LANGUAGE, MEMORY, AND AGING

Edited by Leah L. Light & Deborah M. Burke

Language, memory, and aging

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Preface

Recent years have seen an upsurge of interest in the psychology of aging, particularly in the area of cognition and aging. Much of the experimental research on cognitive aging has dealt with memory, perhaps because of older adults' proverbial complaints about their memory problems. Relatively little has been published on language in the elderly. However, the overlap in mental operations involved in memory and in language has become clear as cognitive psychologists focus on memory for complex linguistic materials such as texts, and as they develop models of natural language comprehension and production. Within the aging literature, there are findings that implicate age-related changes in language as the source of impairment in other cognitive domains, specifically memory. It has been hypothesized that older adults have decreased ability to understand language and that this deficit in semantic processing is a cause of age-related differences in memory for new information. On the other hand, it has also been hypothesized that memory deficits in old age impair language comprehension and production.

The goals of this book are twofold, to review selected aspects of research on language in old age and to consider the relation between language and memory in old age. Many of us who have contributed to the book come to the study of language after years of research on memory and aging. This fact has influenced our choice of topics. Our emphasis is on those aspects of language that are important for understanding memory in old age and on those aspects of memory that are most heavily involved in language. Thus, we do not offer complete coverage of either memory or language in old age. The reader interested in further discussion of memory and aging should see Craik and Trehub (1982), Kausler (1982), Poon, Fozard, Cermak, Arenberg, and Thompson (1980), and Salthouse (1982). Bergman (1980) offers a thorough treatment of speech perception in old age. Bayles and Kaszniak (1987), Obler and Albert (1980), Beasley and Davis (1981), Hooper and Dunkle (1984), and Ulatowska (1985) discuss a range of topics in normal and pathological language in old age.

The individual chapters in this volume present research involving a range of methodologies, including psychometric and neurolinguistic tests and experimental measures, which isolate specific aspects of language comprehension, production, and memory. The studies compare young and older adults (including both normal and pathological populations), using both between-groups and individual-differences approaches. The theoretical perspectives represented in the volume are drawn from major contemporary models in cognitive psychology, and the issues raised reflect current issues in cognition, such as the role of awareness in memory and language, the relation between semantic and episodic memory, the distinction between automatic and attentional processes, and the usefulness of the levels of processing approach.

The opening chapter, by Klatzky, provides a framework for the issues raised in subsequent chapters by giving an overview of relevant paradigms in contemporary cognitive psychology. The next three chapters deal with individual differences in verbal ability in normal aging. Salthouse reviews literature from psychometric tests and identifies processes and mechanisms underlying age-related changes in verbal ability. Hartley discusses components of verbal ability underlying text memory and presents her research using a factor-analytic approach to determine whether a unique set of verbal skills predicts memory at different ages. Kemper considers the role of memory limitations in syntactic processes involved in language comprehension and production in old age.

The next two chapters deal with automatic and effortful aspects of activation of word meanings. Howard reports studies of semantic and episodic priming that reveal age differences and similarities in the representation of information in memory and that raise the possibility that there are age differences in deliberate recollection but not in memory without awareness. Burke and Harrold evaluate the role of automatic and effortful components of semantic activation in language comprehension and retention and provide evidence for disruption of automatic word retrieval processes in old age.

The next three chapters focus on age-related changes in inferential processes involved in comprehension and memory. Zelinski examines integration processes important for discourse comprehension and reports her research on the role of prior knowledge in discourse level and sentence level comprehension processes. Light and Albertson report research which demonstrates that older adults do not experience problems in drawing inferences except in situations involving heavy demands on working memory and that comprehension problems are themselves due in part to more general memory deficits. Zacks and Hasher present a new version of their processing resource model designed to explain comprehension and memory for discourse and apply it to their research on age declines in drawing inferences from text.

The two chapters that follow present overviews of research on interactions between language and memory and frameworks for understanding age differences. Cohen presents a review of studies, mainly from her own laboratory, which suggests that limitations in processing resources underlie impairments in many linguistic processes. This theme is also taken up by Gillund and Perlmutter, who argue that prior knowledge compensates for reduced processing resources in tasks involving memory.

The penultimate two chapters compare language impairment in normal and pathological aging. Huff reviews evidence from his own and others' research suggesting that impaired naming ability in Alzheimer's disease is largely determined by a semantic deficit. Emery describes her research involving a set of neurolinguistic tests that demonstrates patterns of language impairment in both normal aging and Alzheimer's disease that are unlike those found in aphasia.

In the final chapter, we discuss themes that emerge from a reading of the earlier chapters. In particular, we consider the contributions of different approaches represented in the book to our understanding of patterns of spared and impaired functioning of language and memory in old age.

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Contents

1 Theories of information processing and theories of aging

Roberta L. Klatzky

The goal of the present chapter is truly introductory. In it, I attempt to provide a theoretical context for the chapters that follow and to raise some general issues. The chapter first outlines a "modal model" of human information processing, particularly that related to memory and language. It then assesses weak and strong contributions that the information-processing approach could make to research on aging.

The modal model

Some 20 years ago, Murdock (1967) used the term "modal model" to describe the then dominant two-store conception of human memory. An important assumption of this model was that there existed two discrete functional units in the memory system, one for active storage and rehearsal of a limited amount of information (short-term memory), the other a more temporally extended, capacious repository of knowledge (long-term memory). This modal model has come under intensive fire, both for its limited perspective on what memory is, and for its rigid partitioning of the memory system. Nonetheless, the fundamental distinction of the model has persisted, in various forms.

In general, human information-processing theory provides two types of description: *Structural* descriptions pertain to the data stored in memory – both the functional components in which they reside, and the nature of the data themselves. *Processing* descriptions pertain to the use of those data – the states they may enter and the transitions between different data representations and stores. Any account of a behavioral phenomenon in information-processing terms must make assumptions about both structures and processes.

In the section that follows, I assume the reader has a general familiarity with cognitive psychology, so that the purpose of this description is primarily to organize theoretical ideas. The discussion considers first the current "modal" model's assumptions about the structural architecture of the system, and then its basic processes.

Structural assumptions

Models of human memory postulate internal structures for representing data – for example, data about the external world, abstractions, or internal states. We can subdivide structural assumptions according to whether they describe the system components in which data resides – the memory stores – or the data themselves. The first type of assumption is exemplified by the early modal model's distinction between short-term and long-term stores. The second type of assumption, about the nature of the data, often takes the form of a binary contrast between data representations. These contrasts include semantic versus episodic, procedural versus declarative, networks versus production systems, propositional versus analogue, lexical versus conceptual, sensorimotor versus cognitive, and more. Only some of these distinctions are relevant to the present chapter, fortunately. The following sections describe assumptions about memory stores and distinctions between types of data representations.

The short-term/long-term assumption, revisited. Early two-store theories of memory were concerned primarily with verbal stimuli. Accordingly, short-term memory was conceived of as a limited set of acoustic/articulatory elements that could be repetitively rehearsed, with each rehearsal incrementing the strength of a corresponding element in long-term memory.

The demise of a strict dichotomy between short- and long-term storage has been virtually complete. At least three major changes can be identified in theories of short-term memory since the late 1960s: (1) Current theory distinguishes among short-term storage systems for different information modalities, especially visual and verbal. (2) Within the verbal domain, there has been a transition from a strict storage-box model of short-term memory to a more complex, modular view that accommodates several different interacting units and a working-memory component. (3) The notion of rehearsal has been reworked, so as to distinguish between its maintenance and learning functions and to relate the learning function to more general theories of encoding.

The first of these changes, modality-specific, short-term memories, was intertwined with theoretical developments in the area of visual imagery. Discussion of these developments would bring in issues that are largely irrelevant to this volume. Kosslyn (1980) has presented a well-developed model of a system for storing and actively processing visual images.

The second type of change, to a multimodule verbal short-term memory with both storage and working functions, is best exemplified by Baddeley's research program. In a fairly recent version (Vallar & Baddeley, 1984), Baddeley describes short-term memory for verbal stimuli as incorporating an auditory/phonological store, an articulatory process, a graphemic (visual) store, and an executive or "working" component. All of these are needed to account for performance on the simple task of repeating back a short list of verbal items.

For example, the importance of the articulatory process is indicated by the finding that performance in a verbatim recall task of this type is inversely related to the pronunciation time for the verbal stimuli. An auditory store is needed to account for interference with the same task by unattended background verbalization. A visual store accounts for above-chance performance when verbal rehearsal is suppressed and for superior performance with visual presentation. The result, in Vallar and Baddeley's term, is a "fractionation" of short-term memory.

The executive component of this system is its controller, with the various stores serving as subsidiaries or "slaves." It is assumed (Baddeley, 1981) that the executive can itself store information as well as control processing. However, "offloading" of storage demands onto the subsidiary systems is needed because the executive has a limited capacity, much of which must be used for controlling the flow of information and performing processes such as reasoning and comprehension. The executive is therefore more like a resource pool than a storage location. Various processes compete for resources, and processing competes with storage, once the limits of the slave systems are exceeded.

Although the fractionated short-term store might be seen as a set of discrete substores, a more general assumption is that performance in a short-term retention task takes advantage of any transient activity in existing verbal representations (e.g., graphemic, lexical, auditory), using this activity to read out and recall. The fractions defined by Baddeley can be taken to reveal the types of representation that can be used in this manner.

Rehearsal has also come under scrutiny since the early duplex model. An important and convincing demonstration has been made by several parties (e.g., Glenberg, Smith, & Green, 1977) to the effect that mere rote repetition of items (essentially, Baddeley's articulatory process) does little to enhance ultimate recall, although it can maintain the items for immediate memory tests. Enhancement of later recall requires elaborative, not just maintenance, rehearsal. In other words, maintenance rehearsal suffices to serve the storage function of short-term memory, whereas elaborative rehearsal exemplifies its function as a "working" memory. Such rehearsal can come in a number of forms: associative chaining, chunking, and imagery, for example. An important distinction among elaborative rehearsal mechanisms has been made within the "levels of processing" theory (Craik & Lockhart, 1972), which stipulates that the more an event is meaningfully and distinctively elaborated, the better it will be remembered.

While short-term memory was undergoing substantial theoretical change, theories of long-term memory were also developing, influenced substantially by computer models of associative memory structures. Among the best known models of long-term memory are those of Collins and Loftus (1975), the UC San Diego group headed by Norman and Rumelhart (1975), and the ACT model of Anderson (1983). All proposed a memory structure in the form of an associative network, in which "nodes" are tied together with linking associations that are differentially weighted to express associative strength.

The associations in network models take specific relational forms. These forms vary from theory to theory, with the San Diegans favoring relations along the lines of case grammar (Fillmore, 1968), and the ACT model adopting a more simplified set. Using these relations in a particular combination allows the network to go beyond the expression of simple connections between knowledge elements. The most critical combination of relations is that which expresses a *proposition* – the internal counterpart of a fact. For example, in ACT, a proposition connects two nodes by a subject–predicate link.

The nodes in a network correspond to mental elements of some fundamental sort. These elements actually exist at several levels. A node might correspond to a single concept like *dog*, but it might also stand for a whole proposition (*My dog has fleas*) or an even larger interrelated structure that expresses a general knowledge framework, variously called a schema, script, or frame.

Before leaving the major structures of human information processing, I should give at least passing reference to a new wave of models that virtually eliminate distinctions of this sort – in fact, that make only minimal assumptions about memory structure (e.g., Grossberg & Stone, 1986; McClelland & Rumelhart, 1985). These "neural net" models adopt a network approach in which the elements and connections are modeled after neurons. Long-term memory, in such a system, is expressed by the weights on interneural links; short-term memory is expressed by a pattern of activation in the links (see below). One striking difference between these models and the networks described previously is that in the neural net, the representation of a given concept is distributed throughout the associative structure. There is no one node or location corresponding to a mental entity; rather, its representation is constituted by the weights within the entire net. As these change with exposure to new patterns, a concept's representation is constantly changing; thus this sort of system is ideally suited to describe such phenomena as categorical abstraction.

We turn now from major architectural structures to the forms of data represented in memory.

Semantic versus episodic data. The distinction between semantic and episodic knowledge was first suggested by Tulving (1972), in response to what he saw as a major shift in the nature of experimental work on memory. This shift was from list-learning procedures that tested autobiographical (episodic) knowledge about the occurrence of events (i.e., list items) in a particular context, to tests of general factual (semantic) knowledge. In fact, Tulving has suggested (1983) that we speak of "semantic memory" and "episodic memory," since the two types of knowledge appear to be formed and used in quite different ways, to have different retention parameters, and to have different degrees of affective association.

Procedural versus declarative knowledge. The distinction between procedural and declarative knowledge has been called one between knowing *how* and knowing *that*. In theory, procedural knowledge underlies people's ability to perform certain acts, or "procedures." The acts might be perceptual (reading a word), motoric (typing), or cognitive (solving equations). Declarative knowledge concerns facts, not acts. The term *declarative* suggests that it can be readily expressed in words. However, there are many procedures (e.g., driving a car) that can also be described verbally at some level, making them declarative, and there are other mental phenomena that are not verbally declarative but also not obviously procedural (e.g., mood states). Despite these blurred aspects of the distinction, it does seem to capture the fact that we can perform many acts – especially skilled ones – but cannot describe how we do so.

Lexical versus conceptual data. With some onomatopoetic exceptions, and Zipf's (1935) law (common concept = short word) notwithstanding, words are generally arbitrary symbols for corresponding concepts. This separation of sign and meaning is acknowledged in network models that place information about the orthographic, phonological, and syntactic properties of words in a "lexicon," distinct from the "concepticon" of semantic memory. This makes clear that there are multiple pathways to conceptual representations. There are distinct lexical pathways through different sensory channels, and there is also direct conceptual access (e.g., through objects) that may bypass the verbal system entirely. Of course, associative connections put the lexical and conceptual systems into direct communication.

Sensorimotor versus cognitive data. This distinction is motivated by the assumption that the processing system represents information at various levels. Information coming from the sense organs is progressively mapped or transformed. Sensory data are those that are achieved early in this sequence of processes. Similarly, motor data are representations that are achieved late in the stream of processing that ends with a motor output. They are commands to the motor system itself, rather than abstract plans or intentions. Cognitive data, in contrast, are not tied to actions or sensory events; they are the representation of more abstract thought. Sensorimotor data are generally placed at the bottom, and cognitive data at the top, in a hierarchical depiction of representations in the processing system, reflecting the assumption that higher-level abstractions subsume a variety of specific instances and their component features.

Process assumptions of the modal model

Any description of human cognitive behavior must adopt assumptions not only about the data structures, but also about the processes that operate on data. Process descriptions can be made at many levels, of course. The appropriate level of analysis depends on the behavior to be explained and the theory to be tested.

At a primitive level, a fundamental process is that of activation. Activation is a state of nodes in the network; it may be modeled as discrete or continuous. A discrete active/inactive distinction (or a cutoff value on continuous activation) is often functionally equated with short-term memory; that is, active elements in the network are equated with elements currently undergoing short-term storage.

When one node is active, its immediate associates are assumed to become active, and their associates in turn. Such a spread of activation between nodes is a theoretical mechanism to describe the retrieval of associated information. Empirical support for such a mechanism is ample. In a classic experiment, Meyer and Schvaneveldt (1976) demonstrated that deciding that a letter string (e.g., butter) is a word is speeded by prior presentation of a related word (e.g., bread). The initial word's activation is assumed to spread to the representations of related words, thus "priming" the second word and speeding its identification. However, estimates of the speed of activation spread indicate that it is virtually instantaneous (e.g., Ratcliff & McKoon, 1981); thus differences between activation spread over weak versus strong links have been attributed to the ultimate level attained rather than to the speed.

Activation not only spreads between concepts like bread and butter; it also travels between different levels of the system. For example, the perception of a printed word has been viewed as a spread of activation from units at the sensory level representing letter features, to letters, and finally to words, with the most active word being the recognized entity. In contrast to this "bottom-up" spread, there is "top-down" spread, which is initiated by activating a concept. For example, in reading *I put the butter on the. . .* , conceptual expectancies about *bread* might lead to the activation of the word, its letters, and their features.

There are a number of important processing distinctions to be made, including automatic versus attentional processing, on-line versus retroactive processing, encoding versus retrieval, retrieval versus decision, and, within language-related processes, decoding versus lexical access versus parsing versus derivation of propositions (involving anaphora and coreference) versus inference. I will deal with these briefly.

Automatic versus attentional processing. The roots of this distinction are in the domain of pattern recognition, where a long-recognized rule is that many incoming channels are ultimately reduced to one recognized channel. We can fully recognize information only from one region in space, one sensory modality, or one information source within a modality. More recent, and controversial, work suggests that many channels are deeply processed, and the limitation is not so much on depth of processing as on conscious access to the results of this processing (Marcel, 1983). In any case, the channel that has privileged access to overt report is called the attended channel.

A more general distinction that goes beyond the perceptual domain can be made between processes that are attention demanding and those that are automatic, or attention free (e.g., Schneider & Shiffrin, 1977). In these terms, conscious pattern recognition demands attention. Earlier stages of perceptual analysis, however, do not. Nor do many nonperceptual processes, apparently, especially those that have been extensively practiced. The criteria for deeming a process "automatic" include evidence that (1) it shows no decrement as it is applied to more and more information (no "workload effect"), (2) it does not interfere with other ongoing processes (no "dual-task interference"), and (3) it is unamenable to conscious intention or control.

The attentional/automatic distinction has been applied to learning as well as performance (Hasher & Zacks, 1979). Specifically, it is assumed that there are certain processes that lay down accessible traces in long-term memory, without demanding attention. Interestingly, rote rehearsal is *not* such a process: Naveh-Benjamin and Jonides (1984) have provided evidence that rote repetition is quickly automated (at which point it does not produce dual-task interference), and that automation coincides with the point at which further repetition produces no changes in memory performance. In contrast, the practices grouped under "elaborative" rehearsal do not become automatic; they consistently demand attention and pay off in retention. As a middle ground between these extremes, there is evidence for automatic processing that does produce accessible traces in memory. Encoding of information about frequency of repetition and modality of input are potential examples (Hasher & Zacks, 1979; Lehman, 1982; Zacks, Hasher, & Sanft, 1982), but there are also contradictory findings (Fisk & Schneider, 1984; Naveh-Benjamin & Jonides, 1986). (One caveat about such automatic learning: It does not mean acquiring information from entirely unattended channels, but rather, "effortless" and incidental learning of information on an attended channel.)

So general is the distinction between automatic and attentional processes that it might best be thought of as orthogonal to the other process distinctions below. That is, any process might, at least theoretically, be attentional or automatic, depending on the data being processed and the experience of the individual.

On-line versus retroactive processes. The term "on-line" derives from computer terminology, referring to events that go on without interruption or intervention from external sources. In reference to humans, on-line generally refers to here-and-now processing, rather than retrieval of the residue or traces of previous events. Actually, the term might better be applied to experimental techniques than to cognitive processing. Measures like eye-fixation time or target detection are on-line; measures of recall are not.

Remembering processes. Remembering is a general term for the retroactive process of uncovering the traces of previous events. A distinction is commonly made between encoding – experiencing the events in the first place, with concomitant rehearsal or automatic learning processes – and retrieval – getting at the residue. Both of these processes, in turn, have various subcomponents. Encoding often involves retrieving concepts and past experiences that are related to the current event. These are used to interpret and expand on the new experience (elaborative rehearsal) and thus influence its representation in memory. Retrieval includes cue encoding (making the context of retrieval into an effective probe of the memory store), search (through the network of associations), decision (editing information found through search), and response generation.

Retrieval may look very different, depending on the nature of the knowledge being retrieved. For example, episodic retrieval requires access to contextual information that specifies the episode of interest. Retrieval of semantic data is more context-free. Retrieval of declarative and procedural data also differ. Declarative data are evidenced in the form of some explicit statement about the contents of memory: I know these particular facts. Procedural data may be retrieved by reenactment, perhaps without conscious awareness of remembering (e.g., Graf, Mandler, & Haden, 1982).

Another variable aspect of retrieval is the extent to which associative search is needed (Mandler, 1980). Some retrieval cues – for example, printed words shown to skilled readers – provide relatively direct access to target nodes in memory. Indirect cues provide general access to memory, but not to specific target locations, necessitating more extensive search. The contrast between these cuing situations is exemplified in the difference between recognition and free recall tests of memory. Recall gives a general cue; recognition, a specific one. The attentional demands of these two retrieval tests are likely to differ considerably (but see Baddeley, Lewis, Eldridge, & Thomson, 1984).