iarity. *Journal of Experimental Psychology Learning, Memory, and Cognition, 19*, 1235–1253.

Witherspoon, D., & Allan, L. G. (1985). The ef fects of a prior presentation on temporal judgments in a perceptual identification task. *Memory & Cognition, 13*, 101–111.

Wolters, G., & Logan, G. (Eds.). (1998). Fluency and remembering. [Special Issue]. *Acta Psychologica, 98*, 121–125.

Yonelinas, A. P. (1994). Receiver operating characteristics in recognition memory: Evi dence for a dual-process model. *Journal of Experimental Psychology: Learning, Memory & Cognition, 20*, 1341–1354.

Yonelinas, A. P. (1997). Recognition memory ROCS for item and associative information: The contribution of recollection and familiarity. *Memory & Cognition, 25*, 747–763.

Yonelinas, A. P., & Jacoby, L. L. (1994). Dissociations of processes in recognition memory: Effects of interference and of response speed. *Canadian Journal of Experimental Psychology, 48*(4), 516–534.

Yonelinas, A. P., & Jacoby, L. L. (1996). Response bias and the process dissociation procedure. *Journal of Experimental Psychology: General, 125*(4), 422–439.

Yonelinas, A. P., Kroll, N. E. A., Dobbins, I., Lazzara, M., & Knight, R. T. (1998). Recollection and familiarity deficits in amnesia: Convergence of remember-know, process dissociation, and receiver operating characteristics data. *Neuropsychology, 12*, 323–339.