Familiarity and Recollections: Interactions with Larry Jacoby.

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We have both been profoundly influenced by the teaching, writing and ideas of Larry Jacoby, and so welcome this opportunity to record our gratitude to him, both for his theories and for his friendship and inspiration over the years. The present authors are contemplating Jacoby's work from different career vantage points; one (Rose) just setting out and the other (Craik) nearing the end of his professional career. But although our perspectives differ we also share a common approach to the study of memory, and use this platform to comment on Jacoby's ideas as they evolved from classical work on verbal learning and memory stores to current notions on the distinction between familiarity and recollection, and on into the future to speculate on the possible implications of Jacobean thought for cognitive neuroscience. The main focus of the chapter however, will be on the impact that Larry's work has had on the Craik lab across the years.

Fergus Craik's account:

Craik's first contact with Larry Jacoby was at the annual conference of the Psychonomic Society in 1972. Larry was a faculty member at Iowa State University at that time, and the meeting was set up by his colleague, the late Wayne Bartz, himself a prominent figure in memory research and a very nice man. The point of the meeting was to discuss the possibility of Larry spending a year in Craik's lab, with Bartz remarking to Craik that "You will learn at least as much from Larry as he will from you!" This seemed like an intriguing possibility, and the young fresh-faced Larry seemed bright and enthusiastic, so the visit was arranged. In his chapter in a much later Festschrift for Craik (Jacoby, Marsh & Dolan, 2001) Larry remembered another detail of that first meeting. He had recently carried out experiments to show that mere repetition of words was not sufficient to increase subsequent recall from long-term memory; it was necessary to engage the meaning of the words rather than their acoustic properties for such 'transfer' to occur (Jacoby & Bartz, 1972; Jacoby & Goolkassian, 1973). These results were contrary to the predictions from the currently dominant dual-store models, and Larry was hopeful that they would make him famous, if not exactly overnight, in a month or two at most. So he was a little chagrined to learn that the Craik and Lockhart (1972) article was about to be published, and that this paper set out very much the same story but perhaps in a broader context.

The irony, in retrospect, is that the Jacoby and Bartz article appeared in the *Journal of Verbal Learning and Verbal Behavior* a good 100 pages before the appearance of the Craik and Lockhart article, and a full year before Craik and Watkins (1973) published a similar message. In any event, the bad news was that Larry's overnight fame was deferred, although only briefly; but the very *good* news was that Craik and Jacoby were thinking very similar thoughts in the early 1970s, and this boded well for their year of collaboration in Toronto.

The academic year in question (1973-74) was spent at Erindale College, University of Toronto, and it was a fruitful one for both Jacoby and Craik. The main result of their many discussions was a series of theoretical chapters published between 1976 and 1979, plus an empirical paper illustrating some of the same concepts (Jacoby, Craik & Begg, 1979). There is also a much later chapter (Craik & Jacoby, 1996) in which Craik attempted to integrate Jacoby's process dissociation ideas with work on aging and levels of processing—rather unsuccessfully judging by the reactions of the audience when the paper was first read at a conference! Of the four earlier chapters, the one by Jacoby and Craik (1979) is by far the best. It was written to be presented at a meeting on levels of processing (LOP) organized by the late Laird Cermak, and very clearly shows Larry's influence in pushing LOP to further heights (or further depths perhaps!). The main points included a general insistence that memory should not be considered as something separate from the rest of cognition; rather, perception, attention, memory and comprehension are all aspects of an integrated system. Good episodic memory certainly depends on the depth and elaboration of initial processing, but how are 'deep' and 'meaningful' defined?

The suggestion, taken up again by Craik and Jacoby (1979), was that greater depth and elaboration of processing resulted in an encoded representation that was distinctive, and that distinctiveness is more 'diagnostic' for later retrieval (see also Tversky, 1977; Hunt & Worthen, 2006). Further, distinctiveness is not an absolute quality, but must be considered relative to a background. Thus the object or event must be analyzed (or 'described') in sufficient detail during initial encoding to perceive and comprehend it against its contextual background, and that same contextual background must be re-provided or re-created at the time of retrieval if the distinctiveness is to be effective.

Many of these concepts reappeared in Craik's articles and chapters over the next 35 years, and some were also developed by Jacoby in his subsequent work. Here are some further

points that still seem current today. Greater degrees of analysis (more extensive descriptions) are necessary when an object must be discriminated from a set of similar objects. This further analysis is experienced as being more difficult and more effortful, but the improved subsequent memory is a consequence of the more complete description, not the effort as such. With regard to retrieval processing, Jacoby and Craik endorsed Tulving's notion of encoding specificity—essentially the need for overlap between encoding and retrieval processes. If 'appropriate' retrieval processes are not induced directly by the stimulus or current context, then active reconstruction of plausible and relevant contexts are formed with the help of general knowledge, perhaps shaped and guided by feelings of familiarity associated with partial recognition. This conception of retrieval processes is not to be confused with models of recall that postulate a generation phase followed by recognition or rejection of the generated items. Jacoby and Craik stressed that in their view episodic and semantic memory processes interacted throughout retrieval, in much the same way perhaps as a percept is formed by the ongoing interaction of stimulus analysis and interpretation from past experience. In this sense both perception and retrieval are exercises in problem solving -- constructing an acceptable solution by combining relevant knowledge with evidence from the current environment.

Two other ideas about encoding/retrieval interactions arose primarily from Jacoby's thinking. The first is the distinction between spontaneous and directed retrieval, which ties in to the distinction between context-independent and context-dependent retrieval. For example it may be sufficient to recognize an object or piece of information as being familiar, as a known fact or as a known name for example, in which case the original context of acquisition is irrelevant to the task (where and when did you first learn that Paris is the capital of France, for instance?) Typically such information is not needed. In other cases, retrieval of the original context is essential to the task; we could label such tasks 'memory tasks' as opposed to tests of comprehension or knowledge in the previous example. This difference clearly alludes to Tulving's distinction between episodic and semantic memory or between remembering and knowing. Jacoby and Craik acknowledge the episodic/semantic distinction but are skeptical about the idea (e.g. Tulving, 1983) that these two modes of retrieval reflect different memory systems, preferring rather to emphasize the continuity between the two. If only general aspects of a previous event are retrieved, the person 'knows' the event, it feels familiar; if more specific

details of the original context are also retrieved, the event is 'remembered.' This general idea of a hierarchy of representations running from highly specific to general was discussed again some years later by Craik (2007) and is also mentioned later in the present chapter.

The second notion about relations between encoding and retrieval was Jacoby's suggestion that extended practice at a specific task will result in more efficient focusing on relevant dimensions and thus on less need for extensive processing at the time of encoding. Paradoxically then, greater practice or familiarity with the encoded event will result in poorer subsequent memory for the event. Larry's suggestion was that the spacing effect can be understood in these terms; if an item is repeated immediately there is no need to repeat the same set of analytic operations—it is easily perceived and comprehended, but by the same token less well remembered. He had previously developed this idea with some illustrative experiments under the slogan "solving a problem versus remembering a solution" (Jacoby, 1978). Repeated attempts at solving an arithmetic problem (e.g., 47 + 15 = ?) illustrates the point. On the first presentation of this problem it is necessary to compute the solution through calculation but if the same problem is repeated with few intervening events, one can either compute the solution again or retrieve the solution from recent memory. At short lags, subjects likely select the latter route. The consequence of which, according to Jacoby and Craik, is that no new cognitive operations are performed on the stimulus and so subsequent memory will suffer.

The notion that repeated presentations of the same type of material will result in less extensive analysis and thus in poorer memory was also suggested as a possible mechanism for the build-up of proactive inhibition (PI) and release from PI. That is, less extensive processing is necessary for successive items from the same category (Jacoby & Craik, 1979). In our present view, this account of PI may play some role but we are not convinced it is the whole truth. Distinctiveness is another obvious candidate; as items from the same category accumulate it is less easy to distinguish (and retrieve?) items from the similar background. When the category is switched, however, the new items are again salient and discriminable. One result that is more compatible with the distinctiveness viewpoint was reported by Gardiner, Craik and Birtwistle (1972). In this study the authors presented successive lists of words from the same category (e.g. flowers or games) and PI was observed in later lists. Unknown to the participants, the items on trial 4 were still flowers (or games) but the words were drawn from a different subset of the

general category. Thus words in trials 1-3 might be garden flowers and those in trial 4 were wild flowers (or outdoor games vs. indoor games). When participants were not informed about the switch of category at the time of retrieval they still showed PI, but if they *were* informed, release from PI was observed on trial 4. This result suggests that trial 4 words were in fact well analyzed at encoding but were difficult to retrieve unless information was provided that allowed participants to differentiate them from the background of previous items. Two final points arising from the Jacoby and Craik paper are first, retrieval is not all-or-none—like encoding there are degrees of elaboration of the retrieval information. Second, some forms of recognition do not depend on retrieval of the encoding context; this distinction between context dependent and context independent recognition has obvious parallels with the distinction between episodic and semantic memory, and also of course between recollection and familiarity.

The Jacoby and Craik (1979) chapter is thus one whose ideas certainly inspired many further studies in the Craik lab and possibly further work in the Jacoby lab. Some of the ideas are still quite relevant 35 years later—a fact that may either be attributed to Jacoby and Craik's prescience or to the slow progress of the field!

We will briefly allude to one other early chapter, which appeared in a collection entitled *Recognition and Recall* edited by John Brown (1976, of Brown-Peterson fame). The chapter was authored by Lockhart, Craik and Jacoby (1976) and was considered by the authors to be something of an update of the Craik and Lockhart article. It is noteworthy, among other things, for its extravagant metaphors and scientific parallels. For example, Larry's idea of two modes of retrieval—scanning and reconstruction (of which more later)—was compared to von Frisch's discovery that bees signal the location of food to their hive-mates in two different ways depending on how close the food is to the hive. Another idea was that retrieval cues may elicit sought-for items in memory by a process akin to resonance; cues will initially tend to activate *all* items in memory that share their qualitative aspects, and this large set of potential candidates is then whittled down by further interactions between the cue and constructed knowledge of the wanted item. The resonance metaphor was likened to a set of tuning forks that could be selectively set to vibrate by broadcasting a signal at a given frequency. Finally, the point that perception of an object can often precede perception of the components constituting that object

was illustrated by *pointillisme*—the technique in painting in which images are formed by the aggregation of many small dots of pure color (e.g. *A Sunday Afternoon on the Island of La Grande Jatte* by Georges Seurat). Larry was quite doubtful whether he as 'a kid from Kansas' was actually *allowed* to use words such as pointillisme, but went along with it. Ben Murdock was asked to comment on a draft of the chapter; he had been (for him!) quite complimentary about the Craik and Lockhart paper, but his response to this chapter was "Where do you intend to submit this work -- *The Journal of Science Fiction*??" *Some* people liked it!

Nathan Rose's account:

Larry had moved to St. Louis a few years before Rose started his graduate training at Wash U in 2004. With his iconic stature in the field and somewhat gruff appearance, Larry was a pretty intimidating professor to young graduate students. (If you don't know what he looks like, good luck spotting him at a conference – he never wears his nametag, presumably to avoid having to sign autographs!). But this intimidation is quickly softened the first time you hear this gentle giant speak. Rose took Larry's memory rehabilitation course and attended his lab meetings, eager to have Jacoby's brilliance wash over him. The problem was – Rose could barely understand a word! It was only when older students, post-docs, and faculty began translating the many verbal and gestural Larryisms was it possible to grasp the depth of his wisdom. (Anyone who has ever witnessed Larry thrusting one fist forward and smothering it with the other to represent front end constraint will understand.)

Like Larry, Rose was interested in the potential of cognitive training programs for protecting against cognitive decline in older adults. Rose proposed training working memory to see if doing so could reduce age declines in other domains of cognition (i.e., 'far transfer'). Larry had a similar goal, but a different target in mind. He was intrigued by findings from Art Kramer's group of transfer following fixed vs. variable priority training. Larry wanted to do one thing and Rose wanted to do another. Given all the recent research about the limitations of working memory training, Rose should have listened to him! The two were as stubborn as each other and never could come to a resolution. Eventually they realized their repeated attempts to initiate the collaboration were really just to reduce the guilt they both felt when they ran into each other in the restroom. (Speaking of restrooms... Larry tells his grad students that he knew he

had “made it” in psychology when he was waiting in line at a restroom and the person standing in line before him stepped aside and said, “Please Dr. Jacoby, you first!”).

Larry was highly influential to young students’ thinking and training in many ways, two of which were through his axiom, “no task is process pure,” and his preference for a process-based view of memory systems. For example, this view inspired Rose to think critically about the notion that working memory tasks tapped one monolithic construct – the working memory “system.” From this perspective, it was unclear how working memory was really different from a collection of processes also implicated in attention and long-term memory.

In the following sections we comment on some of Jacoby’s major theoretical ideas and how they have impinged on our thinking, such as how a process-based view of working memory helps to resolve conflict about how to conceptualize what working memory *is*.

Consequences of scanning and reconstruction in retrieval from STM

A chapter by Craik and Jacoby (1975) presented a process-based view of short-term retention, and one of the issues discussed is the difference in processes involved in scanning and reconstruction. Scanning was described as a mode of retrieval in which participants report information directly from recent memory – perhaps even from primary memory (PM) or the focus of attention. Reconstruction was described as a more elaborative, generative process similar to the retrieval mode involved in episodic retrieval from secondary memory (SM). To examine the consequences of using these different retrieval modes, Craik and Jacoby hypothesized that deeper processing at encoding would have minimal effect on scanning, but a large benefit to reconstruction. They had subjects perform a continuous recognition task with case, rhyme, or category decisions at encoding, and a varied lag between initial encoding and the recognition test. LOP did not affect continuous (relatively short-term) recognition performance, even for lags up to 24 intervening items (see left panel of Figure 1). Following the continuous recognition task, they had subjects try to recall as many items from the task as possible. Final recall of these items showed a large benefit of deeper processing at encoding (Figure 1, right).

The dissociation in LOP effects was taken to reflect a difference in the retrieval mode utilized by the continuous recognition task and the final free recall task. In the continuous

recognition task, subjects could scan the traces in recent memory to decide if each word had been recently presented whereas, in the final free recall task, subjects had to reconstruct the memory based on whatever diagnostic cues the subject could access at the time. In retrospect it is difficult to believe that up to 24 words are actually maintained in an active PM state, and it seems more likely that the scanning process is yielding recognition decisions based on a relatively superficial feeling of familiarity, regardless of whether a particular encoded item also embodies deeper conceptual information. Participants can somehow check whether the test item feels familiar, and make their recognition decision on that basis – without involving reconstruction of the initial context, and thus without invoking the encoded differences in depth. This deeper information *is* utilized during the final recall test, however, as this test presumably relies entirely on reconstructive processes. If the conditions allowed participants to carry out reconstructive processing during the *online* recognition phase, however, levels effects should emerge in that phase, and final recall performance should show the benefits of differences in both initial encoding and successful online recognition.

Retrieval from SM/LTM may thus be considered a more elaborative type of retrieval that generates effective cues for subsequent memory. For example, initially testing memory benefits subsequent memory – a phenomenon known as the testing or retrieval practice effect. When retrieval practice is coupled with an LOP manipulation at encoding the deeper, generative effect of retrieval practice is revealed. The data below (Figure 2) are from an experiment examining subsequent LTM of items from an immediate (WM) test with or without initial recall (Rose et al., 2010). Target words were processed at a visual, phonological, or semantic level of processing at encoding by choosing as quickly as possible which of two later-presented "processing words" matched the target word in terms of number of vowels, rhyme, or meaning. For the group of subjects with immediate tests, after every 4 or 8 processing decisions, the target words were to be recalled in serial order. Therefore, this condition involved intentional encoding and retrieval practice. For the group of subjects without immediate tests, who believed they were participating in a reaction time experiment, after every 4 or 8 processing decisions they simply paused to rest for the average amount of time it took the group with immediate testing to recall the words, before carrying on with the next series of words. Therefore, this condition involved incidental encoding and no retrieval practice. After processing all of the words and performing

10 minutes of mental arithmetic, all subjects performed the same recognition memory test. Retrieval practice was found to have minimal benefit for subsequent memory if the items were initially encoded in a deep manner. In contrast, shallowly encoded items benefited more from testing. The result was interpreted as follows: relative to deep encoding, shallow encoding has a negative effect on subsequent memory; however, the retrieval practice induced by initial testing is an elaborative, reconstructive process that can generate effective cues which can be used for subsequent retrieval attempts. Thus, retrieval practice can "rescue" shallowly encoded items, so to speak. In contrast, retrieval practice is less beneficial to items that have already been encoded in a deep manner, presumably because the generated cues do not provide additional distinctive information.

Two types of rehearsal?

A difference in subsequent LTM for items initially retrieved by means of scanning as opposed to reconstruction on a short-term recognition task is conceptually similar to findings from research on the negative recency effect and the spacing effect. Madigan and McCabe (1971), for example, showed that the last word of five-word lists was always recalled on immediate tests but was almost never recalled on delayed tests. Negative recency effects on delayed tests have been interpreted to reflect the "fate" of recalling items from primary memory (Craik, 1970). Similarly, massed rehearsal of items does not benefit delayed memory any more than if the items receive no extra rehearsal at all (e.g., Craik & Watkins, 1973; Glenberg, Smith, & Green, 1977; Jacoby & Bartz, 1972; Rundus, 1977; Woodward, Bjork, & Jongeward, 1973).

Jacoby and Bartz (1972), for example, showed that recalling lists of words following 15 seconds of a task designed to disrupt rehearsal *benefited* final free recall of the items relative to either immediate recall or 15 seconds of rehearsal. That is, after encoding each list of words participants either recalled the list immediately, recalled the list following 15 seconds of rehearsal, or recalled the list after performing 15 seconds of math. Final free recall was better for words recalled after distraction than after rehearsal. Thus, although rehearsal was once thought to be critical for the transfer of information to LTM (Waugh & Norman, 1965; Atkinson & Shiffrin, 1968), the Jacoby and Bartz results showed very different results in final recall depending on the nature of initial retrieval. What produces this differential effect on long-term retention? One

possibility is that in the condition in which rehearsal was disrupted, initial recall was mostly from SM, given that PM items have been knocked out by the interfering task. Another possibility, suggested by the Jacoby and Bartz findings, is that 'rehearsal' is not in fact a unitary construct.

Subsequent theorizing argued for a distinction between two types of processing that have different effects on long-term retention. Descriptions of "Type I" processing are similar to the notion of rehearsal in primary memory or recirculating aspects of the stimuli that are still being attended to (Mazuryk & Lockhart, 1974). "Type II" processing essentially refers to deeper, more meaningful processing operations (Craik & Lockhart, 1972), and has also been referred to as elaborative rehearsal (Craik & Watkins, 1973), and secondary rehearsal (Woodward, Bjork, & Jongeward, 1973). In contrast to Type I processing, Type II processing was thought to generate cues that are more effective at eliciting retrieval of the items from the long-term store (Jacoby & Bartz, 1972). Craik and Jacoby (1975) therefore concluded that 'rehearsal' must be broken down into at least two component processes. To the extent that subjects merely maintain activity at one level of analysis – that is, repeat encoding operations already accomplished – rehearsal will maintain the items in mind but will not lead to improved memory performance. Alternatively, if the subject uses the rehearsal period to perform further, more elaborate analyses then better retention will result. The distinction between primary and secondary rehearsal was also made by others (e.g., Elmes & Bjork, 1975).

The present authors have tried to uphold this line of thinking and incorporate it into current conceptualizations of working memory in which 'maintenance' is thought to consist of at least two types of processing – rehearsal and *refreshing* (Camos, Lagner, & Barrouillet, 2009; Johnson, 1992) or *covert-retrieval* (McCabe, 2008; Rose et al., 2010; Rose & Craik, 2012). Using Jacoby- inspired designs, the relative contributions of these two types of processing are shown to vary depending on the demands of the particular task at hand such as test expectancy (Rose & Craik, 2012) and rehearsal disrupting activity (Rose, Buchsbaum, & Craik, 2013). For example, when immediate recall of a short list of items is expected, subjects rehearse the items and recall is accurate and unaffected by LOP at encoding. If, however, recall is unexpected, surprise recall tests show substantial forgetting and a large benefit of deeper LOP at encoding, even for immediate testing (Rose & Craik, 2012; see also Marsh, Sebrechts, & Hicks, 1997).

Test expectations influence the preferential use of a particular maintenance process, which results in differential reliance on shallower, perceptual processes over deeper, conceptual processes (Speer, Braver, & Jacoby, 2006). Similarly, recall of a single word after a 10 second delay shows a large benefit of deeper LOP at encoding if the distractor task during the delay is sufficiently difficult (e.g., a hard math task). If the distractor task can be performed relatively easily (e.g., an easy math task), the LOP effect is substantially smaller, suggesting that subjects covertly retrieved to-be-recalled items during the distractor task to refresh the items so that they were accessible at recall (Rose, Buchsbaum, & Craik, 2013).

Age differences in automatic and controlled processing

One of Jacoby's major accomplishments has been his careful dissection of the concepts of automatic and consciously controlled memory processes, and a means to estimate their respective contributions to complex tasks (Jacoby, 1991). An attractive feature of his work is the way he bases theoretical constructs on down-to-earth real-life examples; his 'fame' paradigm provides a good illustration. The basic idea here is that recent experience of a word, name, or other event may serve as the basis for recollecting that event, but the familiarity associated with re-processing the item at the time of test may also be misattributed to some other dimension of experience. Thus, Jacoby has shown that when participants are shown a list of non-famous names, these names may later be judged as belonging to famous people, simply by virtue of the name's greater than expected familiarity. He has described the tendency of older adults to repeat the same story on numerous occasions to the same audience in the same terms. That is, "automatic influences from an earlier recounting of a story lead it to come easily to mind, such that it seems appropriate for a particular audience" (Jennings & Jacoby, 1997, p. 352)—a phenomenon that may have occurred to readers of this chapter, bearing in mind the age of the first author!

Jacoby's use of these ideas and methods in the study of cognitive aging has been particularly influential to people in Craik's lab over the years. Jennings and Jacoby (1993) demonstrated convincingly that older adults were more likely than young adults to show the false fame effect, and also performed less well on a recognition memory paradigm involving both inclusion and exclusion conditions. Both results nicely illustrate the point that normal aging is associated with a decline in the ability to consciously recollect a prior episode but that automatic

processing is left intact. The failure of recollection leaves the automatic influence unopposed, leading in turn to errors of attribution in perception, memory and sources of knowledge. A second result in a number of Jacoby's experiments (e.g. Jacoby, 1991; Jennings & Jacoby 1993) is that similar results are found in young adults working under conditions of divided attention (DA). Craik has also suggested that the effects of aging can be mimicked in younger adults by having them perform under DA conditions (Craik, 1982; Craik & Byrd, 1982). He had attributed this parallel to a reduction in available processing resources, but Jacoby has argued instead that both DA and normal aging are associated with a decline in executive control functions. These two accounts have much in common, although Craik stubbornly holds to the view that effective cognitive processing requires a source of energy ("cognitive resources") as well as a means of controlling how behavior is directed ("cognitive control").

Another link between the Craik and Jacoby labs is that both Janine Jennings and Janine Hay carried out their graduate work with Larry after spending some undergraduate time in the Craik lab (Craik & Hay, 1999; Craik & Jennings, 1992). An article by Hay and Jacoby (1996) further illustrates Jacoby's notion that habit can either facilitate or oppose conscious recollection and that the two processes are sensitive to different modulating variables. Memory slips can occur when a failure of recollection leaves habit unopposed. Jacoby's anecdote to illustrate this point concerns an aging professor from Winnipeg who went to a conference in Chicago. While preparing to return home he could not find his airline ticket and finally bought a replacement ticket. On his return to Winnipeg he called his wife to drive him home from the airport but she reminded him (caustically no doubt) that atypically he had driven to the conference! Craik was so impressed by this tale that once while on vacation in Scotland and preparing to return to Canada he could not find his airline ticket and wondered for a moment (briefly, only briefly!) "Hmmm—did I *drive* here?"

Hay and Jacoby (1999) used the process dissociation technique to explore age-related differences in elaboration and distinctiveness, finding again that habit and recollection make independent contributions to performance, and also that recollection declines in older individuals whereas habit is relatively unchanged by the aging process. The results of the study also supported the notion that older adults fail to elaborate item and contextual information to the same extent as younger adults do; older adults encode information in a more general manner,

embodying fewer contextually specific details. Hay and Jacoby also showed that older participants failed to capitalize on distinctive associative information at the time of retrieval unless the task was performed under conditions that supported both encoding and retrieval. These findings and conclusions are very congenial to the notion that older people benefit disproportionately from 'environmental support' during both encoding and retrieval (Craik, 1983) and with the idea that memory in older individuals can be restored to levels shown by young adults under supportive conditions. The finding by Hay and Jacoby that older people deal with information in a more general manner is also congenial to a later suggestion by Craik (2007) that encoded representations are organized hierarchically from specific episodes to increasingly general 'semantic' representations (see Figure 3). Craik suggested that older people are unimpaired when retrieving information at higher general levels, but have difficulty 'resolving' retrieval processing to the point of accessing specific episodic detail—a suggestion that has its roots in Jacoby and Craik (1979)!

In slightly greater detail, the idea illustrated in the top half of Figure 3 is that individual episodes are the 'twigs' at the bottom of a hierarchy of representations, and that progressively higher nodes represent increasingly general commonalities among their constituent lower nodes. The lowest representations may be referred to as 'episodic memory' and the highest as 'semantic memory' but these types of memory are seen as being on a continuum of specificity-generality rather than as two separate memory systems. Judgments of 'remember' and 'know' reflect access to different levels of the hierarchy. The lower part of Figure 3 suggests how LOP might fit into this representational scheme. Shallow processing activates perceptual nodes, but does not link the activation to higher conceptual nodes. On the other hand, deep processing integrates perceptual episodic records with pre-existing conceptual information.

Extensions of processing dissociation techniques

Findings and ideas from other recent literatures bear on these Jacobean notions of habit and recollection, and it occurred to us that these other areas could profit from an infusion of process dissociation techniques. One such topic deals with the effects of emotional disorders on retrieval from autobiographical memory. In an extensive review, Williams et al., (2007) describe how patients suffering from depression and also those with a history of traumatic abuse typically

respond with general categories of events rather than with specific episodes when asked to recall memories from their personal past. This tendency to express over-general memories is similar to the pattern shown by older adults (Craik & Simon, 1980; Levine et al., 2002) and it is interesting to speculate on whether there is a common mechanism. Williams and colleagues suggest three factors that may operate in the cases of depression and abuse: (a) the capture of retrieval processes by irrelevant rumination; (b) avoidance of emotionally painful memories; and (c) an impairment of executive control processes. The third factor is clearly similar to that suggested for the pattern in normal aging, so it may be useful to apply the techniques of both process dissociation and environmental support to analyze and alleviate these memory problems associated with affective disorders.

The second topic involves the observation from both animal and human studies that exposure to stress tends to shift the control of behavior from a flexible 'cognitive' mode to a relatively rigid 'habit' mode (Schwabe & Wolf, 2013). These authors describe a number of studies in which stress promotes a shift to control by habit memory and away from goal-directed cognitive control. The article by Schwabe and Wolf is largely concerned with possible neural correlates of these two 'memory systems'—frontal cortex and hippocampus for cognitive control and dorsal striatum for control by habit—but their basic concerns is to estimate how contributions from the two modes of control vary as a function of environmental and other factors. Their statement "These findings are in line with previous evidence showing that the hippocampus and prefrontal cortex are particularly sensitive to stress and stress hormones and suggest that stress disrupts these 'cognitive' systems whereas 'habit' systems remain unchanged by stress, thus allowing the latter systems to control learning and memory" (Schwabe & Wolf, 2013, p. 66), is clearly very similar to Jacoby's discussion of factors that can reduce the efficiency of recollection, thereby allowing habit to dominate behavioral control. Again it seems that process dissociation techniques could help to estimate the behavioral contributions of cognitive and habit control in various situations, and that this in turn would help in the specification of their underlying neural correlates.

Brain implications

With the advent of functional magnetic resonance imaging (fMRI), rather than shy away from this new expensive toy and criticize it as modern-day phrenology, Jacoby embraced and exploited the technology to test long-standing cognitive ideas. For example, Velanova, Jacoby, Wheeler, McAvoy, Peterson, and Buckner (2003) conducted an fMRI study to explore the neural correlates of sustained and transient processes associated with controlled episodic memory retrieval. At the time, neuroimaging evidence of episodic retrieval was complicated by a design limitation. Most neuroimaging studies had not yet worked out how to separate event-related activity from trial to trial – relying instead on blocked designs and averaging trial related activity across blocks. Therefore, as Velanova, Jacoby, and colleagues pointed out, it was unclear whether previously reported neural correlates of retrieval reflected sustained processing associated with the subject being in a task set, i.e., a "retrieval mode" (Tulving, 1983), or a blurred average of more transient processes that vary across trials – e.g., processes associated with recollection on some trials and familiarity on others. Capitalizing on the recently developed "mixed blocked event-related" design, that employs the (now standard) practice of jittering the inter-trial interval which allows one to deconvolve transient trial-by-trial variance in the hemodynamic response from sustained changes during task performance (Donaldson & Buckner, 2001), Velanova and colleagues examined the neural correlates of controlled retrieval during blocks of trials requiring a high degree of controlled retrieval. High control blocks were associated with greater sustained activation in right frontopolar cortex, whereas transient, trial-related retrieval processes were associated with activity in a network involving more posterior frontal and parietal areas. Left frontal and lateral parietal cortex was more active for studied items (hits) than for new items (correct rejections). These findings fit well with Jacoby's (1991) notion of a retrieval mode in episodic memory, and the notion that recollection processes are more transient, occurring on trials involving controlled episodic retrieval of contextual details (Tulving, 1983; Jacoby, Shimizu, Daniels, & Rhodes, 2005).

Another example of how the Jacoby lab has used neuroimaging techniques to complement and illuminate cognitive ideas was demonstrated in a study by Vaidya et al. (2002). The authors had subjects encode pictures and words. When subjects made recognition decisions about words that were initially encoded as pictures, there was greater activation in visual cortex

than there was for recognition decisions about pictures that were initially encoded as words. In a complementary fashion, pictures encoded as words produced greater activations in left inferior temporal regions than words initially encoded as pictures. This dissociation nicely demonstrates that recognition decisions are not driven purely by the current retrieval context; they are also based on some reconstructed reinstatement of the encoding context.

One further example deserves mention, especially because of its relevance to the earlier section on the STM/LTM distinction. In a particularly clever fMRI study, Speer, Jacoby and Braver (2003) compared behavioral and neural differences between maintaining short lists (1, 2, 3, 4, or 5 words) and long lists (7, 8, 9, 10, or 11 words). The fMRI data showed that 84% of the voxels activated in the short-list block were also significantly activated for the long-list block. This finding illustrates that, although short lists emphasized maintenance in STM and long lists encouraged encoding and retrieval from LTM, the two modes of processing were largely overlapping. The critical manipulation was that subjects performed a block with short lists, which encouraged maintenance focused processing, and a block with long lists, which encouraged more elaborative, episodic retrieval-focused processing. Embedded within each block were 6-item lists. This allowed direct comparison of the difference in processing within the same list length, with the same retention interval and same level of difficulty. Maintenance of six-word lists activated several regions of frontal and temporal cortex when embedded in both short- and long-list blocks, but the activations tended to be earlier in the trial in long-list blocks, presumably reflecting more elaborative encoding processes, and later in short-list blocks, presumably reflecting rehearsal processes during the delay and the response phases (Figure 4). The findings show that, despite the exact same task requirements, memory for six-word lists recruited more maintenance focused processes in the context of an STM task and more elaborative encoding and episodic retrieval-focused processing in the context of an LTM task. This Jacobean approach of using task factors such as test expectancy to observe differences in the neurocognitive processes subjects employ to perform a task while holding other factors constant is a strategy that future cognitive neuroscientists would do well to utilize.

Summing Up

Clearly we have touched on only a few of Larry Jacoby's findings and ideas over the years – those that have had a particular influence on the Craik lab. We have tried to emphasize

the similarities in approach, including the processing approach to understanding memory and cognition, the unity of cognition as opposed to treating perception, attention, memory and thought as separate entities, the centrality of context and of cognitive control (or, possibly, "cognitive resources"!). We take the same view about the huge importance of cognitive neuroscience, but tend to see that area as a means to illuminate cognitive concepts rather than as an end in itself. We have all focused on qualitative differences among cognitive representations, although it may also be true to say that Larry has not quite abandoned 'strength' as a memory descriptor; the effects of familiarity may vary in strength, for example.

To end on a personal note, both present authors have profited immensely from interacting with Larry Jacoby over the years. We have learned stuff, appreciated new perspectives, shared ideas of mutual interest – and shared a few good jokes! We wish Larry many more years of creative insights and productive work.

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Figure Captions

Figure 1. Initial recognition (left panel) and final free recall (right panel) in a "levels-of-processing" task (from Craik & Jacoby, 1975).

Figure 2. Mean proportion of words recognized (hits) on the delayed recognition tests as a function of level of processing (from Rose et al., 2010).

Figure 3. (A) A schematic model of knowledge representations. The suggested hierarchical organization with specifc episodic records in lower nodes and general abstract knowledge occupying higher nodes. 'Rmember' and 'Know' judgmentst reflect acces to lower and higher nodes respectively. (B) A schematic model of knowledge representations. Deep semantic processing appears to entail integration of episodic records with pre-existing knowledge, whereas shallow processing lacks such integration (adapted from Craik, 2002).

Figure 4. Time-courses of activation in two of the areas showing differences in the encoding, maintenance, or retrieval phase of six-word list trials when they were embedded in short-list (red line) versus long-list (blue line) blocks of trials (adapted from Speer, Jacoby, & Braver, 2003).

Figure 1

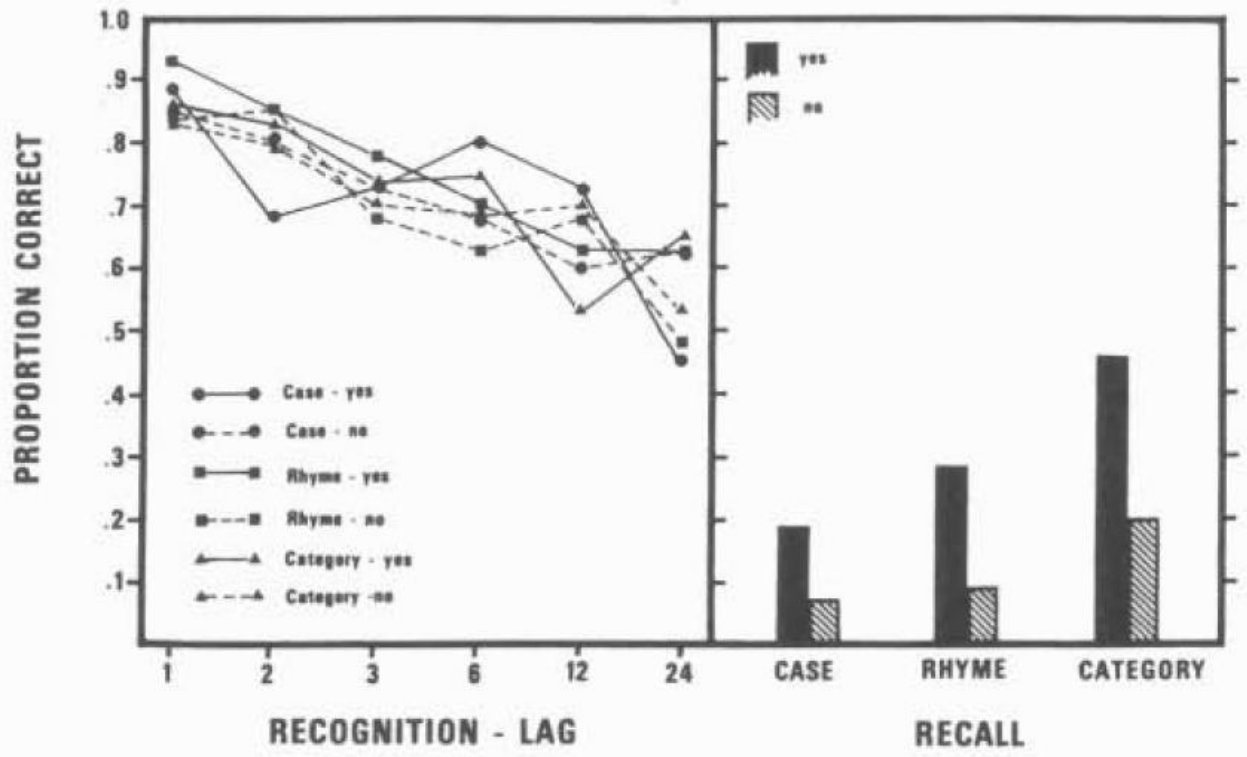

PROPORTION CORRECT
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
Case - yes
Case - no
Rhyme - yes
Rhyme - no
Category - yes
Category -no
1
2
3
6
12
24
RECOGNITION - LAG
yes
no
CASE
RHYME
CATEGORY
RECALL

Figure 2

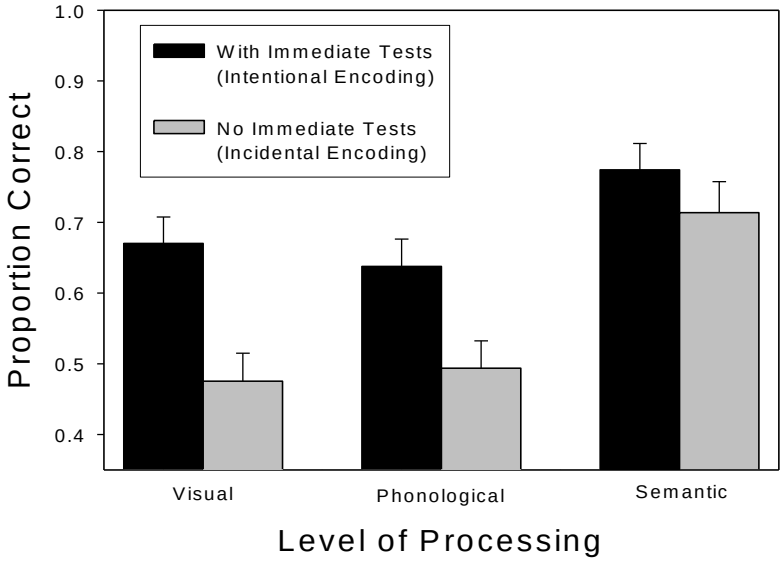
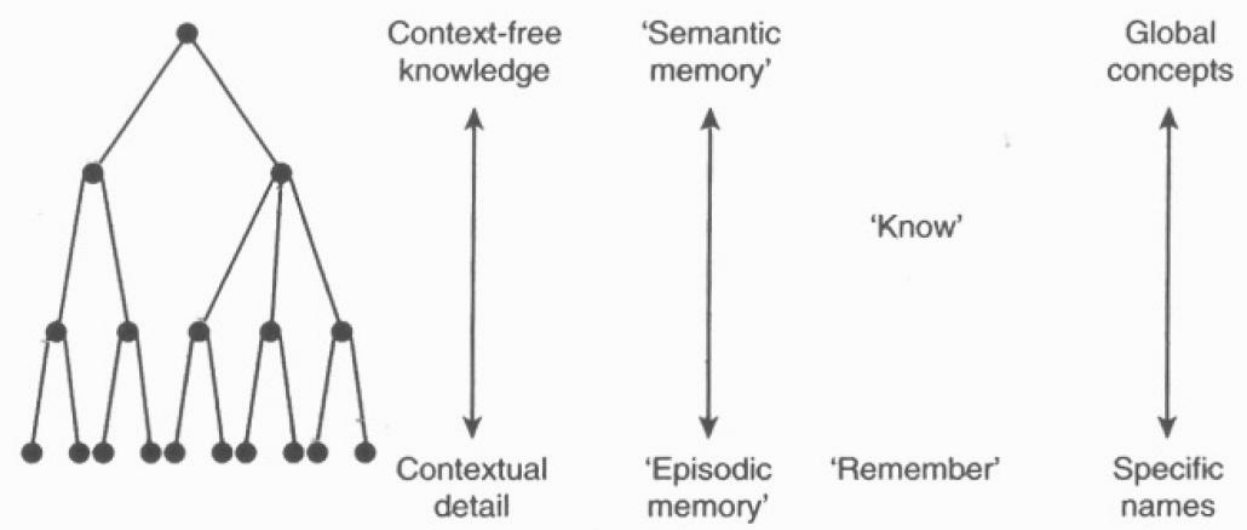

1.0
0.9
0.8
0.7
0.6
0.5
0.4
Proportion Correct
With Immediate Tests
(Intentional Encoding)
No Immediate Tests
(Incidental Encoding)
Visual
Phonological
Semantic
Level of Processing

Figure 3

A.


Context-free knowledge
'Semantic memory'
Global concepts
'Know'
Contextual detail
'Episodic memory'
'Remember'
Specific names

B.

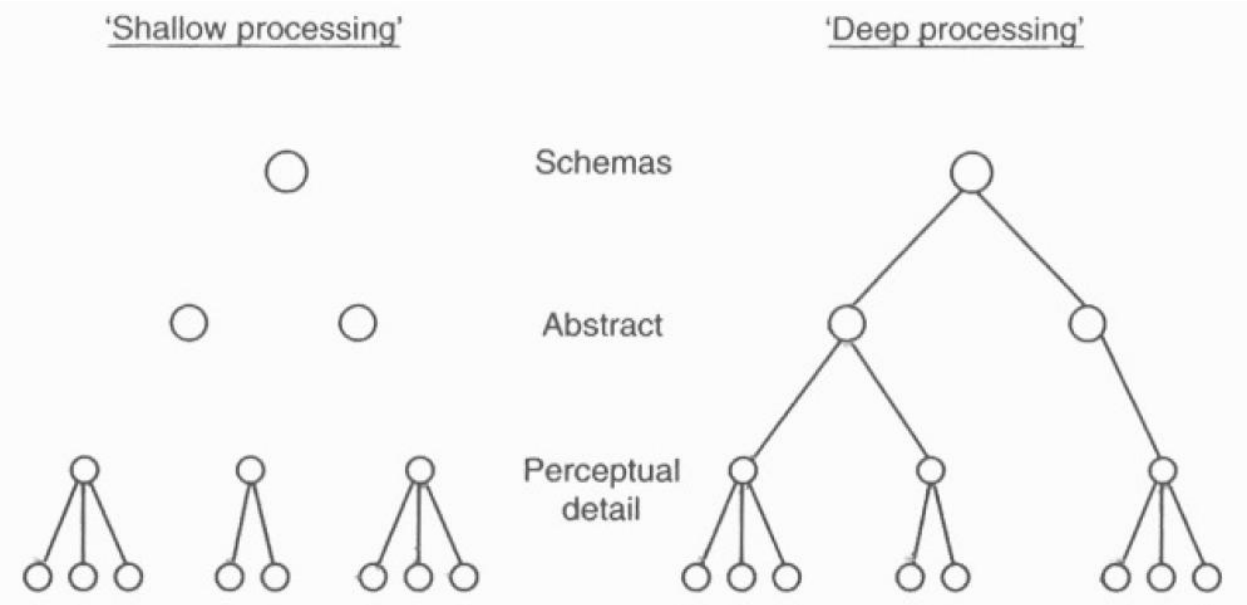
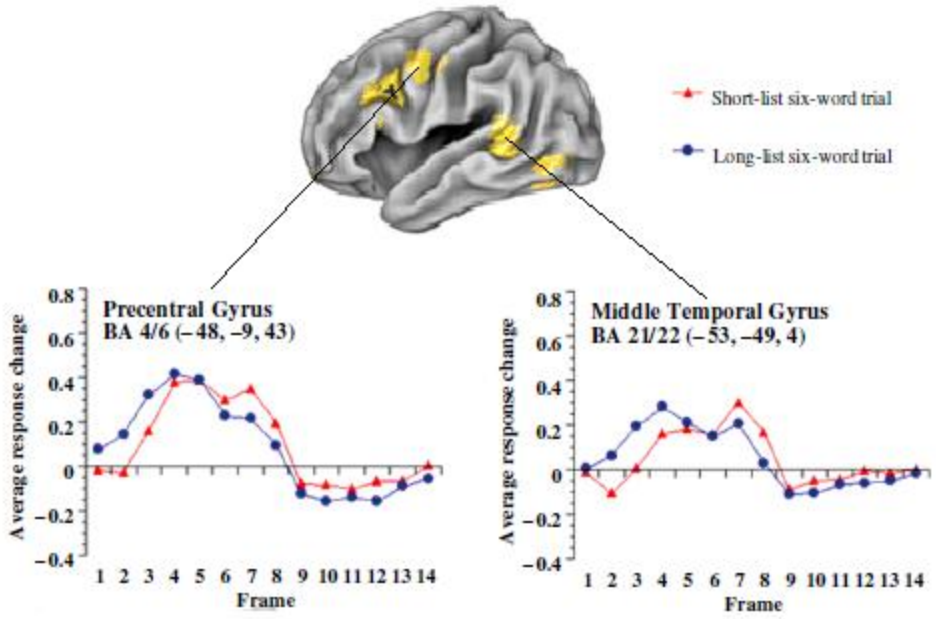

'Shallow processing'
'Deep processing'
Schemas
Abstract
Perceptual detail

Figure 4


Short-list six-word trial
Long-list six-word trial
Precentral Gyrus
BA 4/6 (–48, –9, 43)
Middle Temporal Gyrus
BA 21/22 (–53, –49, 4)
Average response change
0.8
0.6
0.4
0.2
0
–0.2
–0.4
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Frame