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Preserved and Impaired Memory Functions in Elderly Adults

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The existence of age-related impairments in information processing long has been apparent, but the field also has recognized that normal aging does not yield a mere overall decline in cognitive function. Rather, some functions decline, others remain stable, and others even improve. In fact, documenting the pattern of impaired and preserved functioning, or at least differential rates of decline, has emerged as a major theme in research on cognitive aging. This work has been of interest to those outside the field of psychogerontology because of the intuition that any pattern observed will be informative about the structure of the mind in general.

For example, Cattell (1963) and Horn (Horn & Cattell, 1967) argued that fluid intelligence or general problem-solving ability begins to decline approximately with the onset of adolescence, in a pattern paralleling the growth and decline of the neural structures that support human intelligence. In contrast, crystallized intelligence or individual repertoire of declarative and procedural knowledge in various content areas continues to rise as long as the individual continues to be exposed to relevant educational opportunities. Data conforming to this pattern were cited in support of Cattell's theory of the structure of human intelligence. Of course, both claims—that some intellectual functions do not decline with age and that the observed pattern of differential deficit is best understood in terms of

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fluid versus crystallized intelligence—have proved somewhat controversial (Baltes & Schaie, 1976; Denney, 1984; Horn & Donaldson, 1976, 1977; Labouvie-Vief, 1985; Schaie, 1974), but that point is not critical. The critical point is that the question of differential deficit, once raised, leads to research that clarifies what the elderly can and cannot do and leads to an improved understanding of the structures and processes involved in mental life.

The study of aging intelligence has its parallel in the study of aging memory. Although the elderly (and their families) often complain of problems in "memory" without further qualification, careful examination reveals a pattern in which some functions may have declined while others are preserved more or less intact. [For comprehensive reviews, see Burke & Light (1981), Craik (1977,1991), Craik & Byrd (1982), Craik & Simon (1980), Light (1991), Poon (1985), and Schonfield & Stones, (1979)]. Similar findings, of course, are commonplace elsewhere in the literature on memory deficits associated with the amnesia syndrome and dementia. (For a brief review, see Schacter, Kaszniak, & Kihlstrom (1991).] As is the case elsewhere in cognitive neuropsychology, analysis of these differential deficits, or dissociations, has been influenced by and, in return, has influenced our theoretical understanding of the structure of memory.

In early studies of differential memory deficits in the aged, as represented by the seminal work of Talland (1968; see also Poon, Fozard, Cermak, Arenberg, & Thompson, 1980), research was guided principally by the classical multistore model of memory (Atkinson & Shiffrin, 1968), which assumed the existence of several different storage structures and several control processes that transfer information among them. Thus, primary (short-term) memory functioning was sometimes argued to be intact in the elderly, but age was argued to impair encoding and retrieval processes in secondary (long-term) memory. This view helped organize a wealth of literature that showed, for example, age differences in single-trial free recall and in the primacy component of the serial-position curve, but not in forward digit span or the recency portion of the serial-position curve.

In the face of certain anomalies in the evidence (for example, deficits in backward digit span), and the replacement of the multistore model with a levels-of-processing view of memory predicated on a single memory store (Craik & Lockhart, 1972), interpretation of the evidence changed during the 1970s. The new view, exemplified by the work of Craik (e.g., Craik, 1977) suggested that the elderly process information less deeply or less elaborately, perhaps because of a loss of general information-processing capacity or the controlled deployment of attention. This general position has been restated in terms of age-related deficits in the speed and accuracy of working memory, a hypothetical structure in which information is stored while it is actively processed. Thus, aging is thought to affect both the speed and accuracy with which information is processed in working memory; this deficit has a deleterious impact on subsequent secondary memory performance (Craik, Morris, & Gick, 1989).

Whether the analysis is stated in terms of secondary memory, levels of processing, the deployment of attention, or working memory, these analyses tend to support a general, although perhaps relatively benign compared with the deficits in amnesia or dementia, age-related decline in memory function. However, demonstrations of preserved memory function within the domain of secondary or long-term memory necessarily indicate that age-related memory loss is, to some extent, selective. One of the first indications of this selectivity was the discovery of greater age-related impairments in recall than in recognition (Rabinowitz, 1984; Schonfield & Robertson, 1966). The fact that recognition is relatively spared in the elderly shows that, despite the age-related defects in information processing that occur, some information is encoded successfully and retained by the aged. Although Schonfield initially relied on these results to argue that the aged suffered from a deficit in retrieval rather than encoding (Schonfield & Robertson, 1966), he later acknowledged the difficulty in achieving any clear separation between encoding and retrieval processes (Schonfield & Stones, 1979).

Another approach has been to abandon the previous emphasis on storage structures and control processes, and focus instead on the effects of aging on different types, or forms, of memory. For example, memory theorists often find it convenient to classify the contents of memory into declarative and procedural knowledge (Anderson, 1983; Winograd, 1975). Declarative knowledge consists of factual information abut the nature of the physical and social world, whereas procedural knowledge consists of the rules and skills by which declarative knowledge is processed in the course of cognitive activity. Tulving (1983) has argued for a further distinction within the domain of declarative knowledge to establish episodic and semantic memory. Episodic memory is essentially autobiographical, whereas semantic memory is best thought of as a mental lexicon of abstract categorical information. Mitchell (1989) has suggested that aging impairs episodic memory but spares procedural and semantic memory. These distinctions have proved extremely useful in contemporary neuropsychological research on the amnesic syndrome and various dementing illnesses (Schacter, Kaszniak, & Kihlstrom, 1991). The distinctions have come to be applied to the study of aging memory as well. Rather than attempting a comprehensive treatment of this newly emerging literature here, we focus more narrowly on two domains in which we and others have begun to address pertinent issues: the distinctions between implicit and explicit memory on the one hand and between fact and source memory on the other.

I. Aging and Implicit Memory

The distinction between implicit and explicit memory refers to two different ways in which memories can be expressed. Explicit memory entails conscious intentional recollection of previous experiences, as expressed on recall and recognition tests that require subjects to think back to a specific study episode. Implicit memory entails facilitations of test performance that are attributable to specific previous experiences, but are expressed without conscious recollection, on tasks that do not require subjects to think back to a specific study episode (Graf & Schacter, 1985; Schacter, 1987a). For example, one commonly used implicit memory test is the stem-completion task (e.g., Graf & Mandler, 1984), in which subjects are given the first three letters of a word (e.g., tab—) and are asked to complete the stem with the first word that comes to mind (e.g., table). Implicit memory is revealed when subjects complete stems more frequently with previously studied words than with nonstudied words, a phenomenon known as priming (Tulving & Schacter, 1990). Other implicit tasks commonly used to assess priming include word-fragment completion, in which a graphemic fragment of a word is presented (e.g., A—A—I– for ASSASSIN) and the subject attempts to complete it (cf. Hayman & Tulving, 1989; Tulving, Schacter, & Stark, 1982); word identification, in which a word is flashed briefly (e.g., for 35 msec) and subjects attempt to identify it (cf. Jacoby & Dallas, 1981; Morton, 1979); lexical decision, in which a letter string is presented and subjects decide as quickly as possible whether the string constitutes a word or a nonword (e.g., Scarborough, Gerard, & Cortese, 1979); and picture naming, in which subjects name and rename pictures of familiar objects (e.g., Durso & Johnson, 1979; Mitchell & Brown, 1988). Priming is indicated by either improved accuracy or reduced latency in identifying or making decisions about studied items relative to nonstudied items.

Implicit memory, as expressed by priming effects on these and other tasks, has been well established to be dissociated from explicit remembering in various ways. Experimental variables that produce large effects on tests of explicit memory frequently produce no effect, or even opposite effects, on tests of implicit memory; neurological conditions that impair explicit memory, for example, organic amnesia, may have no effect on implicit memory; and various pharmacologic agents affect implicit and explicit memory differently. [For reviews, see Kihlstrom & Schacter (1990), Richardson-Klavehn & Bjork (1988), Roediger (1990), Schacter (1987a), and Shimamura (1986).] The presence of such striking dissociations has contributed to a virtual avalanche of research exploring numerous aspects of the relationship between implicit and explicit memory.

In view of the numerous implicit–explicit dissociations that have been documented, a natural question concerns the effects of cognitive aging on implicit and explicit memory. Not surprisingly, the issue has been addressed in a growing number of experimental studies, most of which have been concerned with priming effects of various kinds. As discussed in several reviews (cf. Graf, 1990; Howard 1991; Light, 1991), two rather different trends have been observed in studies using such implicit tasks as stem and fragment completion, word identification, picture naming, and lexical decision: (1) priming in older adults is robust and does not differ significantly from that observed in young subjects (e.g., Howard, Fry, & Brune, 1993, Experiment 2; Light & Singh, 1987; Light, Singh, & Capps, 1986; Mitchell, 1989; Mitchell, Brown, & Murphy, 1990; Moscovitch, 1982; Moscovitch, Winocur, & McLachlan, 1986) and (2) reduced levels of priming are observed in the elderly relative to the young (e.g., Chiarello & Hoyer, 1988; Davis et al., 1990; Howard et al., 1993, Experiments 1 and 3; Hultch, Masson, & Small, 1991).

Although any number of reasons exist for the apparent discrepancies, both Graf (1990) and Howard (1991) have pointed out that observations of what appear to be priming deficits in the elderly need not imply that implicit memory is impaired in older adults. This interpretive problem arises because, in some experimental conditions, explicit memory processes can "contaminate" performance on a nominally implicit task, that is, subjects may engage in intentional retrieval strategies if they catch on to the memory-related aspects of the test (e.g., Bowers & Schacter, 1990). For example, subjects performing a stem completion task may recognize that some of its items are drawn from a previously studied word list. If so, they may draw strategically on their explicit memory for the study list to create an appropriate mental set and, thereby, facilitate completion performance. Of course, if the elderly do experience a genuine deficit in explicit memory, the young will benefit more from such surreptitious explicit retrieval. Thus, attempts to use such a strategy will result in an apparent—but illusory—age-related deficit in implicit memory. In other words, an effect that appears to be an age-related deficit in implicit memory actually may be a side-effect of an age-related deficit in explicit memory.

Contamination from explicit retrieval processes can be ruled out experimentally by producing dissociations between implicit and explicit memory under conditions in which the cues provided to subjects on the two tests are held constant and only test instructions (i.e., implicit or explicit) are varied (Schacter, Bowers, & Booker, 1989). This type of dissociation has been produced in young subjects by showing differential effects of experimental variables on implicit and explicit tasks in which the same nominal cues are used (e.g., Graf & Mandler, 1984; Graf & Schacter, 1987,1989; Hayman & Tulving, 1989; Jacoby & Dallas, 1981; Musen & Treisman, 1990; Schacter, Cooper, & Delaney, 1990; Schacter & Graf, 1986a). Unfortunately, experiments showing apparent priming deficits in the elderly have not provided dissociations of this kind, so explicit contamination effects cannot be ruled out. A demonstration is needed that, for young and old alike, performance on an explicit memory task is affected by variables such as encoding activity whereas performance on a parallel implicit memory task is not. Better yet would be a demonstration that for both age groups, performance on an explicit task is affected by one experimental variable whereas performance on an implicit task is affected by another. Demonstrations of impaired priming in the elderly are largely uninterpretable unless the experiment also contains evidence of such single or double dissociations.

Nearly all the evidence on implicit memory and aging derives from studies that have used verbal materials—familiar words, word pairs, and the like. We are aware of only two exceptions: the studies by Mitchell and Brown and their colleagues on priming of picture naming (Mitchell 1989; Mitchell et al., 1990) and research by Howard et al. (1993) on learning of nonverbal serial patterns. Interestingly, elderly adults showed normal implicit memory in both paradigms, suggesting that the variable results in other studies may, at least in part, reflect idiosyncratic properties of verbal materials. In view of these results, as well as the need to expand the range of research on implicit memory and cognitive aging, studies in our laboratory have begun to examine priming of nonverbal information in elderly adults.

Object Decision Priming in the Elderly

Our studies on priming of nonverbal information in elderly adults (Schacter, Cooper, & Valdiserri, 1992) have made use of a paradigm that has been developed and explored extensively in young subjects by Schacter and Cooper and their colleagues (Cooper, Schacter, Ballesteros, & Moore, 1992; Schacter, Cooper, & Delaney, 1990; Schacter, Cooper, Delaney, Peterson, & Tharan, 1991; Schacter, Cooper, Tharan, & Rubens, 1991). The paradigm involves study and testing of drawings of objects such as those presented in Figure 1. All the drawings depict novel unfamiliar objects that do not actually exist in the three-dimensional world. Half the objects are structurally possible, that is, they actually could exist in three-dimensional form. The other half are structurally impossible, that is, they contain ambiguous lines and planes that would prevent them from existing in three-dimensional form.

Subjects initially study both possible and impossible objects by performing an encoding task that focuses attention on a particular object property, such as global shape or local features. After a retention interval that is typically on the order of several minutes, explicit memory and implicit memory are tested. Explicit memory is assessed with a standard yes/no recognition task in which subjects indicate whether or not they remember having studied old and new objects. To assess implicit memory, an object decision task was developed. Previously studied drawings and nonstudied drawings are presented briefly on a computer screen; subjects decide whether each drawing is structurally possible or impossible. Note that no reference is made to the prior study episode, and that making an object decision does not require recollection of the episode. However, making the object decision does require access to information about the global three-dimensional structure of each object (Schacter et al., 1990). Thus, if subjects acquire information about global object structure during the study episode, they should make more accurate object decisions about studied objects than about nonstudied objects. Such a priming effect would constitute evidence of implicit memory for novel visual objects.

Experiments with college students have yielded a number of relevant findings (see Cooper et al., 1992; Schacter et al., 1990, 1991a). First, consistent evidence

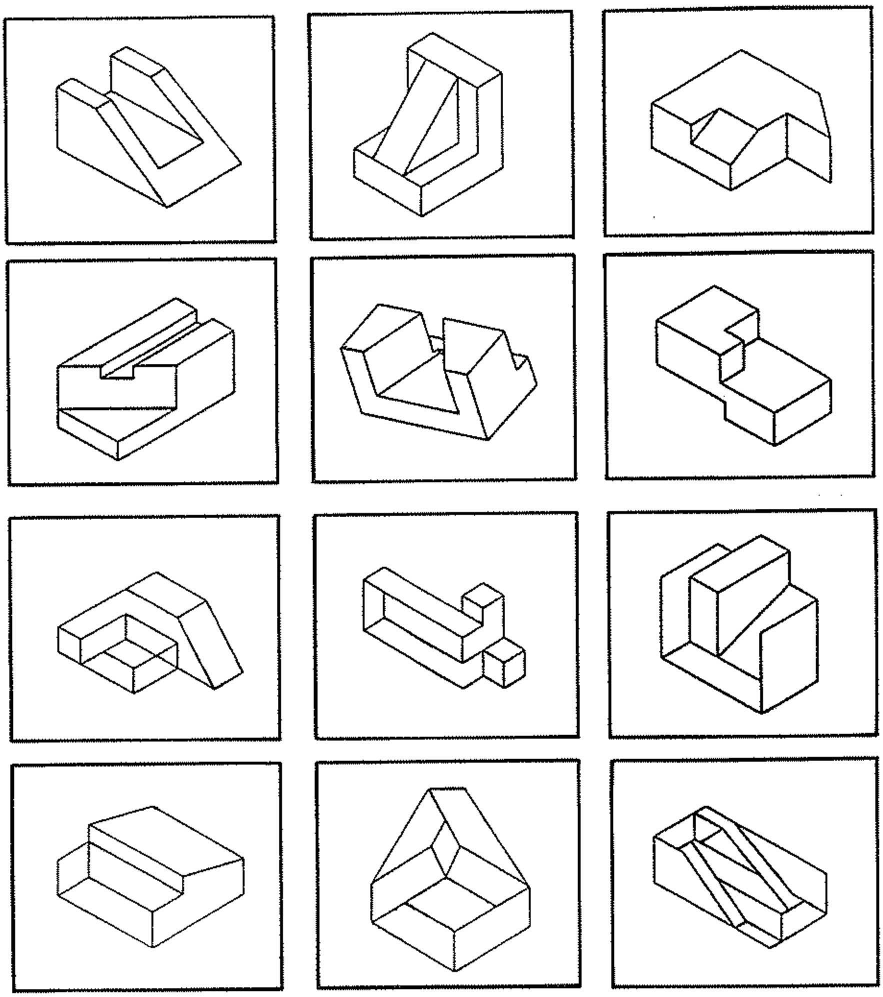

FIGURE 1

Examples of target materials used in object decision experiments with old and young subjects. The drawings in the upper two rows depict structurally *possible* objects: The drawings in the lower two rows depict structurally *impossible* objects. On the object decision task, subjects attempt to determine whether briefly flashed drawings represent possible or impossible objects.

of priming has been observed on the object decision task, but only for possible objects. Little or no evidence exists for priming of impossible objects across a range of experimental conditions. Second, priming of possible objects is observed after encoding tasks that require processing of global object structure (e.g., judging whether an object faces primarily to the left or to the right), but not after encoding tasks that require processing of local object features (e.g., judging whether an object has more horizontal or more vertical lines). Third, whereas explicit memory is enhanced greatly by encoding tasks that require semantic or elaborative processing, object decision priming does not increase and even may be reduced after semantic encoding relative to structural encoding. Fourth, study-list repetitions of an object (beyond an initial presentation) do not increase the magnitude of priming although they do increase recognition memory. Fifth, study-test changes in the size and mirror reflection of targets that impair recognition memory significantly have little or no effect on the magnitude of priming. Finally, two studies have documented that patients with organic memory disorders show intact object decision priming despite impaired recognition memory (Schacter et al., 1991b; Schacter, Cooper, & Treadwell, in press).

This overall pattern of results suggests that object decision priming is mediated by a presemantic representation of global object structure that is both size and reflection invariant—a structural description (e.g., Marr, 1982; Sutherland, 1968) of relationships among object parts. Based on a variety of considerations, Schacter et al. (1990,1991b) argued further that priming is handled by a structural description system—a subsystem of a more general perceptual representation system (Schacter, 1990; Tulving & Schacter, 1990) that is specialized for handling information about the form and structure of words and objects, and that can function independently of episodic memory.

In view of the foregoing considerations, attempting to determine whether object decision priming is spared in elderly adults is of considerable interest. If such priming is spared, it would suggest that aging does not impair the capacity of the structural description system to form representations of novel objects. In this regard, it is important to note that nearly all studies of implicit memory in the elderly have examined priming of familiar materials with pre-existing memory representations such as words or pictures of common objects. Accordingly, to the extent that intact implicit memory is observed in the elderly, "sparing" could be attributed to the automatic activation of pre-existing memory representations (e.g., Graf & Mandler, 1984). The difference between the activation of old knowledge and the formation of new representations is a major issue in the study of implicit memory. Consider, for example, an experiment in which subjects study pairs of highly associated items, such as TABLE–CHAIR. Later, they are presented with the first word, TABLE, and asked to report the first word that comes to mind. Priming is evidenced by a tendency to produce CHAIR relative to control subjects who did not study the list of pairs. Of course, these words are linked already in semantic memory. Thus, in this case, implicit memory is attributable to the activation of pre-existing knowledge. Consider another experiment in which subjects study lists of unassociated pairs, such as WINDOW–SALT. If a subject now gives SALT as the first word that comes to mind when cued with WINDOW, this priming effect must reflect the formation of a novel association between these words that did not exist previously.

Whereas most early demonstrations of implicit memory could be interpreted in terms of the activation or strengthening of pre-existing associations, examples of implicit memory for new associations now exist as well (e.g., Graf & Schacter, 1985; Moscovitch, Winocur, & McLachlan, 1986; Schacter & Graf, 1986a). However, the two forms of implicit memory appear to be somewhat different because they are obtained under different conditions. Thus, amnesic patients typically show normal priming of old pre-existing associations, but the evidence for priming of new associations is more variable (cf. Schacter & Graf, 1986b; Shimamura & Squire, 1989). In normal subjects, priming of old associations occurs relatively independently of encoding activities, whereas priming of new associations requires some degree of elaborative activity during the study phase (e.g., Graf & Schacter, 1985).

As yet, little evidence shows spared implicit memory for novel information or new associations in the elderly. Research by Howard and associates has documented intact learning of a novel nonverbal pattern across numerous trials (Howard & Howard, 1989; cf. Nissen & Bullemer, 1987) and also has demonstrated spared priming of newly acquired verbal associations under some conditions and impaired priming of new associations under other conditions (Howard et al., 1991; cf. Graf & Schacter, 1985; Schacter & Graf, 1986b). Thus, additional data are needed to determine whether priming in the elderly involves more than just activation of pre-existing representations. The object decision paradigm provides a useful vehicle for gathering such data because the target possible and impossible objects have no pre-existing memory representations.

To investigate these issues, we compared performance in a group of healthy community-dwelling elderly subjects with that of college students (details on subjects, materials, and procedures are provided in Schacter et al., 1992). All subjects initially performed a global encoding task, used in numerous previous experiments, that involves judging whether each object faces primarily to the left or to the right. After completing this task, half the subjects performed the object decision task and half performed a yes/no recognition task. On the former task, studied and nonstudied possible and impossible objects were flashed for 100 msec on a computer monitor and subjects made an object decision for each drawing; on the latter task, subjects were shown the same objects and indicated whether or not they remembered having seen them during the encoding task. Subjects who were given the recognition task were, in addition, given an object decision task immediately after the conclusion of recognition testing. Subjects who were given the object decision task first were, in addition, given a recognition task immediately after the conclusion of object decision testing.

A summary of the main results of the two tasks is presented in Figures 2 and 3. The data are collapsed across subjects who received the object decision test first and subjects who received the recognition test first because similar patterns of results were observed across the two conditions in both young and old subjects. Consider first the object decision data (Figure 2). The most important result

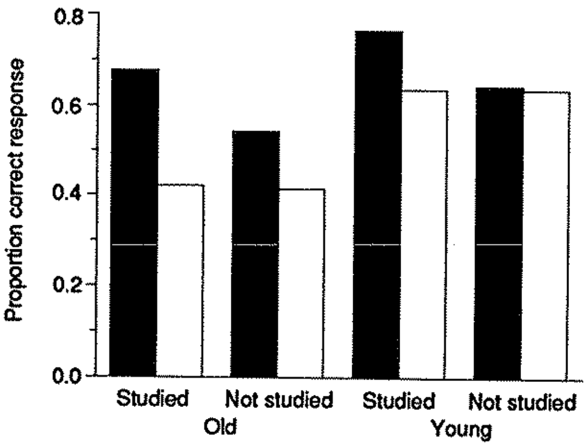

FIGURE 2

Proportion of correct responses to studied and not studied items on the object decision task for old and young subjects. Studied items were presented several minutes prior to the object decision task, whereas not studied items appeared for the first time on the object decision task. Priming is indicated by more accurate object decision performance for studied than not studied items. Both old and young subjects showed priming for structurally possible objects (solid bars) and no priming for structurally impossible objects (open bars).

is that the elderly, like the young, showed priming for possible objects and no priming for impossible objects. The overall magnitude of the priming effect was virtually identical in the two groups. Interestingly, the object decision task was clearly more difficult for the old than for the young. Overall baseline object decision accuracy for nonstudied items, collapsed across possible and impossible objects, was 48% correct in elderly subjects and 64% correct in young subjects. Moreover, the elderly exhibited a curious pattern of response distributions. They tended to use the "possible" response much more frequently than the "impossible" response even for nonstudied items, as indicated by higher baseline accuracy for possible than impossible objects. (A similar trend was observed for studied objects, but this result is partly attributable to priming of possible but not impossible objects.) Young subjects, in contrast, showed a nearly equal division of "possible" and "impossible" responses for nonstudied items, as indicated by the equivalent baseline rates. Although the reasons for the unusual response distribution of the elderly are not entirely clear, in a follow-up experiment using a longer object decision exposure time (250 msec), the elderly showed a more typical response distribution and, once again, displayed intact priming (Schacter, et al., 1992).

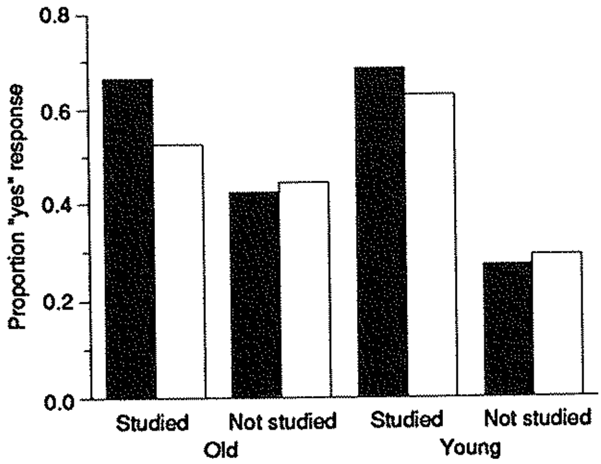

FIGURE 3

Proportion of "yes" responses to studied and not studied items on the recognition task by old and young subjects. A "yes" response to a previously studied item indicates correct recognition (i.e., a "hit"); a "yes" response to a not studied item indicates false recognition (i.e., a "false alarm"). Recognition accuracy is indicated by subtracting false alarms from hits. Elderly subjects showed less accurate recognition memory for both possible (solid bars) and impossible (open bars) objects than did young subjects.

In contrast to their normal levels of implicit memory, the explicit memory of old subjects was impaired relative to that of the young, as indicated by lower recognition accuracy (Figure 3). Corrected recognition scores (i.e., hits minus false alarms) were significantly lower in old than in young individuals for possible and impossible objects, although the elderly, like the young, showed higher recognition memory for possible than impossible objects. For possible objects, old subjects actually attained a hit rate comparable to that of the young (.66 vs. .68), but this success was accompanied by a much higher false alarm rate in the elderly (.42 vs .27), indicating impaired recognition accuracy in the elderly as well as a looser criterion to respond "yes" to old and new items.

Overall, results indicate that implicit memory for novel objects is spared in the elderly despite impaired explicit memory for the same objects. Note that intact priming was observed despite the fact that the object decision task was quite difficult for the old subjects to perform, as indicated by their chance levels of object decision accuracy for nonstudied items. The elderly have been suggested to show preserved priming effects because implicit tasks are typically "easier", or less effort demanding, than explicit tasks (e.g., Craik, 1983). Such an account cannot accommodate our current results easily.

The fact that old subjects had difficulty performing the object decision task is, perhaps, not surprising because the task involves extremely brief presentation of target objects; elderly subjects typically are characterized by slowed information processing (e.g., Cerella, 1985; Salthouse, 1985). Moreover, studies of perceptual function in the elderly suggest that they have problems processing three-dimensional aspects of object stimuli (e.g., Cerella, Milberg, & Plude, 1991); this difficulty may have contributed to, and been reflected by, the low level of object decision baseline performance in the elderly. Despite these difficulties, however, old subjects did show normal priming of possible objects.

In the context of the ideas discussed earlier, these data suggest that the elderly can form and retain normal structural descriptions of novel objects. However, in view of their documented problems processing three-dimensional aspects of objects (e.g., Cerella et al., 1991), conceivably the structural descriptions that underlie object decision priming in the elderly are in some respects abnormal relative to the structural descriptions that underlie priming in the young. One way to test this idea would be to determine whether priming in the elderly is invariant across study-test changes in object size and mirror reflection, as has been observed in the young (Cooper et al., 1992). If priming in the elderly is diminished by such changes, the result would suggest that the structural descriptions of older adults may preserve more "literal" information about object form than those of the young, that is, the structural descriptions of the elderly may preserve size and reflection information (hence, changing these attributes reduces priming) whereas the structural descriptions that subserve object decision priming in the young may be based on more abstract information about structural relationships that are independent of actual size and reflection. On the other hand, the encoding task used in the object decision experiments conducted to date with the elderly (i.e., judging whether the object faces primarily to the left or to the right) conceivably constrains processing sufficiently that elderly subjects are guided to construct a structural description that is functionally indistinguishable from that of young subjects. If so, priming in the elderly should transfer normally across study-test changes in size and reflection.

Although additional studies of object priming in the elderly clearly are warranted and likely will be informative regardless of the results, the initial results summarized here provided compelling evidence that elderly adults can show priming for novel information that has no pre-existing memory representation. These findings complement and extend previous observations on implicit learning of novel nonverbal patterns (Howard & Howard, 1989) and priming of new associations (Howard et al., 1991) in the elderly and, thereby, extend the range of preserved learning abilities in older adults. Specifying additional manifestations of preserved implicit memory for novel objects in the elderly across different tasks, materials, and conditions would be of considerable empirical and theoretical interest.

II. Fact Memory and Source Memory

The studies considered in the previous section suggest that some implicit memory processes are spared in the elderly relative to explicit memory functions. As noted earlier, conceptually related lines of research have investigated whether different processes within the domain of explicit memory are affected differentially by cognitive aging (cf. Craik, 1977; Light, 1991). Some precedent for this concept was set by the studies by Schonfield, Rabinowitz, and others cited earlier that compared recall and recognition memory. This work was guided by various forms of a theory that memory retrieval is affected by two qualitatively different processes. In early versions (e.g., Anderson & Bower, 1972), these processes were described as generation and recognition; in later versions (e.g., Mandler, 1980), they were characterized as activation and retrieval of context. Recall requires both these processes, whereas recognition requires only one. Thus, the finding that recall is more impaired than recognition in the elderly suggested that an important locus of older adult retrieval problems was in the process of generating candidate items for subsequent recognition check or in the process of retrieving the context in which an item had been encoded previously. Because episodic memories are associated with the unique spatiotemporal contexts in which the events they represent occurred, distinguishing between two different aspects of explicit memory—the memory that an event occurred (or that a factual statement is true) and the memory for the circumstances under which that event occurred (or the factual knowledge that was acquired)—is sensible. To remember having heard Beethoven's Fifth Symphony is different from knowing when and where the performance occurred. Over the past several years, a growing number of studies has examined this issue of the relationship between fact memory—memory for items or facts acquired during a specific episode—and source memory—memory for the episodic circumstances under which the information was acquired.

Part of the impetus for this research has been provided by studies of hypnotized subjects and brain-damaged amnesic patients that have demonstrated that fact and source memory can be dissociated. For example, Evans and Thorn (1966) reported that subjects who had been given suggestions for hypnotic amnesia sometimes could retrieve some obscure facts that had been presented to them by an experimenter, but failed to recollect that the experimenter was the source of the facts. This phenomenon is referred to as source amnesia. In a study by Schacter, Harbluk, and McLachlan (1984), amnesic patients were told fictitious facts about well-known and unknown people by one of two experimental sources; memory for the facts and sources was tested after delays of several minutes. The critical finding was that amnesic patients showed significant source amnesia for correctly recalled facts, that is, they frequently failed to recollect that either of the experimenters had told them a retrieved fact (see also Shimamura & Squire, 1987). Note, however, that fact memory is by no means unimpaired in subjects who exhibit source amnesia. For example, in the study by Schacter and co-workers, amnesic patients showed considerably poorer fact recall than did control subjects, in addition to impaired source recall. Thus, the mere demonstration of source amnesia need not imply that fact memory is preserved relative to source memory. To address this question, Schacter and colleagues equated levels of fact recall in amnesics and controls by testing the latter group after a 1-week retention interval. Even under these conditions of matched fact recall, control subjects showed significantly less source amnesia than did the patient group. Thus, some basis exists for suggesting that fact memory is preserved relative to source memory in amnesic patients. However, the term "preserved fact memory" must be used in a very weak sense here, because both fact and source memory are seriously impaired in amnesics relative to control subjects.

A. Fact and Source Memory in the Elderly: A Brief Review

Motivated in part by the foregoing findings, studies exploring the relationship between fact and source memory in elderly adults have been reported. These investigations raise issues concerning the relationship between fact memory and source memory similar to those discussed earlier. The first direct investigation of the fact–source memory relationship in the elderly was reported by McIntyre and Craik (1987). In an initial experiment, subjects were presented initially with trivia questions about geography, history, and so forth. Questions were presented visually (on an overhead projector) or auditorily (read by the experimenter) for 10 sec; the correct answers were provided and subjects were asked to indicate whether they knew the answer (on the basis of pre-experimental knowledge). After a 1-week delay, target questions were presented with new questions; subjects attempted to recall the facts and were asked to indicate the source. Elderly subjects showed poorer source memory than did young subjects. However, whether source memory was impaired disproportionately relative to fact memory was not clear. Although old and young subjects recalled similar proportions of facts, McIntyre and Craik noted that their paradigm did not allow them to determine unambiguously whether fact recall was based on the study episode or on pre-experimental general knowledge. Subjects who thought they did not know a fact during the initial study session nevertheless might have retrieved that fact on the basis of pre-experimental knowledge during the test. Since elderly adults were presumably slower to retrieve facts initially, their fact recall scores were likely to be inflated more by this sort of fluctuation across tests than those of young subjects. Such a phenomenon also could have inflated estimates of source amnesia in the elderly. If subjects did retrieve some facts on the basis of pre-experimental knowledge during the test, they would have been correct to attribute those facts to a source outside the experiment.

To address this problem, McIntyre and Craik performed a second experiment using the materials (fictitious facts about well-known and unknown people) and experimental procedure (facts were presented by two different experimenters) of Schacter et al. (1984). Because the target materials were fictitious facts, subjects could not recall them on the basis of pre-experimental knowledge; both fact and source memory were based necessarily on information acquired during the experiment. McIntyre and Craik replicated their initial finding of significant source memory deficits in the elderly. However, they also found that fact memory of older subjects was significantly worse than that of young subjects. Thus, these experiments do not provide compelling evidence that fact memory is preserved relative to source memory. Some evidence consistent with this possibility was provided in a follow-up study by Craik et al. (1990), who reported that degree of source amnesia in the elderly correlates with performance on tasks sensitive to frontal lobe pathology (cf. Schacter, 1987b; Schacter et al., 1984), whereas level of fact recall does not correlate significantly with performance on frontal-sensitive tasks. However, this evidence is both indirect and correlational, and hence can be considered, at best, suggestive.

Further relevant data are found in a study by Janowsky, Shimamura, and Squire (1989). Although their study focused on source memory in patients with frontal lobe lesions, these researchers included groups of old and young control subjects. Using a paradigm similar to the one developed by Schacter et al. (1984) with a 1-week retention interval, the first experiment by Janowsky and colleagues revealed no significant differences between old and young subjects in either fact recall or source recall. However, these results probably should not be considered evidence of preserved memory functions in the elderly because (1) relatively few subjects participated in the study (9 old and 7 young), thereby raising concerns about statistical power, and (2) the age differences between the "young" (mean age = 49.4 yrs.) and "old" (mean age = 63.9 yrs.) individuals were not large. A second experiment using retention intervals of 5 min and 2 hr yielded equivocal results with respect to the normal elderly subjects. An overall trend was for lower fact memory and lower source memory in the old subjects relative to the young subjects. The authors did not report a statistical test of young–old differences in fact memory at either delay; source memory was significantly lower in old subjects than in young subjects at the 5 min delay but was not significantly lower at the 2 hr delay.

The data from the foregoing studies, then, do not indicate unambiguously whether fact memory is any less impaired than source memory in the elderly. Evidence for source memory deficits also has been reported in studies using reality monitoring paradigms (Johnson & Raye, 1981) in which old and young subjects decide whether various input events had been observed, imagined, or acted (cf. Cohen & Faulkner, 1989; Hashtroudi, Johnson & Chrosniak, 1989; Rabinowitz, 1989). However, as Schacter, Kaszniak, Kihlstrom, & Valdiserri (1991) point out, whether source memory is more impaired than memory for target items or actions is not entirely clear from these studies (see also Dywan & Jacoby, 1990).

B. Investigating Fact and Source Memory with Multiple Matching Points

As indicated by the foregoing discussion, simply demonstrating that elderly adults show lower source recall than do young individuals is not sufficient to provide evidence for disproportionate impairment of source memory or, correspondingly, for relative preservation of fact memory, because fact memory deficits are observed typically. As noted earlier, one strategy that has been adopted to address the same problem in the amnesia literature is to match levels of fact recall in amnesic patients and control subjects, and subsequently show that patients still exhibit deficits of source recall (cf. Schacter et al., 1984; Shimamura & Squire, 1987).

Although use of the matching strategy employed in the amnesia literature may bring us closer to understanding the relationship between fact and source memory in the elderly, this approach is not without problems. One major difficulty arises from the fact that performance typically is equated at only a single point (Schacter et al., 1991d). Thus, although source memory might be impaired in the old relative to the young, when fact recall of the two groups is equated at a particular level of performance, the possibility exists that a different result would be observed if fact recall were equated at a different performance level. To obtain a more adequate picture of the relationship between source and fact memory, performance must be matched at multiple points and whether the same pattern of relationship between fact and source memory holds at each matching point must be determined.

We performed a study of fact and source memory in old and young subjects that incorporates the multiple matching point strategy (Schacter et al., 1991d). Specifically, we investigated memory for facts and sources in an experiment that allowed for the orthogonal combination of two different encoding conditions and two different retention intervals, thus yielding four different matching points. The basic experiment made use of a modified version of the procedure employed by Schacter et al. (1984) and McIntyre and Craik (1987). Subjects were read a long list of fictitious facts by each of two experimental sources (one male, one female) who were seated side-by-side and appeared on a videotape. The two encoding conditions were defined by the manner in which the study list was organized with respect to source: in the random condition, the order in which the two sources read the target facts was determined randomly with the constraint that neither source read more than three facts consecutively; in the *blocked* condition, blocks of facts were read by each source in accordance with an ABAB scheme. In addition to providing multiple points at which to match fact recall in old and young, the main purpose of the blocking manipulation was to determine whether contextual organization improves source recall in either old or young. Although the idea is well-established that organizing a list according to conceptual categories improves recall of target words (e.g., Mandler, 1969; Tulving, 1962); nothing is known about effects of contextual organization on either fact or source recall.

In the main experiment, subjects were tested for fact and source recall after delays of 2 min and 2 hr. The expectation was that older adults would recall fewer facts than the young, and that additional subjects would have to be run under different experimental conditions to equate levels of fact recall in the two age groups. To accomplish this objective, we provided a new group of elderly adults with additional study-list presentations so their level of fact recall was indistinguishable from that of the young. (For details on the matching procedure and other aspects of subjects, design, and procedure, see Schacter et al., 1991d.)

Results from the main experiment are presented in Table 1. Consider first the data on fact recall. As expected, young subjects recalled significantly more facts at both delays than did the old in the random condition. Surprisingly, however, no difference existed between the two groups in the blocked condition. The elderly recalled nonsignificantly more facts than did the young at both delays. Thus, fact recall of old and young in the blocked condition was matched "naturally" at two different levels of performance. Nevertheless, as indicated by the source recall data in Table 1, elderly adults recalled significantly fewer sources than did the young at both retention intervals in the blocked condition. Accordingly, the results from the blocked condition suggest that fact recall is preserved relative to source recall in the elderly.

The elderly also exhibited lower source recall than did the young in the random condition (Table 1). However, because the fact recall of the elderly was impaired as well in this condition, additional elderly subjects were tested under conditions in which their fact recall performance matched that of young subjects, by giving them four presentations in the study list. As indicated by Table 2, source recall by the elderly in this matching group did not differ from source recall in the young (Table 1).

The pattern of results achieved raises a number of issues with respect to understanding preserved memory function in elderly adults. First, the finding that older subjects showed entirely normal levels of fact recall at both delays in the blocked condition—in contrast to their impaired performance in the random condition—is quite surprising. Although it is known that recognition memory can, under some circumstances, be reasonably well preserved in the elderly (cf., Burke & Light, 1981; Craik, 1977; Schacter et al., 1991c), we do not know of any prior finding of normal recall of novel facts. Thus, this result suggests the presence of aspects of explicit memory function in the elderly that are preserved more fully than previously suspected. Of course, the reliability of our findings needs to be established by replication and extension before too many conclusions can be drawn. Moreover, why fact recall but not source recall in old subjects (but not in young subjects) benefits from blocking a list according to source is not at all clear. We have considered a number of alternative possi-

TABLE 1
Proportions of Facts and Sources Recalled by Old and Young Subjects as a Function of Encoding Condition and Retention Interval

		Encoding condition and retention interval					
		Blocked			Random		
Subject group	Item type	2 min	2 hr	M	2 min	2 hr	M
Old	Fact	.84	.75	.80	.65	.53	.59
	Source	.65	.57	.61	.66	.52	.59
Young	Fact	.80	.70	.75	.82	.74	.78
	Source	.75	.65	.70	.75	.69	.72

bilities, none of which is entirely satisfactory (see Schacter et al., 1991d). Understanding the nature of this phenomenon clearly will require additional analytic experiments.

Whatever the reason for the apparently normal levels of fact recall in the blocked condition, our results do have relatively direct implications for studies on the relative preservation and impairment of specific memory processes in aging. Matching performance of old and young on task *X* at a single point to assess whether performance on task *Y* is differentially impaired is not sufficient. Had we considered only the data from the blocked condition, we would have been led to conclude that source recall is impaired disproportionately in the elderly. Had we considered only the data from the random condition, we would have been led to conclude that source recall is no more impaired than fact recall. Inspection of the overall pattern of results, however, suggests a more complex state of affairs: the relationship between fact and source recall may vary across conditions. As we have pointed out elsewhere (Schacter et al., 1991d), such a variable relationship necessarily implies some degree of relative preservation of fact recall and impairment of source recall. If no disproportionate source memory deficit exists in the elderly, then differential deficits of the kind that we observed in the blocked condition should not be found at all. However, to the extent that a disproportionate source memory deficit does exist, the data from the random condition suggest that the impairment is neither general nor across-the board. Attempting to account for such an outcome is no doubt going to be difficult, but the critical strategic point is that the seemingly paradoxical unexplained pattern of results would not have been uncovered without the use of multiple matching points.

TABLE 2
Proportion of Facts and Sources Recalled by Old Subjects Following Four Exposures to the Random List as a Function of Retention Interval

Item type	Retention interval		
	2 min	2 hr	M
Fact	.83	.78	.80
Source	.82	.73	.77

III. Concluding Comments

As noted by Hultsch and Dixon (1990), a major theme in research on aging memory is an interest in determining those memory systems that show changes with age as opposed to those that do not. In earlier studies, this theme was explored in comparisons of age-related declines in primary versus secondary memory or episodic versus semantic memory. This research has continued, especially with regard to the episodic–semantic distinction, and has been joined by two additional trends concerned with explicit–implicit and fact–source differences.

These two bodies of literature are relatively new, and a completely coherent pattern has yet to emerge. The available evidence indicates that recall of new facts, although not fully intact, is relatively preserved in the elderly under some conditions whereas recall of source is relatively impaired under some conditions. However, this comparison has been made under only a limited set of experimental conditions and must remain tentative. Research on explicit and implicit memory is further advanced and correspondingly more complex. Studies of implicit memory for nonverbal information have shown clearly that older adults have a preserved ability to form and retain structural descriptions of novel objects, as evidenced by their demonstration of priming effects on an object decision task. However, conceptually similar studies with lexical decision priming paradigms have yielded inconsistent results (cf. Graf, 1990; Light, 1991). Part of the problem may reflect contamination of nominally implicit tasks by explicit memory. However, part of the problem may lie in differences between perceptual and linguistic memory representations.

Despite these somewhat puzzling inconsistencies, research on preserved memory functioning will continue to be a major theme in the study of aging memory. Difficult methodological and theoretical issues remain to be resolved;

there is no reason to think that these resolutions will come easily. On the other hand, this research holds the promise of both enhancing our understanding of the complex interrelationships among various forms of memory and providing an empirical foundation on which the practical problems of aging memory can be addressed.

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ADULT INFORMATION PROCESSING: LIMITS ON LOSS

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