

Is Memory Schematic?

Joseph W. Alba
University of Florida

Lynn Hasher
Temple University

This article proposes a prototypical schema theory of memory. Such a theory assumes the operation of four central encoding processes: selection—a process that chooses only some of all incoming stimuli for representation; abstraction—a process that stores the meaning of a message without reference to the original syntactic and lexical content; interpretation—a process by which relevant prior knowledge is generated to aid comprehension; and integration—a process by which a single, holistic memory representation is formed from the products of the previous three operations. The article evaluates the supportive and critical evidence for these processes in light of the need for any theory of memory to account for three fundamental observations: accuracy, incompleteness, and distortion. The central retrieval process of schema theory, reconstruction, is also discussed in this context. Evidence seems to indicate that the memory representation is far richer and detailed than schema theory would suggest.

The scientific literature on memory confirms the everyday observation that although one's memory for complex events is sometimes startlingly accurate, it is also frequently incomplete and occasionally even highly distorted. Accounting for these observations poses the fundamental problem for any theory of memory. For the past 15 years, the most popular theories (called collectively *schema* theories) have been descendants of a view that emphasized the incompleteness and distortions characteristic of memory. This viewpoint was originally proposed by Bartlett (1932) to account for recall of complex stories. Lineal descendants of the theory largely share Bartlett's rejection of the notion that memory representations consist of accurate traces that are stable over long durations. Current proponents of this rejected viewpoint emphasize the potential accuracy of memory; incompleteness in recall is attributed to retrieval failure, distortions to associative encoding processes. In contrast, current schema theorists propose that what

is encoded, or stored in memory, is heavily determined by a guiding schema or knowledge framework that selects and actively modifies experience in order to arrive at a coherent, unified, expectation-confirming and knowledge-consistent representation of an experience. Such theories necessarily place emphasis on the incompleteness and inaccuracy of memory, although they can account for accuracy as well. The concern with inaccuracy and distortion rather than with accuracy has made these theories especially attractive in fields such as clinical, forensic, educational, developmental, and social psychology (e.g., Ausubel, 1968; Greenwald, 1980; Loftus, 1979a; Paris & Lindauer, 1977; Taylor & Crocker, 1981).

Although schema theories either guide or are used to explain a considerable portion of current research in human memory, it is widely agreed (e.g., Brewer & Treyens, 1981; Taylor & Crocker, 1981) that the term *schema* has no fixed definition. It is most often used to refer to the general knowledge a person possesses about a particular domain. A schema allows for the encoding, storage, and retrieval of information related to that domain. Beyond this, however, there are few systematic, contemporary explications of schema theory.

Two exceptions to this question are notable: frame theory and script theory. A frame (Minsky, 1975) is a schema that contain

We thank Robert Weisberg, Eugene Zechmeister, Michael McCloskey, and especially Rose Zacks for many helpful comments; their contributions to this article were extremely important. Preparation of this manuscript was supported by NIMH Grant MH33140 and in part by a Biomedical Sciences Research grant to Temple University.

Requests for reprints should be sent to Joseph Alba, Department of Marketing, 205 Matherly Hall, University of Florida, Gainesville, Florida 32611.

knowledge about the structure of a familiar event, for example the knowledge a person possesses about the structure of a short story. It specifies not the exact contents of the event but rather the general type of information expected in that situation and the order in which it should be encountered (for example, in a story, setting information would be followed by theme information and so on). A script (Schank & Abelson, 1977) is very similar to a frame in that it too contains general information about particular, frequently experienced events (e.g., a visit to a restaurant). Scripts also contain more specific information about the contents of the event as well (e.g., being seated, ordering the meal, and so on). Although frame and script theories have recently been used to guide some research in memory (e.g., Bower, Black, & Turner, 1979; Graesser, Woll, Kowalski, & Smith, 1980), by far the majority of research is not aimed at testing particular provisions of such well articulated theories.

Instead, the bulk of the memory literature dealing with complex events such as prose learning consists of a series of studies investigating a number of loosely connected issues whose results are either predicted by or interpreted with reference to schema theory or its originator, Bartlett (1932). This situation poses a substantial difficulty to anyone who would evaluate the adequacy of schema theories; it is difficult to evaluate a set of partially overlapping assumptions spread across 15 years of research, a sizeable number of paradigms, and the research of a large number of investigators.¹

Our first goal then was to try to impose some structure on the research literature by identifying the central assumptions of schema theories. We propose that according to a modal theory, schema-driven encoding of complex information is characterized by four basic processes: selection, abstraction, interpretation, and integration. A schema theory which asserts that all four processes occur would state that from any environmental event, only the information that is relevant and important to the currently activated schema will be encoded. Of the information selected, the semantic content of the message will be abstracted and the surface form will be lost. Further, the semantic content will

then be interpreted in such a way as to be consistent with the schema. The information that remains will then be integrated with previously acquired, related information that was activated during the current encoding episode. The operation of one or more of these processes is likely to result in a representation that is less than totally accurate.

A fifth schema theory process, reconstruction, is one that operates at the time a person attempts to reproduce a memory episode. This process uses whatever details were selected for representation and are still accessible together with general knowledge to essentially fabricate what might have happened. Several critical reviews of this process are available (e.g., Gomulicki, 1956; Spiro, 1977; Zangwill, 1972). The consensus is that reconstruction is quite rare and occurs only under special circumstances. Because of this, we do not undertake a full-scale review of reconstruction and instead focus on the encoding processes proposed by schema theory. However, because of recently renewed interest in the process of reconstruction (see e.g., Bower et al., 1979; Graesser et al., 1980; Spiro, 1980a), the topic is discussed in several sections of this article.

In the first part of the article we explicate the four central encoding processes of a modal schema theory and the evidence that supports the existence of these processes. In so doing, we show how schema theories account for the three central phenomena of memory—accuracy, incompleteness, and distortion. In the second part we evaluate the quality of the evidence supporting the four major schema theory encoding processes. As will be seen, there is a good deal of evidence that is not as supportive as might be desired as well as a fair amount of evidence that is directly contradictory. In the third part of the article, we consider and evaluate alternative

¹ Apparently, a similar situation confronted Taylor and Crocker (1981) as they attempted to formulate and evaluate a schema theory from research in social psychology. In the memory domain, there are two excellent reviews (Gomulicki, 1956; Zangwill, 1972), but these are now both quite out of date. In addition, there are a few scattered attempts to present a cohesive schema theory, at least for limited domains, including scene perception (Brewer & Treyns, 1981) and text comprehension and representation (Thorndyke & Yekovich, 1980).

explanatory mechanisms. These alternatives offer a viable means of resolving the inconsistencies in the research literature.

Evidence Consistent With Schema Theory

The support for schema theory will be considered in the context of the four schema theory principles mentioned above—selection, abstraction, interpretation, and integration—whose origins can be traced to Bartlett's (1932) classic work. They are presented here, not as a description of any specific current model, but rather as an outline of a prototypic schema theory.

Selection

Of all the concepts in a given event or message, only some will become part of the memory representation. Schema theories have proposed three conditions that determine whether or not a particular piece of information will be selected for encoding: (a) the existence of a relevant schema, (b) the activation of that schema, and (c) the importance of the incoming information with respect to the schema. The operation of each of these selection principles will be considered in turn.

Prior knowledge. A critical condition for the acquisition of new knowledge is the existence of previously acquired relevant knowledge, that is, of a well developed schema. In the absence of such knowledge, memory is generally poor. Experimentally providing subjects with background information or with ways to link the new information with already stored information greatly enhances memory (Ausubel, 1960; Ausubel & Fitzgerald, 1961, 1962; Bransford & Johnson, 1972, Experiment 1; Royer & Cable, 1975, 1976; Royer & Perkins, 1977; see also Thorndyke, 1977; Wilkes & Alred, 1978).

Similar findings have been reported for subjects purposely selected because their prior knowledge of a particular topic (here baseball) was known to vary substantially (Chiesi, Spilich, & Voss, 1979; Spilich, Voss, Chiesi, & Voss, 1979). These subjects were presented with narratives about typical baseball situations. High-knowledge subjects

recalled substantially more of the narrative, as well as more of its essential information, than did low-knowledge subjects (see also Ausubel & Fitzgerald, 1961, 1962). Similarly, skilled chess players have a memory advantage over novices when the subject of memory is the location of pieces on the chessboard of a real game (Chase & Simon, 1973). The advantage of relevant prior knowledge has also been found when the usual positive correlation between knowledge and age is reversed, that is, when those with the knowledge are in grade school and those without are graduate students and faculty members (Chi, 1978).

Frame theory (Minsky, 1975) also asserts the importance of prior knowledge. If the structure of incoming information does not match one's knowledge, memory for that particular type of information should be adversely affected. Mismatches between incoming and existing structures can occur either because the structure of the incoming stimulus is quite deviant from the prototypical structure or because the person lacks adequate knowledge about the prototypical structure. In fact, when parts of a short story or fairy tale are rearranged so as to carry the same information but in an unexpected order, or when a story from a culture with different structural rules is read, comprehension is difficult and recall of the story content is significantly reduced (Day, Stein, Trabasso, & Shirey, Note 1; Kintsch & Greene, 1978; Kintsch, Mandel, & Kozminsky, 1977; Mandler, 1978; Meyers & Boldrick, 1975; Stein & Nezworski, 1978; Thorndyke, 1977).

In agreement with schema theory, therefore, specific domain-related prior knowledge appears to result in improved acquisition of new, domain-related information. Assimilation of new information appears to be a function of the amount of prior relevant knowledge, whether structural (e.g., frame) or content (e.g., theme) based. Without this knowledge, there is no available schema into which new information can be integrated or subsumed and it is therefore quickly lost. The encoding of new information is a mapping process, new onto old, which depends on a sufficiently well developed knowledge base.

Activation of an existing schema. The mere possession of relevant knowledge is not

sufficient for it to play a role in encoding: The knowledge must be activated at the time of encoding. Research has focused on two situations in which information is presented in the absence of activated knowledge bases. In one case, new information is presented in such a way as to avoid contact with old, relevant knowledge. In the other, a schema is activated but is congruent with only a portion of the incoming information.

Consider the case in which prior knowledge exists but is not activated. The classic studies in this area were performed by Bransford and Johnson (1972, Experiments 2-4). They presented subjects with short passages that, without a title, were highly abstract and extremely difficult to understand. In these instances the passages were also very poorly recalled. Similar memory deficits and processing difficulties resulting from insufficient contextual support have been reported frequently (e.g., Dooling & Lachman, 1971; Dooling & Mullet, 1973; Johnson, Doll, Bransford, & Lapinski, 1974; Ortony, Schallert, Reynolds, & Antos, 1978; Thorndyke, 1977). Thus, when knowledge structures lie dormant during encoding, new knowledge cannot be easily assimilated; "the absence of an appropriate semantic context can under some circumstances seriously affect the acquisition process" (Bransford & Johnson, 1973, p. 397).

The critical importance of schema activation during the encoding process can also be seen in studies in which schema-activating cues were given after a story was read or heard. In such cases, recall was as poor as it was when no cues were provided (Bransford & Johnson, 1973; Dooling & Mullet, 1973; see also Thorndyke, 1977).

An interesting developmental implication of these findings has been drawn by Bransford and Nitsch (1978). They speculate that less experienced people will have greater difficulty than more experienced people in discovering the situational cues that can lead to activation of a knowledge context. Hence, younger children will ordinarily show poorer retention than older children and adults. On those rare occasions in which children have a knowledge advantage (e.g., Chi, 1978), the usual advantage of adults will be lost.

A second line of research involves the situation in which an activated schema can be

applied to only some portion of the incoming information. Schema theory predicts that the relevant information will be easily encoded but the remainder will either be rejected or distorted so as to fit the schema. Pichert and Anderson (1977) presented stories that could be viewed from either of two perspectives (e.g., a description of a house from the perspective of a prospective purchaser or of a burglar). Information that was relevant to one perspective was irrelevant to the other. Subjects were biased toward one perspective while reading the stories and later recalled from that perspective. Results showed that subjects preferentially recalled the information that was consistent with their perspective at encoding (see also Kozminsky, 1977). Presumably, the biasing manipulation activated only one of the two schemata subjects possessed. Information irrelevant to the activated schema may never have been permanently encoded or may have been encoded but processed less elaborately than relevant information. Both possibilities are consistent with schema theory. Similar results have been obtained using a recognition test. Given a recognition test containing items that were consistent or inconsistent with respect to the two themes of a story, subjects selected items that were consistent with the theme biased during encoding (Schallert, 1976).

The congruency between a schema and the incoming information has also been studied by manipulating the stimulus rather than the subject's frame of reference (Morris, Stein, & Bransford, 1979). In simple stories, characters were described as involved in an activity that was either consistent or inconsistent with their physical attributes (e.g., The strong man lifted the piano; The fat man got stuck in a cave; or, The bald man got stuck in a cave; The old man lifted the piano). After reading the initial passage, subjects read a second story, which referred to the activities of the characters. Recall of both the initial and following stories was better when they described or referred to character-appropriate situations than when they did not.

The data reviewed in this and in the previous section seem to indicate that both structural and semantic schemata play influential roles in the assimilation of new information. Retention appears to be better when incoming information is consistent

with one's possessed and activated knowledge and expectancies about the world. Inconsistent information may not be well represented in the memory code.

The importance effect. An existing schema that is activated during the presentation of a mass of information will enable selection of only some of that information for encoding. Two selection principles have been proposed. The first principle stems from traditional schema theories and states that the ideas that are most important to the theme of the information (Owens, Bower, & Black, 1979) and that cannot be derived from previously encoded information (Spiro, 1980b) will be given special attention and will be remembered best. Using stories as stimulus materials, several studies have demonstrated that recall of ideas is a positive function of the independently rated importance of those ideas to the overall meaning of the story (e.g., Brown & Smiley, 1977; Christie & Schumacher, 1975; de Villiers, 1974; Graesser, 1978a; Graesser, Robertson, Lovelace, & Swinehart, 1980; Johnson, 1970; Johnson & Scheidt, 1977; Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975; Kozminsky, 1977; Meyer, 1975, 1977; Meyer & McConkie, 1973; Miller & Kintsch, 1980; Smiley, Oakley, Worthen, Campione, & Brown, 1977; Thorndyke, 1977; Waters, 1978).

A related selection principle comes from script theory (Schank & Abelson, 1977). This theory deals with situations in which people process information relevant to high frequency events (e.g., eating in a restaurant). The theory predicts that the memory traces representing highly typical events that occurred in a particular episode will be forgotten (or omitted from the representation). Typical information need not be stored, since it can always be derived from the prototypical script. One need only remember that a scripted event occurred to recall highly probable components. Thus, according to script theory, atypical information will be selected to receive special representation in memory.

One advantage of a representational scheme like Schank and Abelson's is that it allows for economical storage in the space allocated for memory; highly typical individual episodes that occur in real-world experiences may be forgotten, since they are already represented in, and so can be recalled

from, the prototypical script. Economy of storage is a concept central to computer analogies of the memory process.

Summary: Selection and memory theory. Considerable evidence appears to support all three schema theory principles regarding what will be encoded. Prior knowledge, whether semantic or structural, increases the likelihood of encoding new information. However, the existence of prior knowledge is not sufficient to guarantee encoding of incoming information; the knowledge must be concurrently activated. Ideas important to an activated schema are likely to have a selection advantage for storage.

Because of the selection process, the representation of any event is likely to be quite incomplete. As a result people cannot reproduce from memory an exact copy of an event, even when they are motivated to do so. Rather, according to Bartlett (1932), people will attempt to reconstruct the event. Stored information will be recalled together with "probable detail" from general schematic knowledge. That people have no trouble freely generating such details is well documented (Bower et al., 1979; Brockway, Chmielewski, & Cofer, 1974; Cofer, Chmielewski, & Brockway, 1976).

From such a perspective, accurate recall can stem from two sources: (a) aspects of the original event that were actually selected for representation in memory and (b) chance matches between the reconstruction process and the original event. The likelihood of such matches (or, of correctly "guessing") increases whenever the original event contains elements in common with other similar events—the presumed source of the "probable detail" from which people are thought to reconstruct.

Distortions of the original event will occur whenever the probable detail produced was not actually part of the original event. Much of Bartlett's data consisted of recall protocols containing considerable amounts of information that was not in the original stimulus. Although Bartlett's results have been difficult to replicate (see e.g., Gomulicki, 1956; Zangwill, 1972), others have found "thematic intrusions" in retrieved information (Dooling & Christiaansen, 1977a; Kintsch et al., 1975). Similarly, people occasionally "remember" typical actions that never actually happened.

in the particular experience of an event (e.g., Bower et al., 1979; Graesser, Gordon, & Sawyer, 1979; Graesser et al., 1980; Smith & Graesser, 1981).

Recently, Spiro (1977, 1980a, 1980b) has argued that the reconstructive process is most likely to result in distortion when one encounters (at least under conditions in which memory is not intentional) some additional schema-relevant knowledge that is contradictory to an encoded schema. Subsequent recall will be based partly on both sources of information. Such a situation results in distortions that are a by-product of the reconstructive process and that will serve to resolve inconsistencies between the sources of information. Again, recall will contain additional information not present in the event.

The selection process is instrumental in accounting for one of the three fundamental memory phenomena, incompleteness of recall. Much of an original event is simply not represented in memory. The other two phenomena, accuracy and distortion, are at least in part the product of the reconstruction process that is thought to operate at retrieval.

Abstraction

Information that has been selected because it is important and/or relevant to the schema is further reduced during the encoding process by abstraction. This process codes the meaning but not the format of a message (e.g., Bobrow, 1970; Bransford, Barclay, & Franks, 1972). Thus, details such as the lexical form of an individual word (e.g., Schank, 1972, 1976) and the syntactic form of a sentence (e.g., Sachs, 1967) will not be preserved in memory. Because memory for syntax appears to be particularly sparse as well as brief (e.g., J. R. Anderson, 1974; Begg & Wickelgren, 1974; Jarvella, 1971; Sachs, 1967, 1974), the abstraction process is thought to operate during encoding.

Additional support for the notion that what is stored is an abstracted representation of the original stimulus comes from studies that demonstrate that after a passage is read, it takes subjects the same amount of time to verify information originally presented in a complex linguistic format as it does to verify that same information presented in a simpler

format (e.g., King & Greeno, 1974; Kintsch & Monk, 1972).

There are a considerable number of theories that assume that memory consists of sets of propositions and their relations (e.g., J. R. Anderson, 1976; Bransford, et al., 1972; Brewer, 1975; Frederiksen, 1975a; Kintsch, 1974; Norman & Rumelhart, 1975; Schank, 1972, 1976). One formalized presentation of this idea is Schank's conceptual dependency theory (1972). The theory asserts that all propositions can be expressed by a small set of primitive concepts. All lexical expressions that share an identical meaning will be represented in one way (and so stored economically) regardless of their presentation format. As a result people should often incorrectly recall or misrecognize synonyms of originally presented words, and they do (e.g., Anderson & Bower, 1973; R. C. Anderson, 1974; Anisfeld & Knapp, 1968; Brewer, 1975; Graesser, 1978b; Sachs, 1974).

Abstraction and memory theories. Since considerable detail is lost via the abstraction process, this process can easily account for the incompleteness that is characteristic of people's recall of complex events. In light of the abstraction process, the problem for schema theories becomes one of accounting for accurate recall. Schema theories do this by borrowing a finding from psycholinguistic research, to wit, that speakers of a language share preferred ways of expressing information. If both the creator and perceiver of a message are operating with the same preferences or under the same biases, the perceiver's reproduction of the input may appear to be accurate. The accuracy, however, is the product of recalling the semantic content of the message and imposing the preferred structure onto it. Thus, biases operate in a manner that is similar to the "probable detail" reconstruction process. Biases have been documented for both syntactic information (J. R. Anderson, 1974; Bock, 1977; Bock & Brewer, 1974; Clark & Clark, 1968; James, Thompson, & Baldwin, 1973) and lexical information (Brewer, 1975; Brewer & Lichtenstein, 1974).

Distortions may result from the abstraction process if biases are not shared by the person who creates the message and the one who receives it. More importantly, the ab-

straction process sets the stage for distortions because it is the necessary precondition for two other schema theory processes, interpretation and integration. These two are usually thought to be the major sources of distortions.

Interpretation

Thus far, distortion in the recall of complex materials has been attributed to processes that reduce information. The encoding deficit that results from selection and abstraction is, in part, compensated for at recall by reconstruction and by shared speech production biases. Distortions also occur because those semantic propositions that are encoded are actually interpretations of the explicitly presented information—interpretations that are based on the perceiver's activated schematic knowledge. Such errors are often referred to as constructive errors because they involve the addition of information to the memory representation of a complex event. In contrast to reconstructive errors, constructive errors are the product of an elaboration process occurring during or shortly after encoding.

Interpretations are typically inferences (see Harris & Monaco, 1978). Two varieties can be identified. The first, pragmatic implication, involves converting explicitly stated information into its probable underlying intent. The second involves inferences made during comprehension when there is a need to (a) concretize vague information, (b) fill in missing detail, or (c) simplify complex information.

Pragmatic implication. A variety of examples of this aspect of interpretation can be found (see Harris & Monaco, 1978, for a review); a few will suffice. Given Sentence 1, people will often recall it in the form of Sentence 2 (Schweller, Brewer & Dahl, 1976):

1. The housewife spoke to the manager about the increased meat prices.
2. The housewife complained to the manager about the increased meat prices.

Given Sentence 3, people recall Sentence 4 (Brewer, 1977):

3. The paratrooper leaped out of the door.
4. The paratrooper jumped out of the plane.

Given Sentence 5, people equate its meaning with Sentence 6 (Harris, 1974; Harris & Monaco, 1978):

5. The frightened farmer was able to raise chickens.
6. The frightened farmer raised chickens.

In each case, subjects are encoding information that goes beyond the explicit. The distortion that results can range in degree from minor to extreme. It will be minor if the perceiver's interpretation corresponds to the meaning intended by the creator of the message. Distortion will, of course, be more extreme if the perceiver misinterprets the message.

Interpretation and comprehension. Successful comprehension heavily depends on the interpretation process. Consider the situation in which a presented concept is general or vague. According to theory, the schema will serve to concretize the information and store it in its interpreted form. This process is called instantiation. It can be demonstrated by presenting people with sentences that contain general concepts (e.g., animal, container) but provide enough context to allow the general terms to be understood as specific ones (e.g., dog, bottle). On a cued recall test, the never-presented specific terms serve as better retrieval cues than the actually presented general terms (Anderson et al., 1976). Thus, general terms are interpreted and stored as specific instantiations.

A second, closely related form of interpretation-dependent comprehension occurs when implied facts are inserted into the representation of an incomplete stimulus. When subjects are given sentences that imply the presence of an unstated object, instrument, or action, the subjects construct the missing information (Paris & Lindauer, 1976; Paris, Lindauer, & Cox, 1977; Paris & Upton, 1976) and may then remember it as having been part of the original stimulus (Johnson, Bransford, & Solomon, 1973). Thus, subjects who hear a passage describing a person pounding a nail will infer the presence of a hammer as the probable instrument and incorporate the instrument into their representation of the passage (Johnson et al., 1973).

Additions made to explicit information go beyond one-word instruments and objects. Frequently, speakers and writers will struc-

ture their output in such a way as to induce listeners and readers to infer connections between ideas. Haviland and Clark (1974) and Kintsch and van Dijk (1978) have argued that information in a text is most easily understood when it can be related to immediately preceding information. When this is not possible, the comprehender searches memory for some relevant information that can serve as a connecting idea. If none is found, people will construct an inference that bridges the information gap. In fact, when an inference must be generated in order to understand a recent input, people do construct the missing information (Keenan & Kintsch, 1974; McKoon & Keenan, 1974) and sometimes later misrecognize it as having been part of the text (Thorndyke, 1976). Similarly, inferences may be made and incorporated into memory when they simply increase the coherence of otherwise understandable ideas (Owens et al., 1979).

Frame theory predicts a related type of inference making. If a stimulus generally conforms to an existing frame but does not contain all of the information categories specified by that frame, the missing information will be provided in the form of "default values" (Minsky, 1975). Thus, if a story grammar proposes slots for setting or theme information and a stimulus conforming to that grammar possesses no information that can instantiate those slots, the missing information will be inferred and attached to the representation of the stimulus (e.g., Glenn, 1978; Mandler & Johnson, 1977; Stein & Glenn, Note 2). Further, if the order of ideas in a frame-like stimulus does not conform to the ideal order, the encoding frame may be used to rearrange those story ideas (Mandler, 1978; Stein & Glenn, 1979; Stein & Nezworski, 1978; see also Lichtenstein & Brewer, 1980).

Finally, inferences will also be made if they help to simplify the propositional structure, especially when the information processing load is heavy (Frederiksen, 1975a, 1975b). These inferences too are often incorporated into the recall of the text.

The possibility of distorting an original event arises because the interpretation process allows the perceiver to add to or change the information conveyed by the stimulus.

Interpretation results in distortion because it occurs with two other processes. The first is abstraction, which eliminates the surface structure form of the stimulus and stores only a meaning-based representation. The second process, discussed next, is integration.

Integration

That people contribute information to an incoming message is not a notion unique to schema theory. What is unique is the prediction made about the memory representation that is the product of interpretation. A single integrated memory representation is thought to be created from whatever accurate information is selected, whatever interpretations are drawn, and whatever general knowledge exists that is relevant to the stimulus. Thus, individual ideas exist only as a part of a complex semantic whole. Integration processes are thought to occur at two different stages of memory: (a) when a new schema is formed and (b) when an existing schema is modified. These will be considered in turn.

Schema formation. One method of demonstrating integration is to show that memory for a set of related propositions consists solely of the overall intent of those propositions. Consider the following sentences.

7. There is a tree with a box beside it and a chair is on top of the box.
8. The box is to the right of the tree.
9. The tree is green and extremely tall.

People who read Sentences 7-9 will misrecognize 10 as an originally presented sentence.

10. The tree is to the left of the chair.

But, they will call Sentence 11 new (Bransford et al., 1972; Paris & Carter, 1973; Prawatt & Cancelli, 1976).

11. The chair is to the left of the tree.

Evidence for the integration of individual sentences into a holistic representation is also found when, during acquisition, subjects are presented with a set of sentences that contain different sized subsets of ideas from a more complex, unrepresented parent sentence. Subjects' confidence that a particular sentence was actually presented during acquisition increases with the degree to which that sentence approximates the never-presented complex

parent sentence regardless of whether or not that sentence was originally presented (Bransford & Franks, 1971; Cofer, 1973; Griggs, 1974; Singer, 1973; Walsh & Baldwin, 1977).

Integration during schema formation can also be seen in the linear ordering paradigm. Here subjects are presented with a series of sentences that describe a one-dimensional ordering of objects or people. Dimensions may include weight, height, and speed. The sentences may simply state that a is taller than b, b is taller than c, d is shorter than c, and so on. Barclay (1973) presented such sentences and asked subjects to determine the relations involved in the total set by imagining the entire array in its proper order. On a subsequent recognition test, he presented some of the originally presented sentences along with some new sentences that either did or did not express valid relations. Subjects were unable to discriminate actually presented sentences from new ones that were valid statements about the ordering (see also Potts, 1973). Similar conclusions may be drawn from studies using class inclusion relations (Potts, 1976), artificial terms (Potts, 1977), and complex nonlinear arrays (Moesser & Tarrant, 1977).

The schema theory explanation of these findings is that the meanings inferred from individual sentences during encoding are integrated into a larger semantic whole. On a memory test, sentences that are consistent with the integrated representation are judged to have been part of the original array.

Schema modification. The previous studies demonstrate integration for brief and related pieces of information on topics about which subjects had limited prior knowledge. Another demonstration of the integration process occurs when new information is presented on a topic about which the person already has considerable information in memory. Consider first a study by Sulin and Dooling (1974). Here subjects read a short passage that they believed to be about either a famous person or a fictitious person. On a recognition test, subjects were given some of the passage sentences along with some distractors that varied in their thematic association to the famous character. Subjects who were told that the passage described the fa-

mous person, misrecognized as old the items that were thematically related to the famous person. This did not occur for subjects in the fictitious person condition (see also Brown, Smiley, Day, Townsend, & Lawton, 1977; Royer, Perkins, & Konold, 1978).

Consider next the work of Loftus and her colleagues (e.g., Gentner & Loftus, 1979; Loftus, 1975; Loftus, Miller, & Burns, 1978; Loftus & Palmer, 1974). In these experiments, subjects are typically shown a short film or set of slides depicting, for example, a traffic situation. Afterward, a question is asked about the scene that either implies the presence of additional information that was never actually present or that contradicts information that was present. On a subsequent memory test, subjects often misrecognize new slides containing the additional or contradictory information. Loftus and Loftus (1980) argue that new information introduced after an event has been witnessed may add to or replace the person's knowledge of the original scene, resulting in a single, integrated memory for the scene.

Finally, consider the phenomenon of the "knew-it-all-along" effect (Fischhoff, 1977). In this paradigm, subjects are asked to rate the probability of occurrence of an event (Fischhoff, 1975; Fischhoff & Beyth, 1975) or to assess the validity of factual statements that are beyond their specific knowledge but that pertain to topics with which they are familiar (Fischhoff, 1977; Wood, 1978). They are then told of the occurrence or nonoccurrence of the event or are given the truth values of the statements. Subjects are then asked to estimate their preoutcome knowledge states or to recreate their original probability or validity judgments, uninfluenced by the outcome information. The result is that subjects overestimate the degree to which they were originally correct. They cannot accurately recall their judgments and the inaccuracy is systematically in the direction of the answers supplied to them. These data suggest that new information is immediately integrated into the prior knowledge system that subjects possessed about the topics, resulting in an inseparable combination of the new and old information. When trying to recall their original ratings, subjects base their responses on the only representation available to them

at test time, one which has been modified by the incorporation of the new information.

Integration and memory theory. Once integration occurs and old knowledge has been altered or updated, accurate retrieval of actually presented information becomes highly unlikely. New information will be integrated into old knowledge structures. This new information can originate in the external environment (as suggested by the Loftus or Fischhoff work) or in the internal environment (as suggested by the work on inferences). Regardless of the information source, schema theory predicts that inaccurate retrieval will occur because individual traces of a to-be-remembered event do not exist.

Summary

Schema theory has become an enormously popular framework guiding considerable amounts of research in human memory. One source of this popularity is the apparent success that the major assumptions of the theory have had in explaining experimental results. According to schema theory what is stored is some highly selected subset of all that has been presented, and it is the schema that guides the selection process. Memory is abstractive in that a verbatim record is not left behind; rather, meaning appears to have highest priority for storage. Memory is interpretive in that the schema serves to fill in missing details and distort others so as to be schema-consistent. Memory is integrative in that incoming information joins with other related elements in that episode, with whatever prior knowledge is available, and with relevant, subsequent information to create a single unified representation of a complex event.

When retrieval is required, probable detail is generated, and the representation is given a modal surface form. Thus the original meaning is retained, and on occasion, the production is a duplication of the original stimulus. Accuracy stems from those ideas that were actually selected for storage, from culture-normal biases in expressing information, and from serendipitous productions from the reconstructive process. This latter category is most likely to occur for high-probability events.

On other occasions, recall may be quite distorted. This is attributed to a number of

sources: reconstruction, construction, unshared language production biases between the originator and receiver of the message, interpretations not actually intended by an originator, and the integration of memory episodes over time.

Incompleteness in recall is largely the product of two encoding operations: selection and abstraction. Not all ideas are selected for representation. Not all elements are part of the abstracted meaning. The integration process further attenuates those ideas that were selected and abstracted, thus reducing the amount of information that can be recalled.

In the next section of this article we consider a body of research, much of it quite recent, that is either inconsistent with or directly contradictory to the central assumptions of schema theory. Each of the four basic encoding assumptions of schema theory will be considered in turn.

Evidence Inconsistent With Schema Theory

Selection

The importance of the schema to the selection process is based on the interpretation of five sets of findings: (a) in the absence of any schema, not much can be encoded and so not much will be recalled (e.g., Bransford & Johnson, 1972, 1973); (b) the greater the level of prior knowledge, the greater the amount of new, relevant information that can be selected and subsequently recalled (e.g., Chiesi et al., 1979); (c) when an existing schema is not activated, recall is extremely poor (e.g., Bransford & Johnson, 1972); (d) information that is congruent with an activated schema is far more likely to be encoded and so recalled than is information that is incongruent (e.g., Pichert & Anderson, 1977); (e) the more important an idea is to a schema, the greater the likelihood that it will be recalled (e.g., Johnson, 1970; Meyer & McConkie, 1973).

Consider first the idea that the encoding of new information is a function of the amount of prior relevant information. A review of the education literature (Barnes & Clawson, 1975) found more research in conflict with Ausubel's (1968) version of this principle than in support of it. Although recall has been shown to vary substantially with the amount of prior knowledge (Chiesi et al.,

1979), the same research has shown that recognition varies minimally (Experiments 1 and 2). Similarly, although an inactivated schema may leave subjects at a considerable recall disadvantage compared with subjects with an activated schema (e.g., Bransford & Johnson, 1972), this disadvantage too disappears when memory is tested using a recognition procedure (Alba, Alexander, Hasher, & Caniglia, 1981). That an activated schema does not benefit recognition as it does recall has been shown for a variety of stimulus materials including prose (Alba et al., 1981), individual sentences (Birnbaum, Johnson, Hartley, & Taylor, 1980), lists of sentences (Hannigan, 1976), and pictures (Bower, Karlin, & Dueck, 1975). Finally, although important ideas have an advantage in recall, this advantage is not always present on a recognition test (Britton, Meyer, Hodge, & Glynn, 1980, Experiment 3; Goetz, 1979; Kintsch & Bates, 1977; Thorndyke & Yekovich, 1980; Walker & Meyer, 1980; Yekovich & Thorndyke, 1981).

That recall but not recognition varies with the activation of a schema, with the knowledge content of that schema, and with the importance of individual ideas to that schema poses problems for a selection process presumed to operate at the time of encoding. Information that is not part of a memory representation should be the equivalent of information that was never presented; it should be neither recalled nor recognized. That there are substantial effects of a schema on the amount that is recalled as well as on the content that is recalled suggests that the schema influences retrieval rather than selection for storage in memory.

The suggestion that a schema operates at retrieval to influence what is recalled is strengthened considerably by the work of Anderson and Pichert (1978). When information agrees with two different schemata, only one of which is activated during encoding, superior recall is seen for the information that is congruent with whatever schema was activated during acquisition (see also Pichert & Anderson, 1977). However, if one tests for recall a second time from the perspective of the previously inactive schema, recall of the once irretrievable information is significantly raised (Anderson & Pichert, 1978). These findings have been replicated by Fass and

Schumacher (1981), who in some conditions did not introduce the alternative (or new) theme until 12 minutes *after* the original story had been read, long after the selection process should have operated. These cuing studies suggest that more is encoded than is consistent with the operation of a schema-based selection principle.

Strong evidence for the operation of retrieval processes in prose recall comes from a study by Hasher and Griffin (1978). They showed that as long as 2 weeks after the encoding of a story the nature of recall could be dramatically influenced. In that study, one group of subjects showed a typical "reconstructive" pattern, with substantial forgetting of specific ideas along with thematically relevant intrusions. However, another group showed a quite untypical pattern (termed "reproductive" by the experimenters); these subjects produced virtually no thematic intrusions and forgot far less of the original story information. The manipulation that induced reproductive recall was one that created doubt about the validity of the schema used during encoding. Hasher and Griffin argued that subjects were then forced to revise their retrieval plan (of using the encoding schema) and so exerted special effort to gain access to otherwise inaccessible information. Further evidence that a schema operates at retrieval is found in a study in which recall deficits for unimportant (and so presumably unselected) information were greatly attenuated by providing subjects with both semantic (content words) and contextual (the background color of the printed page) retrieval cues (Britton et al., 1980, Experiments 1 and 2).

Selection and reconstruction. Selection presumably allows for mnemonic distortion because the memory representation of any event is substantially reduced compared with the original. According to Bartlett (1932), the subject must then rely on his or her general knowledge together with what few details were actually encoded to produce a recounting of an event. This recall procedure is called reconstruction. The evidence just presented, however, suggests that memory for an event is often quite good, though details may not always be readily accessible. In fact, the evidence for a reconstructive process at retrieval is itself actually fairly weak. Under

normal circumstances, distortion is either rare or nonexistent (Zangwill, 1972). In fact, a recent analysis of Bartlett's stimuli show them to be rather poorly structured and unrepresentative of normal prose (Mandler & Johnson, 1977), perhaps accounting for his apparently unique findings. Indeed, a contemporary replication of Bartlett's procedures showed little evidence of distortion (Kintsch & Greene, 1978; see also Gomulicki, 1956; Paul, 1959). Recall errors that do occur can sometimes be eliminated by manipulating recall conditions (cf. Cofer et al., 1976), by stressing accuracy (Gauld & Stephenson, 1967), or by changing the subjects' retrieval strategy (Hasher & Griffin, 1978).

If reconstructive processes exist, they may be an optional, perhaps (compared with reproduction) even a relatively effortless, recall strategy, rather than, as Bartlett proposed, and others have assumed, a necessary strategy. After all, one's general knowledge on a topic is presumably acquired by virtue of repeated, distributed exposures to that topic. Since both study and retrieval episodes are implicated in recallability (see Spear, 1978), it should be relatively easy to gain access to general knowledge, especially when compared with the ease of gaining access to one's memory for an episode that occurred only once. At the very least, reconstruction is not a necessary consequence of selective encoding; far more is encoded than the selection principle would suggest, and a great deal of this original information remains available in memory. Finally, the circumstances at retrieval play a critical role in determining what can be accessed (see Tulving & Pearlstone, 1966, for a discussion of the distinction between availability and accessibility).

Yet to be considered are those reconstruction processes associated with script theory and collectively referred to as the typicality effect (e.g., Bower et al., 1979; Graesser et al., 1979). Script theory predicts a failure on memory tests to discriminate between presented and unpresented events that are typical of a given script. Although the few studies that have been performed in order to test this prediction have reported decreased discriminability with increased typicality, these studies have also demonstrated that (a) people generally can discriminate between presented and unpresented typical script actions, espe-

cially when interference is reduced (Bower et al., 1979); and (b) complete failure to discriminate occurs only with those very few script actions that can be labeled very typical (Graesser et al., 1979)—a finding that considerably weakens the cognitive economy argument of script theory.

Possible explanations of the typicality effect that exclude the principle of selection will be presented in the final portion of this article.

Abstraction

The abstraction process is thought to further reduce what has been stored in memory by operating on what has been selected; semantic content is believed to be the important target of storage. Although it is now widely held that memory is abstractive, a number of recent findings cast some doubt on this process.

First, memory is not inevitably abstractive. Consider memory for highly overlearned messages such as the Pledge of Allegiance. Detailed memory for such material will persist for years (Rubin, 1977; see also Smith, 1935). Even memory for information presented only *once* has been shown to contain considerable detail. College students are able to discriminate actual utterances heard in the context of a lecture from highly similar utterances (Kintsch & Bates, 1977). Accurate recognition was found in that study for content that was largely extraneous to the topic (e.g., jokes) as well as for low-salient, relevant information. Memory for syntactic and lexical details in the lecture was quite profound; the rejected paraphrases included such subtle changes from the original sentences as rearrangement of clauses and meaning-preserving word substitutions.

Still more difficult paraphrases than those used by Kintsch and Bates (1977) were included in a follow-up study in which recognition memory was tested for sentences from a television soap opera (Bates, Masling, & Kintsch, 1978). The paraphrases in this study were constructed by substituting proper names for pronouns, roles for names, elliptical clauses for full clauses, and vice versa. Memory for the original utterances was surprisingly good (see also Bates, Kintsch, Fletcher, & Giuliani, 1980).

The ability of adults to distinguish between paraphrases and actual utterances is not easily explained by any theory which assumes that memory is selective and abstractive. If only general impressions plus a few details remain in memory after a lecture or a TV show, recognition performance for alternatives discriminable only on the basis of details should be at chance. A schema-theory explanation might claim that the utterances and their paraphrases differed in terms of their "probable detail," or in their conformity to the stylistic habits of the speakers, aspects of messages to which listeners are presumably sensitive. However, Keenan, MacWhinney, and Mayhew (1977) demonstrated that memory for utterances from a lecture was not based on sensitivity to such aspects; rather, subjects appear to remember the *actual form* of the original statements. Other research confirms this conclusion; people are able to discriminate between the frequency with which verbatim versus gist repetitions of sentences occur (Burnett & Stevenson, 1979; Gude & Zechmeister, 1975; see also Morris, Bransford, & Franks, 1977).

Thus, memory for detail has been shown for both well-learned (Rubin, 1977) and far less well-learned information (Bates et al., 1978; Bates et al., 1980; Keenan et al., 1977; Kintsch & Bates, 1977). It should be noted that in all of the experiments dealing with memory for once-presented messages, the recognition test was a surprise. Thus these findings cannot be explained away by appealing to unusual and "unnatural" task demands made under conditions of rote memorization.

Recent research appears to stand in marked contrast to the earlier evidence often cited as support for the abstraction process. In fact it does not. What those early studies found was *superior* recognition of semantic as compared with syntactic information. Syntax was frequently remembered at levels well above chance; that is, syntactic information was not totally forgotten, (e.g., J. R. Anderson, 1974; Anderson & Paulson, 1977; Begg, 1971; Begg & Wickelgren, 1974; Dooling & Christiaan- sen, 1977b; Olson & Filby, 1972; Sachs, 1967, 1974; Soli & Balch, 1976). Three recent studies have shown above-chance recognition of lexical and syntactic detail at the surprisingly long retention intervals of 1 hour (Yekovich

& Thorndyke, 1981; see also James et al., 1973; Kemper, 1980) and 1 week (Christiaan- sen, 1980).

A second version of the abstraction process states that word meanings are represented conceptually, and that therefore lexical information is lost (e.g., Schank, 1972). A number of findings contradict this view. For example, people rarely make synonym substitution errors, are better able to identify sentences when they contain their original words rather than synonyms, and show greater interference in sentence verification when stimulus sentences all contain a common word than when they contain different synonyms of the word (Hayes-Roth & Hayes-Roth, 1977). Along with Anderson's (1971; see also Hayes-Roth & Thorndyke, 1979) finding that verbatim cues enhance recall more than do synonymous paraphrases of words, there seems to be good evidence for the hypothesis that lexical information is also retained and forms part of the representation of a verbal event.

One study that can still be taken as evidence in favor of the conceptual representation notion did find reliable synonym substitution errors in recall (Brewer, 1975). However, of the total number of possible responses, synonym substitution occurred only 6% of the time (Experiment 1). Thus, either memory is not conceptually based, or very few words have identical synonyms. (If few words do have identical synonyms, the storage efficiency argument of computer-based models—e.g., script theory—is not very convincing.)

Memory appears to contain far more syntactic and lexical detail than is consistent with the view that memory is highly abstractive. Thus a central assumption of schema theory appears to be incorrect; the representation of both syntactic and lexical information is richer and more detailed than the abstraction process allows.

Interpretation

That people interpret and elaborate on incoming information is not a notion unique to schema theory. In the traditional human learning literature, "interpretation" processes were recognized and explored in research dealing with the distinction between

the nominal and functional stimulus (Underwood, 1963), with the role of mediation and elaboration in the learning of simple stimuli (Bugelski, 1968; Underwood & Schulz, 1960), with subjective organization (Tulving, 1962), and more recently with the distinction between "fact" and "fantasy" (Johnson & Raye, 1981). What is at issue in an evaluation of schema theories is the question of how interpretive behaviors alter the memory representation of the original stimulus. That is, are subject-generated interpretations of incoming stimuli necessarily integrated with the representation of the nominal stimulus so as to lose tags that mark the origin of an idea? This question is considered in the next section of the article.

There are two important points about interpretation to be made here. Contrary to some schema theories that predict sizable amounts of inference making during comprehension (e.g., Schank, 1976), several researchers have found that inference making is not an obligatory process. People may completely fail to make even a simple inference (Corbett & Doshier, 1978; Hayes-Roth & Thorndyke, 1979; Singer, 1979, 1981); they may generate inferences only to some information in a message (Goetz, 1979; Walker & Meyer, 1980); or they may engage in extensive inference making only when the task demands require it (Frederiksen, 1975b).

Second, whatever retrieval errors subjects do make in recall may not even be indicative of their underlying memory representations. Consider a prediction of frame theory: If a stimulus is structured differently from the frame used to encode it, the stimulus should be reorganized to conform to the frame, and recall studies suggest that subjects do reorganize information (e.g., Stein & Glenn, 1979; see also Mandler, 1978; Stein & Nezworski, 1978). However, in at least certain cases, e.g., a story presented with episodes occurring in flashback order, there is evidence that subjects retain input order information (Baker, 1978).

Integration

Schema formation. Integration is the set piece of schema theories. Theoretically, meaning is abstracted from the stimuli that

have been selected, and related abstractions are joined into a single representation. The most impressive contemporary evidence in support of this notion came from Bransford and Franks (1971). As is now widely acknowledged, there are many grounds on which to challenge their conclusions. The most basic is the fact that integration is not a necessary product of encoding related events (Mooser, 1976, 1977). In fact, the Bransford and Franks (1971) findings are difficult to replicate unless their methods are followed closely. Changes in presentation modality (Flagg & Reynolds, 1977; see also Katz & Gruenewald, 1974), in presentation of materials (Flagg, 1976; Flagg & Reynolds, 1977; James & Hillinger, 1977; Katz, Atkeson, & Lee, 1974), in instructions (James, Hillinger, & Murphy, 1977), and in testing procedures (Anderson & Bower, 1973; Griggs & Keen, 1977; James & Hillinger, 1977) greatly reduce or eliminate the integration effects found with the original Bransford-Franks paradigm. Finally, "integration" will occur for nonsemantic or arbitrary materials (e.g., letter-digits, nonsense syllables) if the original procedures are used (Flagg, 1976; Katz & Gruenewald, 1974; Reitman & Bower, 1973; Small, 1975). Since integration is assumed to be tied to similarities in the representation of meaning, evidence of such a process operating on meaningless material is troublesome.

Results from research using the linear ordering paradigm (e.g., Barclay, 1973; Potts, 1973) were also interpreted as being the result of integration. The argument was that when related propositions (e.g., $a < b$, $b < c$, $c < d$) are presented, the individual ideas are lost, leaving a subject-constructed, holistic array ($a < b < c$). There are now several grounds on which to challenge this conclusion. Again, the most basic is that the construction of a holistic order is not a necessary by-product of encoding materials bearing ordered relations (Potts, Keller, & Rooley, 1981). In fact, a sizeable proportion of subjects (30%) showed no evidence of even creating such an ordering (Potts et al., 1981). Further, recent evidence suggests that the ordering effect may be an artifact of the testing procedures used. Giving subjects unlimited time to make old-new decisions, as well as more information on

which to base their decisions, eliminates integration effects (Lawson, 1977). Even under less favorable conditions, an ability to make proper discriminations seems to exist (Tzeng, 1975). Subjects appear to store individual ideas, even if they are related to others in the memory set.

Strong evidence for integration processes in the formation of a schema seemed to come from both the semantic integration and linear ordering paradigms. Integration effects appear to be more tied to aspects of the procedures used than to an inevitable process of the human memory system. In addition, in both cases there is evidence that subjects have stored in memory separate, unintegrated units of the original stimulus complex.

Schema modification. A schema is a repository of prior knowledge on a topic. Thus, one might argue that the failure to demonstrate integration across a newly acquired knowledge base is not so critical for schema theory as would be the failure to demonstrate integration of new facts into a preexistent knowledge base. (Such an argument creates the problem of explaining where schemas come from in the first place; see Yekovich & Thorndyke, 1981). Putting aside for the moment the negative evidence concerning the abstraction process itself (on which the occurrence of integration necessarily depends), we now evaluate the evidence for integration of new information with well-learned (or previously acquired) data bases.

Studies investigating this type of integration have attempted to show that following integration (a) people cannot remember their original knowledge state and (b) the newly acquired piece of information loses its unique, context-specifying character. Three different lines of research would appear to provide strong evidence for these two views.

The "knew-it-all-along" effect shows that people tend to overestimate the quality of their original knowledge about facts after they have been provided with relevant information. The overestimation is theoretically the result of the new information's having been inseparably integrated into a person's general knowledge, making it impossible for the person to correctly remember his or her original knowledge state. However, Wood (1978) showed that if subjects are specifically

told to memorize their previous knowledge states, the size of the knew-it-all-along effect is reduced. Apparently, subjects can to some extent keep old and new information separate. More critically, however, there is evidence that people can accurately remember their original knowledge states even after new information has been provided, that is, after the integration has presumably occurred. Accurate recall of original information occurs if people are led to believe that the truth value of the new facts is unreliable (Hasher, Attig & Alba, 1981). Under these circumstances, people show very little knew-it-all-along behavior. What is critical about this study is that the manipulation discrediting the new "facts" was provided after the integration process was presumed to have occurred, which, according to schema theory, is an impossible finding. Thus, it appears to be possible to induce subjects to remember their original knowledge state, which was otherwise thought to be lost to memory by an integration process. These data suggest, as well, that subjects can discriminate the origin of recently provided information.

There is also a substantial volume of research on the integration of new with older knowledge conducted by Loftus and her colleagues. This research, too, appears to support both predictions. Subjects misinformed—after seeing a series of slides depicting an accident—that the traffic sign at a critical corner was a stop sign (not a yield sign, or vice versa) later incorrectly report having seen a stop sign. Recent evidence (Bekerian & Bowers, 1983) suggests that this dramatic and widely cited instance of integration may be an artifact of the testing procedure, in which the test slides are presented without regard to the original temporal sequence. The integration effect can be virtually eliminated by a testing procedure that preserves the original presentation order. Subjects can apparently use temporal-sequential information to distinguish the original slide (e.g., the yield sign) from the updating slide (the stop sign). Such discrimination should not of course be possible after the integration process has occurred; the original information should no longer exist.

Two other points about this work should be made. First, it is possible (as Loftus,

1979a, acknowledges) that other conditions necessary to demonstrate recollection of the preassimilated knowledge have not yet been discovered (for example, the Hasher et al., 1981, discrediting treatment might be such a condition). The second point relates to the generality of the data. Loftus has been successful in modifying people's memory of an event only when she deals with information peripheral to the main focus of the event. In recent studies (Alba, 1981; Loftus, 1979b), attempts at altering memory for focal information were shown to be almost totally ineffective. These findings suggest an alternative interpretation of the original results (also see Shaughnessy & Mand, 1982). The relative ease with which nonfocal information can be updated, compared with the difficulty of updating focal information, suggests that the "integration" process can work most easily on memories that are either already lost or difficult to retrieve. In these instances the updating information will be (at least on the basis of its recency to the memory test) more accessible than the original traces. It is of course important to account for the difficulty of gaining access to nonfocal information (ordinarily evidence for the selection process). We will consider a possible explanation shortly.

A further finding suggests that this differential retrieval hypothesis has validity: modification of a nonfocal fact does not occur if updating information is presented along with blatantly incorrect information (Loftus, 1979b). Similarly, updating does not occur if the provider of the new information is distrusted (Dodd & Bradshaw, 1980), nor if subjects are forewarned about the possibility of receiving misinformation (Greene, Flynn, & Loftus, 1982). These three manipulations may actually be the equivalent of the schema discrediting procedure (Hasher et al., 1981; Hasher & Griffin, 1978), which in the latter studies apparently induced subjects to retrieve ordinarily forgotten facts.

Thus, updating (or the integration of related memories) is not an inevitable consequence of the mere provision of related, contradictory, or supplementary information. New information may be disregarded (Dodd & Bradshaw, 1980; Greene et al., 1982; Lof-

tus, 1979b) at the time of presentation—or, more importantly, afterwards (Hasher et al., 1981). Subjects can, even in the face of new relevant information, continue to remember their original knowledge state. Discriminative markers for newly provided information do not appear to be inevitably lost.

A second set of studies more directly addressed the question of whether newly presented information loses its unique identity after it is integrated into a relevant, preexisting schema. Initial support for this notion was provided by Sulin and Dooling (1974) who reported that subjects aware of the connection between information in an experimenter-provided passage and a famous person, later misrecognized information about the famous person that was never actually presented. Subjects unaware of the connection between the story and the famous person were less likely than other subjects to misrecognize the critical information. One interpretation of these results is that the passage information became inextricably integrated into the relevant knowledge schema of those subjects who read it in the context of the famous person's name. Because of the integration process, subjects no longer possessed individual traces of the experimental passage and so on the recognition test could only respond on the basis of their holistic schematic knowledge.

There are several problems with these findings. First, integration effects were found to be minimal at brief delay intervals (Sulin & Dooling, 1974); memory was quite accurate immediately after the story was read. Integration then appears to take place over time, presumably (as Sulin & Dooling explain) because memory for specific detail is only gradually lost. And so with time, subject's recollections increasingly depend on schematic knowledge. This view of integration contrasts directly with an integration mechanism that operates during encoding, the type of integration assumed in the schema formation literature, as well as by Fischhoff (e.g., 1977) and by Loftus (e.g., Loftus et al., 1978).

There are further problems with an assimilation interpretation of the Sulin and Dooling data. Consider the results subsequently reported by Dooling and Christiaansen

(1977a).² In this study, subjects were again either informed or uninformed about the connection of the experimenter-provided passages to some famous person. Here, all subjects showed very good memory for the original sentences—even over long durations. Nonetheless, subjects in the famous condition did show a reliable propensity toward misrecognizing some (but not all) information about the famous person. One possible explanation assumes that the memory representations for the experimental materials were equivalent for the two groups of subjects. However, subjects who knew of the connection with a famous person might easily have been operating under response biases that were different from those of subjects uninformed about the connection. Informed subjects might have decided that some of the foils were old if they believed their memories imperfect, since after all, the foils were indeed true of the famous person. This response bias interpretation of these data becomes more plausible because systematic response biases have recently been discovered in research investigating the question of how people discriminate among various sources of information (e.g., originating with themselves vs. with others; see Johnson, Raye, Foley, & Foley, 1981).

To conclude this critique of integration, the processes of schema formation and modification via integration have not received very substantial support. For both processes there is evidence that integration is not a necessary by-product of merely presenting related or orderable information. In both literatures there is evidence that subjects have stored in memory unintegrated information about the original situation. That misrecognition of related information occurs is not deniable. The claim that integration is a major, inevitable product of schema-based processing is.³

Summary

Schema theory assumes that the representation of a complex event is both incomplete and inaccurate. This is because what is stored is highly selected and depends on whether the appropriate schema is activated, on the

knowledge content of that schema, and on the importance of the incoming information to the schema. Further reductions in the memory representation occur because the abstraction process favors the storage of meaning rather than of individual lexical units or syntactic sequences. Evidence from a sizeable number of studies suggests that the memory trace is richer and more detailed than these information reduction processes would allow.

Schema theory also posits two processes that enrich the representation of complex events: interpretation and integration. Here we considered evidence that suggests that neither of these processes is obligatory. Indeed, subjects can remember uninterpreted and unintegrated information. In several places we considered studies that demonstrated that much of the original support for schema theory encoding processes stemmed from procedural peculiarities of landmark experiments.

This review has revealed that memory for complex events is rather detailed, but some aspects of information are far more easily accessed than are others. In the next section of the article, we attempt to explain the findings reviewed in the first two sections.

Alternative Explanations

A considerable body of research findings exists that is not easily accounted for by the major encoding assumptions of schema theory. Unfortunately it is not currently possible to propose an alternative theory that is capable of integrating all of the relevant evidence as well as generating new predictions that could not themselves be accounted for by schema theory. What appear to exist are a set of explanations, not necessarily related to one another, each of which can be tied to

² Dooling and Christiaansen (1977) interpret their own data, as well as those of Sulin and Dooling (1974), with reference to the operation of reconstruction. That is, as episodic memory for an event fades, people rely on their thematic knowledge to reconstruct the event. The process of reconstruction will be considered in the next section.

³ See Johnson and Raye (1981) for an argument that a schema is neither a necessary nor logical source of misrecognition errors.

a set of findings in the schema literature as well as to a set of findings elsewhere in the memory literature. We consider some of these briefly in this section of the article. Again we consider in turn each major schema-theory encoding process.

Selection

The representation of a prose passage appears to include more details than a selection process allows. Nonetheless a literature exists showing a predictable advantage in recall for some ideas and not for others. There is no doubt that sizeable differences in recall (if not recognition) are associated with differences in degree of and/or activation of prior knowledge. Clearly, what is stored (or available) in memory is not always accessible (Tulving & Pearlstone, 1966). The question thus becomes: What is it that determines accessibility?

Classical research in human memory has identified a number of factors that are relevant for determining what is recalled. Four of these are important for present purposes: (a) the nature of connections established during encoding, (b) differences in the number and distribution of rehearsals, (c) the role of retrieval cues at recall, and (d) the order in which elements or sets are recalled. We propose that these four factors are important in determining recall of prose materials. First, however, we need to consider how textual material may be represented in memory.

Text processing theories such as Kintsch's (1974; Kintsch & van Dijk, 1978) assume that when complex material is presented, a "text base" is formed as part of the comprehension process. Briefly, a text base is an ordered hierarchy of propositions with the theme at the highest level and argument-sharing propositions descending from it. All related propositions are interconnected in a network due to argument overlap and to such grammatical elements as articles (de Villiers, 1974) and pronouns (Lesgold, 1972). Not every proposition will be connected directly to every other one, but many should be linked by indirect connections. Finally, if a passage contains a set of propositions not related to the theme proposition, these too will be en-

coded but will occupy a place outside of the integrated network (Kozminsky, 1977).

According to such models, individual propositions can have either or both of two sets of relations: (a) hierarchical connections descending from the theme and (b) connections that link individual propositions directly to others via shared arguments.⁴ Components of these two types of connections can then serve as retrieval cues and should (as do retrieval cues for simpler materials; e.g., Tulving & Thomson, 1973) play a large part in determining how many and what particular ideas are recalled.

Substantiating evidence exists for such a network of relations. For example, when argument overlap is low, as occurs when a new idea cannot be related directly to a previously mentioned idea (called a violation of the "given-new contract"; Haviland & Clark, 1974), both comprehension and recall are poor (e.g., Haviland & Clark, 1974; Hupet & LeBouedec, 1977; Kieras, 1978; Lesgold, Roth, & Curtis, 1979; Yekovich, Walker, & Blackman, 1979). On the other hand, when connections can be established (e.g., by drawing inferences to link the new and old ideas) recall is good (Kieras, 1978; Yekovich & Manelis, 1980).

Consider now the Bransford and Johnson (1972) materials that provided the classic demonstration for the existence of the selection process. Their passages contain no explicit, concrete referents, and without a context to suggest exemplars for these referents, none is likely to be inferred. This should inhibit construction of networks of connections among the sentences at least by preventing extensive use of the given-new strategy. This would serve to reduce the possibility that one sentence could cue another at recall. It is not surprising then that recall of these materials is so poor; subjects had in effect been presented with a set of unrelated sentences.

It has long been known of course that units related to one another either hierarchically

⁴ Such a notion is reminiscent of views about the connections established during the learning of arbitrary pairs of simple verbal units; for example, connections are established between the two members of each pair as well as among all items serving as stimuli and all items serving as responses (Segal & Mandler, 1967).

or associatively are easier to recall than are unrelated units (e.g., Deese, 1959). Recent demonstrations of this point also exist for stimulus sets ranging from individual words (e.g., Bower & Clark-Meyers, 1980; see also Bower, Clark, Lesgold, & Winzenz, 1969) to prose (Schustack & Anderson, 1979; Thorndyke, 1977). When subjects are prevented from forming connections either by omitting a cue to the existence of a hierarchy or by presenting such a cue only after the story has been read, recall is poor for both prose (Schustack & Anderson, 1979; Thorndyke, 1977) and simpler verbal materials (Bower et al., 1969).

A similar analysis applies to frame theory studies in which sentences constituting a story are presented in scrambled versus story-normal order (e.g., Thorndyke, 1977).³ Random sentence order could easily reduce the ability of a subject to determine the connections among ideas or elements in the passage, and the relative absence of such intersentence connections should reduce recall. Similarly, recall of stories taken from other cultures may be poor, in part because of the difficulty American students have in establishing appropriate intersentence or propositional links during the encoding process (Kintsch & Greene, 1978; Mandler & Johnson, 1977).

On some occasions, one message may lead to the establishment of two or more independent propositional networks, each with its own hierarchical structure. This is the situation that should prevail whenever a story can be read from two different perspectives and the ideas related to one perspective are irrelevant to the other. Given one encoding context, connections among related sentences should be established. All others will exist outside of this network, either as unrelated sentences or as sentences related in their own network. During recall, the proposition at the top of the hierarchy (often the theme) is the most easily recalled proposition (for reasons to be discussed shortly) and is used to access subordinate, related ideas. If the subject uses only the main theme as his or her retrieval plan, ideas irrelevant to that theme (i.e., those ideas existing outside of the text base) may never be accessed. This corresponds to the findings of Pichert and An-

derson (1977). However, when subjects are given the alternative theme as a retrieval cue, previously irrelevant ideas become accessible (Anderson & Pichert, 1978). These newly relevant ideas may not be particularly well recalled; after all, they were not encoded in the context of their theme, and so the theme's use as a retrieval cue will likely be limited (Schustack & Anderson, 1979; Thorndyke, 1977; Tulving & Thomson, 1973).

The ability to relate sentences to one another during encoding may be a determining factor involved in recalling the propositions of a text. If ideas are not or cannot be connected to a higher-order cue (Pichert & Anderson, 1977; Thorndyke, 1977) or to each other (e.g., Bransford & Johnson, 1972; Chiesi et al., 1979) during encoding, recall will be poor. Retrieval deficits ordinarily found with free recall may be circumvented by the use of either retrieval cues or recognition tests (e.g., Alba et al., 1981; Britton et al., 1980; Chiesi et al., 1979).

Similar processes can be used to explain the importance effect, that is, the fact that ideas important to the theme are more likely to be recalled than ideas that are not so important. The majority of research on the importance variable confirms its role in recall, but again, it is not necessary that the underlying process be a differential encoding one. A number of recent findings suggest that items at all levels of importance receive the same amount of initial processing (Britton, Meyer, Simpson, Holdredge, & Curry, 1979; Johnson & Scheidt, 1977; Waters, 1978). Since low-importance information has recently been shown to be forgotten at the same rate as high-importance information (Christiaansen, 1980), the explanation for the recall advantage of high-importance information must lie with its advantage in accessibility. An explanation favoring this view involves Kintsch and van Dijk's (1978) propositional hierarchy algorithm for establishing a text base. If the first idea retrieved is the highest level proposition (or theme), recall will occur

³ For recent critiques of story grammars as models of comprehension, representation, and recall of text materials see Black and Bower (1980), Brewer and Lichtstein (1981), and Thorndyke and Yekovich (1980).

in a top-down manner with each recalled proposition cuing one or more below it. The model favors the recall of higher level propositions (Bower, 1976). For a low-level proposition to be recalled, the complete chain of propositions above it must be kept intact. This kind of text analysis has been quite successful in predicting recall performance (Kintsch & Keenan, 1973; Kintsch et al., 1975; Kozminsky, 1977; Meyer, 1975; Thorndyke, 1977). Others have also proposed that text material is retrieved in a top-down order (Britton et al., 1979; Waters, 1978; Yekovich & Thorndyke, 1981).

That recall of prose ordinarily proceeds in a top-down manner through a hierarchy means, of course, that items higher in the hierarchy are likely to be recalled before items lower in the hierarchy. Output order, too, is a variable long known (see Postman & Underwood, 1973; Spear, 1978) to influence recall; items recalled early in a series decrease the probability that other actually stored items will be recalled.

Kintsch and van Dijk's (1978) model offers a reasonably objective determination of proposition importance. Important ideas may be ones that are referred to by others and so tend to be called into working memory more frequently and/or spend more time in working memory than others. As a consequence of the rehearsal processes that occur in working memory, such ideas will tend to have connections to a greater number of other ideas than will less important ideas. Components of each connection may then serve as retrieval cues (see also Graesser, 1978a; Graesser et al., 1980).

Rehearsal now becomes an important determinant of recall of prose elements, as it has long been considered to be in recall of simpler units (e.g., Rundus, 1971). It is entirely possible that what is loosely called the "theme" is the proposition or concept that is most frequently rehearsed or referred to during encoding—hence its relatively easy accessibility (Hasher & Griffin, 1978; Perfetti & Goldman, 1974).⁶ Some evidence for the rehearsal hypothesis does exist. The more ideas that descend from a particular piece of information, the greater the likelihood of its recall (Meyer & McConkie, 1973). Main actions in an episode are recalled better as the

number of related subordinate actions that accompany them increases (Black & Bower, 1979). Rehearsal of connected ideas may also account for the finding that recall of high-importance ideas is good even when subjects (in this case children) are unable to discriminate between ideas of high and low importance (e.g., Brown & Smiley, 1977).

Thus, a number of nonschema theory memory processes appear to be involved in prose recall: the existence and extent of connections among ideas; differential rehearsal processes based on (covert) intersentence cuing during the comprehension process; the availability and usefulness of retrieval cues at recall; and output-order produced accessibility problems. These are all conceptualizations with origins in nonschema theory research. Such processes, when coupled with contemporary associationist views of the representation of prose (e.g., Anderson & Bower, 1973; Kintsch & van Dijk, 1978), offer the possibility of accounting for differences in idea recallability without invoking selective encoding.⁷ More is stored in memory than any version of a schema-based selective encoding mechanism can account for. Alternative conceptions must begin to take this into consideration.

Abstraction

Abstraction may also be amenable to explanations that emphasize retrieval rather than encoding factors. Although meaning is undoubtedly the easiest aspect of a passage to recall, subjects appear to store, and sometimes remember, the syntactic and lexical vehicles by which meaning is conveyed. Meaning may be the most persistent attribute (e.g., McKoon, 1977) in part because it is the

⁶ Another nonschema explanation of the importance effect involves response biases. That is, there seems to be a predisposition to label as the theme the initially encountered idea in a prose passage (Kieras, 1980). Thus, surface structure variables may influence a person's choice of the most important proposition.

⁷ We do not wish to ignore the concept of macrostructure in the Kintsch and van Dijk model of prose comprehension. This aspect of the model is indeed a schema process in that a few important propositions are selected for representation in the macrostructure. The macrostructure alone, though, cannot account for the levels and importance effects.

information that the perceiver is most intent on remembering (Kintsch, 1977; Wanner, 1968) and/or the attribute most rehearsed, and/or the attribute least susceptible to interference.

Task demands may also influence the accessibility of nonsemantic detail. For example, instructions to process grammatical features of a sentence result in a marked increase in memory for those features (e.g., Anderson & Paulson, 1977; Graesser & Mandler, 1975; Johnson-Laird & Stevenson, 1970). By contrast, most story materials and instructions probably emphasize the importance of meaning.

Breakdowns in the retrieval process may also account for the occasional failure to remember lexical details. One theory that assumes that memory contains accurate traces even of complex events proposes that discrimination among related traces is a central source of lexical errors (e.g., Hayes-Roth & Hayes-Roth, 1977). For example, processing of a lexical unit may activate related, sometimes synonymous, traces in memory either through spread of activation (Hayes-Roth & Hayes-Roth, 1977) or through the implicit generation of associative responses (e.g., Underwood, 1965). Errors may occur on a memory test if the associated lexical traces have been strongly activated and can compete with the target information. Hence occasional substitution errors may occur even though veridical traces are stored in memory.

In summary, there are alternatives to schema theory that can account for the abstraction errors traditionally explained by schema theory but that also account for the not infrequent cases of mnemonic accuracy without appealing to "probable detail" explanations.

Interpretation and Integration

These are probably the most interesting and widely discussed schema-theory constructs. This is so because, together with abstraction, they are held to be responsible for distortions of past events, and distortions are inherently interesting. However, distortions are not really all that common. Although it is the case that schema theory can account for them, schema theory is at its weakest in

accounting for accurate memory of past events; a fair number of studies have shown rather startling levels of accuracy even when subjects had no particular reason to expect a memory test (e.g., the work of Kintsch, Bates, and their collaborators).

What is needed, in our view, is a theory of memory that can account both for accuracy and for distortion. A recent model of memory processes may be a useful candidate (see Johnson & Raye, 1981). According to this model, memory for an event will normally consist of individual traces from the external event as well as traces from any internal (subject-produced) generation done during the comprehension process or during any subsequent reprocessing of the event. Associated with each trace are a variety of attributes (see Underwood, 1969), and the relative amounts of these attributes serve as a base for distinguishing between internally generated and externally derived traces. When a trace is retrieved during a memory test, the information that identifies its origin will be used to determine whether or not the trace was part of the original stimulus. If a trace was not part of the original event, and if accuracy is encouraged, the trace will not be recalled (nor will it be misrecognized), and accuracy will result. On some occasions, however, the critical discriminative attribute information may become inaccessible, and source-of-origin discriminations will not be possible. Misrecognition of information internally generated during encoding (constructive errors or interpretations) will result (see also Anderson & Bower, 1973; Hayes-Roth & Thorndyke, 1979).

There exists some preliminary evidence to support this portion of the Johnson-Raye theory. Conditions that make source discrimination more difficult should increase the rate of confabulation. In fact, fact versus fantasy discrimination ability for inferences decreases when a delay (Owens et al., 1979) or an interfering task (Brockway et al., 1974) is inserted between acquisition and recall. Discrimination increases when source-identifying attributes are made more salient (Alba, 1981; Johnson et al., 1981).

The reality-monitoring model has the added advantage of being able to explain a wide variety of mnemonic errors. The same

explanation that is used to account for pragmatic inference errors, can also be used to account for logical inference misrecognition errors (e.g., linear orderings), single word errors (e.g., Underwood, 1965; Underwood & Freund, 1968), elaborative prose errors (e.g., Kintsch et al., 1975; Sulin & Dooling, 1974), default value errors (Minsky, 1975), and importantly, alleged reconstructive errors (e.g., Spiro, 1977, 1980a, 1980b). That is, when responding on a memory test, people may confuse internally generated memory traces with traces resulting from the encoding of the (external) stimulus array.

Reconstructive errors can be distinguished from most other types of errors discussed in this article in that they are believed to be the result of processes occurring at some point after initial encoding. The most frequently cited evidence in support of the reconstruction process is the work of Spiro (1977, 1980a, 1980b). As Royer (1977) points out, however, the results do not necessarily imply reconstruction; reconstruction errors may be considered highly similar to other inferences generated during encoding and thereby perfectly consistent with a reality-monitoring account of mnemonic error. Although it is merely speculation at this point, the same explanation, combined with other factors discussed below, may account for those reconstructive errors predicted by script theory and known as the typicality effect.

Two other aspects of the reality monitoring theory can help to explain other forms of mnemonic inaccuracy. First, the model assumes that confidence that a particular trace is internally or externally generated is distributed in a way similar to some models of recognition memory (e.g., Atkinson & Juola, 1973). That is, some traces are easily identified as internally generated, whereas others are easily identified as externally derived. In between, a region of uncertainty exists. How these items are identified may depend on test conditions. If subjects are urged to be conservative (e.g., Gauld & Stephenson, 1967) or are given additional time or cues with which to make discriminations (e.g., Hasher & Griffin, 1978; Lawson, 1977), fewer internally generated traces in the uncertain region will be produced, and accuracy will increase.

Second, Johnson and Raye (1981) report that traces in the uncertain region are subject to response biases. When the source of a trace is uncertain, there is a tendency to attribute it to external sources (Johnson et al., 1981). Thus, when familiar ideas (e.g., thematic ideas) are encountered on a recognition test, subjects may misrecognize them not because they are confidently recalling them from an integrated schema, but rather because they have a particular response bias. Explanations that appeal to reconstruction processes such as the typicality effect predicted by script theory (e.g., Bower et al., 1979; Graesser et al., 1979; Graesser et al., 1980) and schema theory (e.g., Sulin & Dooling, 1974) may be better accommodated by the response biases discussed within the framework of the reality-monitoring model.⁸

An Overview

As we noted at the outset, recent research in cognitive psychology has been greatly influenced by schema theoretic. Although the present article has in large part questioned the specifics of schema theory, there can be no denying its generally beneficial impact on the field of memory. Schema theory has revitalized the area and moved researchers to consider a number of new issues about the nature of memory as well as about the parameters of the comprehension process (see for example, Graesser, Hoffman, & Clark, 1980; Kieras, 1981; Miller & Kintsch, 1980; Vipond, 1980). Although we have noted that certain interpretive processes are not the sole domain of schema theory, it has been within

⁸ Script theory assumes that highly typical aspects of scripted events are already stored as part of a script; when such events are actually encountered, there is no need to restore these aspects. Subjects may, as a result, not be able to distinguish between highly typical aspects of events that did versus did not actually occur in a particular instantiation of a script; this is termed the typicality effect (e.g., Smith & Graesser, 1980). This effect is the single most powerful demonstration of a reconstruction process. As just mentioned, response biases seem a likely nonschema explanation. Some recent evidence also suggests that the effect is tied to particular confusing aspects of the "typical" procedures used in typicality research and is not an inevitable consequence of activating a script and encountering (or not encountering) highly typical events (Chromiak, Note 3).

the context of schema theory that these processes have been explored.

Nevertheless, we must return to the basic problem confronting schema theory: its definition. Taylor and Crocker (1981) present an excellent discussion of the adequacy of schema theory as a theory. We will not attempt to elaborate on their discussion except to once again point out the nebulous character of the theory and to restate our attempt to place some structure on what has transpired in the past 15 years.

We have proposed that schema theories share a belief in one or more of four basic memory encoding processes: selection, abstraction, interpretation, and integration. Three of these, selection, abstraction, and integration, are processes that reduce the amount of information that will be stored in memory. Selection does this by allowing only some information to receive further processing. Abstraction does this by dropping from the representation all but the underlying meaning of a message. Integration does this by creating a holistic representation of whatever remains after selection and abstraction with whatever relevant knowledge exists in memory. This holistic representation does not include markers that would enable the person to inevitably distinguish old from new information. The final process, interpretation, is the only one that enriches the memory representation, and it does so by adding inferences, omitted details, and relevant prior knowledge to the incoming message.

A final evaluation of schema theories hinges on two issues. These are (a) what is really stored in memory and (b) what causes distortions of factual information. Our review of the literature suggests that memory for complex events is far more detailed than schematic processes would allow. At least some schematically unimportant information is stored. At least some details are stored no matter what the extent of a person's prior knowledge, and no matter whether that knowledge is activated at encoding. Lexical and syntactic information, along with semantic information, are all accorded representation in memory. Memory of a topic does not seem to consist of a tightly integrated set of all relevant information. Although subjects

may impose their own interpretations on incoming stimuli, they appear to do so less often than schema theory would suggest. When people do generate interpretations, source identifying markers are not necessarily lost.

The final questions center on what determines recall. We have suggested that the schema theory research can be accounted for by assuming that a detailed representation of a complex event is actually stored in memory, perhaps in a format suggested by such text-comprehension models as Kintsch and van Dijk's (1978). What a subject shows of what he or she has stored will hinge on a variety of circumstances, some having to do with connections formed or not formed during encoding and with rehearsal processes during encoding and/or the retention interval, as well as with processes such as cuing, output order, response biases, task demands, and so forth, that operate during retrieval. We have argued that there are a variety of nonschematic concepts available to explain memory for complex events. Whatever the ultimate usefulness of these latter arguments may prove to be, however, we think it clear that the stored record of any event is far more detailed than prototypical schema theories imply. Contemporary theories of memory cannot disregard the richness of the stored trace.

Reference Notes

1. Day, J., Stein, N. L., Trabasso, T., & Shirey, L. *A study of inferential comprehension: The use of a story schema to remember picture sequences*. Paper presented at the meeting of the Society for Research in Child Development, San Francisco, 1979.
2. Stein, N. L., & Glenn, C. G. *The role of structural variation in children's recall of simple stories*. Paper presented at the meeting of the Society for Research in Child Development, New Orleans, 1977.
3. Chromiak, W. Personal Communication. May 1982.

References

- Alba, J. W. *The representational nature of inferences*. Unpublished doctoral dissertation. Temple University, Philadelphia, 1981.
- Alba, J. W., Alexander, S. G., Hasher, L., & Caniglia, K. The role of context in the encoding of information. *Journal of Experimental Psychology: Human Learning and Memory*, 1981, 7, 283-292.
- Anderson, J. R. Verbatim and propositional representation of sentences in immediate and long-term mem-

- ory. *Journal of Verbal Learning and Verbal Behavior*, 1974, 13, 149-162.
- Anderson, J. R. *Language, memory and thought*. Hillsdale, N.J.: Erlbaum, 1976.
- Anderson, J. R., & Bower, G. H. *Human associative memory*. Washington, D.C.: Winston, 1973.
- Anderson, J. R., & Paulson, R. Representation and retention of verbatim information. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 439-451.
- Anderson, R. C. Encoding processes in the storage and retrieval of sentences. *Journal of Experimental Psychology*, 1971, 91, 338-340.
- Anderson, R. C. Substance recall of sentences. *Quarterly Journal of Experimental Psychology*, 1974, 26, 530-541.
- Anderson, R. C., et al. Instantiation of general terms. *Journal of Verbal Learning and Verbal Behavior*, 1976, 15, 667-679.
- Anderson, R. C., & Pichert, J. W. Recall of previously unrecalled information following a shift in perspective. *Journal of Verbal Learning and Verbal Behavior*, 1978, 17, 1-12.
- Anisfeld, M., & Knapp, M. Association, synonymy, and directionality in false recognition. *Journal of Experimental Psychology*, 1968, 77, 171-179.
- Atkinson, R. C., & Juola, J. F. Factors influencing speed and accuracy of word recognition. In S. Kornblum (Ed.), *Attention and Performance IV*. New York: Academic Press, 1973.
- Ausubel, D. P. The use of advance organizers in the learning and retention of meaningful material. *Journal of Educational Psychology*, 1960, 51, 267-272.
- Ausubel, D. P. *Educational psychology: A cognitive view*. New York: Holt, Rinehart & Winston, 1968.
- Ausubel, D. P., & Fitzgerald, D. The role of discriminability in meaningful verbal learning and retention. *Journal of Educational Psychology*, 1961, 52, 266-274.
- Ausubel, D. P., & Fitzgerald, D. Organizer, general background, and antecedent learning variables in sequential verbal learning. *Journal of Educational Psychology*, 1962, 53, 243-249.
- Baker, L. Processing temporal relationships in simple stories: Effects of input sequence. *Journal of Verbal Learning and Verbal Behavior*, 1978, 17, 559-572.
- Barclay, J. R. The role of comprehension in remembering sentences. *Cognitive Psychology*, 1973, 4, 229-254.
- Barnes, B. R., & Clawson, E. U. Do advance organizers facilitate learning? Recommendations for further research based on an analysis of 32 studies. *Review of Educational Research*, 1975, 45, 637-659.
- Bartlett, F. C. *Remembering: A study in experimental and social psychology*. Cambridge, England: Cambridge University Press, 1932.
- Bates, E., Kintsch, W., Fletcher, C. R., & Giuliani, V. The role of pronominalization and ellipsis in texts: Some memory experiments. *Journal of Experimental Psychology: Human Learning and Memory*, 1980, 6, 676-691.
- Bates, E., Masling, M., & Kintsch, W. Recognition memory for aspects of dialogue. *Journal of Experimental Psychology: Human Learning and Memory*, 1978, 4, 187-197.
- Begg, I. Recognition memory for sentence meaning and wording. *Journal of Verbal Learning and Verbal Behavior*, 1971, 10, 176-181.
- Begg, I., & Wickelgren, W. A. Retention functions for syntactic and lexical vs. semantic information in sentence recognition memory. *Memory & Cognition*, 1974, 2, 353-359.
- Bekerman, D. A., & Bowers, J. M. Eyewitness testimony: Were we misled? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 1983, 9, 139-145.
- Birnbaum, I. M., Johnson, M. K., Hartley, J. T., & Taylor, T. H. Alcohol and elaborative schemas for sentences. *Journal of Experimental Psychology: Human Learning and Memory*, 1980, 6, 293-300.
- Black, J. B., & Bower, G. H. Episodes as chunks in narrative memory. *Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 309-318.
- Black, J. B., & Bower, G. H. Story understanding as problem-solving. *Poetics*, 1980, 9, 233-250.
- Bobrow, S. A. Memory for words in sentences. *Journal of Verbal Learning and Verbal Behavior*, 1970, 9, 363-372.
- Bock, J. K. The effect of a pragmatic presupposition on syntactic structure in question answering. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 723-734.
- Bock, J. K., & Brewer, W. F. Reconstructive recall in sentences with alternative surface structures. *Journal of Experimental Psychology*, 1974, 103, 837-843.
- Bower, G. H. Experiments on story understanding and recall. *Quarterly Journal of Experimental Psychology*, 1976, 28, 511-534.
- Bower, G. H., Black, J. B., & Turner, T. J. Scripts in memory for text. *Cognitive Psychology*, 1979, 11, 177-220.
- Bower, G. H., Clark, M. C., Lesgold, A. M., & Winzenz, D. Hierarchical retrieval schemas in recall of categorized word lists. *Journal of Verbal Learning and Verbal Behavior*, 1969, 8, 323-343.
- Bower, G. H., & Clark-Meyers, G. Memories for scripts with organized vs. randomized presentations. *British Journal of Psychology*, 1980, 71, 369-397.
- Bower, G. H., Karlin, M. B., & Dueck, A. Comprehension and memory for pictures. *Memory & Cognition*, 1975, 3, 216-220.
- Bransford, J. D., Barclay, J. R., & Franks, J. J. Sentence memory: A constructive vs. interpretive approach. *Cognitive Psychology*, 1972, 3, 193-209.
- Bransford, J. D., & Franks, J. J. The abstraction of linguistic ideas. *Cognitive Psychology*, 1971, 2, 331-350.
- Bransford, J. D., & Johnson, M. K. Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior*, 1972, 11, 717-726.
- Bransford, J. D., & Johnson, M. K. Considerations of some problems of comprehension. In W. G. Chase (Ed.), *Verbal information processing*. New York: Academic Press, 1973.
- Bransford, J. D., & Nitsch, K. E. Coming to understand things we could not previously understand. In J. F. Kavanagh & W. Strange (Eds.), *Speech and language in the laboratory, school, and clinic*. Cambridge, Mass.: MIT Press, 1978.
- Brewer, W. F. Memory for ideas: Synonym substitution. *Memory & Cognition*, 1975, 3, 458-464.

- Brewer, W. F. Memory for the pragmatic implications of sentences. *Memory & Cognition*, 1977, 5, 673-678.
- Brewer, W. F., & Lichtenstein, E. H. Memory for marked semantic features versus memory for meaning. *Journal of Verbal Learning and Verbal Behavior*, 1974, 13, 172-180.
- Brewer, W. F., & Lichtenstein, E. H. Event schemas, story schemas, and story grammars. In J. Long & A. Baddeley (Eds.), *Attention and performance IX*. Hillsdale, N.J.: Erlbaum, 1981.
- Brewer, W. F., & Treyns, J. C. Role of schemata in memory for places. *Cognitive Psychology*, 1981, 13, 207-230.
- Britton, B. K., Meyer, B. J., Hodge, M. H., & Glynn, S. M. Effects of the organization of text on memory: Tests of the retrieval and response criterion hypotheses. *Journal of Experimental Psychology: Human Learning and Memory*, 1980, 6, 620-629.
- Britton, B. K., Meyer, B. J. F., Simpson, R., Holdredge, T. S., & Curry, C. Effects of the organization of text on memory: Tests of two implications of a selective attention hypothesis. *Journal of Experimental Psychology: Human Learning and Memory*, 1979, 5, 496-506.
- Brockway, J. F., Chmielewski, D., & Cofer, C. N. Remembering prose: Productivity and accuracy constraints in recognition memory. *Journal of Verbal Learning and Verbal Behavior*, 1974, 13, 194-208.
- Brown, A. L., & Smiley, S. S. Rating the importance of structural units of prose passages: A problem of metacognitive development. *Child Development*, 1977, 48, 1-8.
- Brown, A. L., Smiley, S. S., Day, J. D., Townsend, M. A. R., & Lawton, S. C. Intrusion of a thematic idea in children's comprehension and retention of stories. *Child Development*, 1977, 48, 1454-1466.
- Bugelski, B. R. Images as mediators in one-trial paired-associate learning. II: Self-timing in successive lists. *Journal of Experimental Psychology*, 1968, 77, 328-334.
- Burnett, S. A., & Stevenson, J. M. Instructional effects on frequency judgments for sentence meanings. *American Journal of Psychology*, 1979, 92, 711-721.
- Chase, W. G., & Simon, H. A. Perception in chess. *Cognitive Psychology*, 1973, 4, 55-81.
- Chi, M. T. H. Knowledge structures and memory development. In R. S. Siegler (Ed.), *Children's thinking: What develops?* Hillsdale, N.J.: Erlbaum, 1978.
- Chiesi, H. L., Spilich, G. J., & Voss, J. F. Acquisition of domain-related information in relation to high and low domain knowledge. *Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 257-274.
- Christiaansen, R. E. Prose memory: Forgetting rates for memory codes. *Journal of Experimental Psychology: Human Learning and Memory*, 1980, 6, 611-619.
- Christie, D. J., & Schumacher, G. M. Developmental trends in the abstraction and recall of relevant versus irrelevant thematic information from connected verbal materials. *Child Development*, 1975, 46, 598-602.
- Clark, H. H., & Clark, E. V. Semantic distinctions and memory for complex sentences. *Quarterly Journal of Experimental Psychology*, 1968, 20, 129-138.
- Cofer, C. N. Constructive processes in memory. *American Scientist*, 1973, 61, 537-543.
- Cofer, C. N., Chmielewski, D. L., & Brockway, J. F. Constructive processes and the structure of human memory. In C. N. Cofer (Ed.), *The structure of human memory*. San Francisco: Freeman, 1976.
- Corbett, A. T., & Doshier, B. A. Instrument inferences in sentence encoding. *Journal of Verbal Learning and Verbal Behavior*, 1978, 17, 479-491.
- Deese, J. On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology*, 1959, 58, 17-22.
- de Villiers, P. A. Imagery and theme in recall of connected discourse. *Journal of Experimental Psychology*, 1974, 103, 263-268.
- Dodd, D. H., & Bradshaw, J. M. Leading questions and memory: Pragmatic constraints. *Journal of Verbal Learning and Verbal Behavior*, 1980, 19, 695-704.
- Dooling, D. J., & Christiaansen, R. E. Episodic and semantic aspects of memory for prose. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, 3, 428-436. (a)
- Dooling, D. J., & Christiaansen, R. E. Levels of encoding and retention of prose. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 11). New York: Academic Press, 1977. (b)
- Dooling, D. J., & Lachman, R. Effects of comprehension on retention of prose. *Journal of Experimental Psychology*, 1971, 88, 216-222.
- Dooling, D. J., & Mullet, R. L. Locus of thematic effects in retention of prose. *Journal of Experimental Psychology*, 1973, 97, 404-406.
- Fass, W., & Schumacher, G. M. Schema theory and prose retention: Boundary conditions for encoding and retrieval effects. *Discourse Processes*, 1981, 4, 17-26.
- Fischhoff, B. Hindsight \neq foresight: The effect of outcome knowledge on judgment under uncertainty. *Journal of Experimental Psychology: Human Performance and Perception*, 1975, 1, 288-299.
- Fischhoff, B. Perceived informativeness of facts. *Journal of Experimental Psychology: Human Performance and Perception*, 1977, 3, 349-358.
- Fischhoff, B., & Beyth, R. I knew it would happen—Remembered probabilities of once-future things. *Organizational Behavior and Human Performance*, 1975, 13, 1-16.
- Flagg, P. W. Semantic integration in sentence memory? *Journal of Verbal Learning and Verbal Behavior*, 1976, 15, 491-504.
- Flagg, P. W., & Reynolds, A. G. Modality of presentation and blocking in sentence recognition memory. *Memory & Cognition*, 1977, 5, 111-115.
- Frederiksen, C. H. Acquisition of semantic information from discourse: Effects of repeated exposures. *Journal of Verbal Learning and Verbal Behavior*, 1975, 14, 158-169. (a)
- Frederiksen, C. H. Effects of context-induced processing operations on semantic information acquired from discourse. *Cognitive Psychology*, 1975, 7, 139-166. (b)
- Gauld, A., & Stephenson, G. M. Some experiments relating to Bartlett's theory of remembering. *British Journal of Psychology*, 1967, 58, 39-49.
- Gentner, D., & Loftus, E. F. Integration of verbal and visual information as evidenced by distortions in picture memory. *American Journal of Psychology*, 1979, 92, 366-375.

- Glenn, C. G. The role of episodic structure and of story length in children's recall of simple stories. *Journal of Verbal Learning and Verbal Behavior*, 1978, 17, 229-247.
- Goetz, E. T. Inferring from text: Some factors influencing which inferences will be made. *Discourse Processes*, 1979, 2, 179-195.
- Gomulicki, B. R. Recall as an abstractive process. *Acta Psychologica*, 1956, 12, 77-94.
- Graesser, A. C. How to catch a fish: The memory and representation of common procedures. *Discourse Processes*, 1978, 1, 72-89. (a)
- Graesser, A. C. Tests of a holistic chunking model of sentence memory through analyses of noun intrusions. *Memory & Cognition*, 1978, 6, 527-536. (b)
- Graesser, A. C., Gordon, S. E., & Sawyer, J. D. Recognition memory for typical and atypical actions in scripted activities: Tests of a script pointer + tag hypothesis. *Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 319-332.
- Graesser, A. C., Hoffman, N. L., & Clark, L. F. Structural components of reading time. *Journal of Verbal Learning and Verbal Behavior*, 1980, 19, 135-151.
- Graesser, A., II, & Mandler, G. Recognition memory for the meaning and surface structure of sentences. *Journal of Experimental Psychology: Human Learning and Memory*, 1975, 1, 238-248.
- Graesser, A. C., Robertson, S. P., Lovelace, E. R., & Swinehart, D. M. Answers to why-questions expose the organization of story plot and predict recall of actions. *Journal of Verbal Learning and Verbal Behavior*, 1980, 19, 110-119.
- Graesser, A. C., Woll, S. B., Kowalski, D. J., & Smith, D. A. Memory for typical and atypical actions in scripted activities. *Journal of Experimental Psychology: Human Learning and Memory*, 1980, 6, 503-515.
- Greene, E., Flynn, M. S., & Loftus, E. F. Inducing resistance to misleading information. *Journal of Verbal Learning and Verbal Behavior*, 1982, 21, 207-219.
- Greenwald, A. G. The totalitarian ego: Fabrication and revision of personal history. *American Psychologist*, 1980, 35, 603-618.
- Griggs, R. A. The recall of linguistic ideas. *Journal of Experimental Psychology*, 1974, 103, 807-809.
- Griggs, R. A., & Keen, D. M. The role of test procedure in linguistic integration studies. *Memory & Cognition*, 1977, 5, 685-689.
- Gude, C., & Zechmeister, E. B. Frequency judgments for the "gist" of sentences. *American Journal of Psychology*, 1975, 88, 385-396.
- Hannigan, M. L. The effects of frameworks on sentence perception and memory. Unpublished doctoral dissertation, Vanderbilt University, 1976.
- Harris, R. J. Memory and comprehension of implications and inferences of complex sentences. *Journal of Verbal Learning and Verbal Behavior*, 1974, 13, 626-637.
- Harris, R. J., & Monaco, G. E. Psychology of pragmatic implication: Information processing between the lines. *Journal of Experimental Psychology: General*, 1978, 107, 1-22.
- Hasher, L., Attig, M. S., & Alba, J. W. I knew it all along: Or did I? *Journal of Verbal Learning and Verbal Behavior*, 1981, 20, 86-96.
- Hasher, L., & Griffin, M. Reconstructive and reproductive processes in memory. *Journal of Experimental Psychology: Human Learning and Memory*, 1978, 4, 318-330.
- Haviland, S. E., & Clark, H. H. What's new? Acquiring new information as a process in comprehension. *Journal of Verbal Learning and Verbal Behavior*, 1974, 13, 512-521.
- Hayes-Roth, B., & Hayes-Roth, F. The prominence of lexical information in memory representations of meaning. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 119-136.
- Hayes-Roth, B., & Thorndyke, P. W. Integration of knowledge from texts. *Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 91-108.
- Hupet, M., & LeBouedec, B. The given-new contract and the constructive aspect of memory for ideas. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 69-75.
- James, C. T., & Hillinger, M. L. The role of confusion in the semantic integration paradigm. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 711-721.
- James, C. T., Hillinger, M. L., & Murphy, B. J. The effect of complexity on confidence ratings in linguistic integration. *Memory & Cognition*, 1977, 5, 355-361.
- James, C. T., Thompson, J. G., & Baldwin, J. M. The reconstructive process in sentence memory. *Journal of Verbal Learning and Verbal Behavior*, 1973, 12, 51-63.
- Jarvella, R. J. Syntactic processing of connected speech. *Journal of Verbal Learning and Verbal Behavior*, 1971, 10, 409-416.
- Johnson, M. K., Bransford, J. D., & Solomon, S. K. Memory for tacit implications of sentences. *Journal of Experimental Psychology*, 1973, 98, 203-205.
- Johnson, M. K., Doll, T. J., Bransford, J. D., & Lapinski, R. H. Context effects in sentence memory. *Journal of Experimental Psychology*, 1974, 103, 358-360.
- Johnson, M. K., & Raye, C. L. Reality monitoring. *Psychological Review*, 1981, 88, 67-85.
- Johnson, M. K., Raye, C. L., Foley, H. J., & Foley, M. A. Cognitive operations and decision bias in reality monitoring. *American Journal of Psychology*, 1981, 94, 37-64.
- Johnson, R. E. Recall of prose as a function of the structural importance of the linguistic unit. *Journal of Verbal Learning and Verbal Behavior*, 1970, 9, 12-20.
- Johnson, R. E., & Scheidt, B. J. Organizational encodings in the serial learning of prose. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 575-588.
- Johnson-Laird, P. N., & Stevenson, R. Memory for syntax. *Nature*, 1970, 227, 412.
- Katz, S., Atkeson, B., & Lee, J. The Bransford-Franks linear effect: Integration or artifact? *Memory & Cognition*, 1974, 2, 709-713.
- Katz, S., & Gruenewald, P. The abstraction of linguistic ideas in "meaningless" sentences. *Memory & Cognition*, 1974, 2, 737-741.
- Keenan, J. M., & Kintsch, W. The identification of explicitly and implicitly presented information. In W. Kintsch (Ed.), *The representation of meaning in memory*. Hillsdale, N.J.: Erlbaum, 1974.
- Keenan, J. M., MacWhinney, B., & Mayhew, D. Pragmatics in memory: A study of natural conversation.

- Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 549-560.
- Kemper, S. Memory for the form and force of declaratives and interrogatives. *Memory & Cognition*, 1980, 8, 367-371.
- Kieras, D. E. Good and bad structure in simple paragraphs: Effects on apparent theme, reading time, and recall. *Journal of Verbal Learning and Verbal Behavior*, 1978, 17, 13-28.
- Kieras, D. E. Initial mention as a signal to thematic content in technical passages. *Memory & Cognition*, 1980, 8, 345-353.
- Kieras, D. E. Component processes in the comprehension of simple prose. *Journal of Verbal Learning and Verbal Behavior*, 1981, 20, 1-23.
- King, D. R. W., & Greeno, J. G. Invariance of inference time when information was presented in different linguistic formats. *Memory and Cognition*, 1974, 2, 233-235.
- Kintsch, W. *The representation of meaning in memory*. Hillsdale, N.J.: Erlbaum, 1974.
- Kintsch, W. *Memory and cognition*. New York: Wiley, 1977.
- Kintsch, W., & Bates, E. Recognition memory for statements from a classroom lecture. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, 3, 150-159.
- Kintsch, W., & Greene, E. The role of culture-specific schemata in the comprehension and recall of stories. *Discourse Processes*, 1978, 1, 1-13.
- Kintsch, W., & Keenan, J. M. Reading rate and retention as a function of the number of propositions in the base structure of sentences. *Cognitive Psychology*, 1973, 5, 257-274.
- Kintsch, W., & van Dijk, T. A. Toward a model of text comprehension and production. *Psychological Review*, 1978, 85, 363-394.
- Kintsch, W., Kozminsky, E., Streby, W. J., McKoon, G., & Keenan, J. M. Comprehension and recall of text as a function of content variables. *Journal of Verbal Learning and Verbal Behavior*, 1975, 14, 196-214.
- Kintsch, W., Mandel, T. S., & Kozminsky, E. Summarizing scrambled stories. *Memory & Cognition*, 1977, 5, 547-522.
- Kintsch, W., & Monk, D. Storage of complex information in memory: Some implications of the speed with which inferences can be made. *Journal of Experimental Psychology*, 1972, 94, 25-32.
- Kozminsky, E. Altering comprehension: The effect of biasing titles on text comprehension. *Memory & Cognition*, 1977, 5, 482-490.
- Lawson, R. Representation of individual sentences and holistic ideas. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, 3, 1-9.
- Lesgold, A. M. Pronominalization: A device for unifying sentences in memory. *Journal of Verbal Learning and Verbal Behavior*, 1972, 11, 316-323.
- Lesgold, A. M., Roth, S. F., & Curtis, M. E. Foregrounding effects in discourse comprehension. *Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 291-308.
- Lichtenstein, E. H., & Brewer, W. F. Memory for goal-directed events. *Cognitive Psychology*, 1980, 12, 412-445.
- Loftus, E. F. Leading questions and the eyewitness report. *Cognitive Psychology*, 1975, 7, 560-572.
- Loftus, E. F. *Eyewitness testimony*. Cambridge, Mass.: Harvard University Press, 1979. (a)
- Loftus, E. F. Reactions to blatantly contradictory information. *Memory & Cognition*, 1979, 7, 368-374. (b)
- Loftus, E. F., & Loftus, G. R. On the permanence of stored information in the human brain. *American Psychologist*, 1980, 35, 409-420.
- Loftus, E. F., Miller, D. G., & Burns, H. J. Semantic integration of verbal information into a visual memory. *Journal of Experimental Psychology: Human Learning and Memory*, 1978, 4, 19-31.
- Loftus, E. F., & Palmer, J. C. Reconstruction of automobile destruction: An example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior*, 1974, 13, 585-589.
- Mandler, J. M. A code in the node: The use of a story schema in retrieval. *Discourse Processes*, 1978, 1, 14-35.
- Mandler, J. M., & Johnson, N. S. Remembrance of things parsed: Story structure and recall. *Cognitive Psychology*, 1977, 9, 111-151.
- McKoon, G. Organization of information in text memory. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 247-260.
- McKoon, G., & Keenan, J. M. Response latencies to explicit and implicit statements as a function of the delay between reading and test. In W. Kintsch (Ed.), *The representation of meaning in memory*. Hillsdale, N.J.: Erlbaum, 1974.
- Meyer, B. J. F. *The organization of prose and its effect on recall*. Amsterdam: North Holland, 1975.
- Meyer, B. J. F. The structure of prose: Effects on learning and memory and implications for educational practice. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge*. Hillsdale, N.J.: Erlbaum, 1977.
- Meyer, B. J. F., & McConkie, G. What is recalled after hearing a passage? *Journal of Educational Psychology*, 1973, 65, 109-117.
- Meyers, L. S., & Boldrick, D. Memory for meaningful connected discourse. *Journal of Experimental Psychology: Human Learning and Memory*, 1975, 1, 584-591.
- Miller, J. R., & Kintsch, W. Readability and recall of short prose passages: A theoretical analysis. *Journal of Experimental Psychology: Human Learning and Memory*, 1980, 6, 335-354.
- Minsky, M. A framework for representing knowledge. In P. H. Winston (Ed.), *The psychology of computer vision*. New York: McGraw-Hill, 1975.
- Moesser, S. D. Inferential reasoning in episodic memory. *Journal of Verbal Learning and Verbal Behavior*, 1977, 15, 193-212.
- Moesser, S. D. Recognition processes in episodic memory. *Canadian Journal of Psychology*, 1977, 31, 41-70.
- Moesser, S. D., & Tarrant, B. L. Learning a network of comparisons. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, 3, 643-659.
- Morris, C. D., Bransford, J. D., & Franks, J. J. Loss of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 519-533.

- Morris, C. D., Stein, B. S., & Bransford, J. D. Prerequisites for the utilization of knowledge in the recall of prose passages. *Journal of Experimental Psychology: Human Learning and Memory*, 1979, 5, 253-261.
- Norman, D. A., & Rumelhart, D. E. Memory and knowledge. In D. A. Norman & D. E. Rumelhart (Eds.), *Explorations in cognition*. San Francisco: Freeman, 1975.
- Olson, D. R., & Filby, N. On the comprehension of active and passive sentences. *Cognitive Psychology*, 1972, 3, 361-381.
- Ortony, A., Schallert, D. L., Reynolds, R. E., & Antos, S. J. Interpreting metaphors and idioms: Some effects of context on comprehension. *Journal of Verbal Learning and Verbal Behavior*, 1978, 17, 465-478.
- Owens, J., Bower, G. H., & Black, J. B. The "soap-opera" effect in story recall. *Memory & Cognition*, 1979, 7, 185-191.
- Paris, S. G., & Carter, A. Semantic and constructive aspects of sentence memory in children. *Developmental Psychology*, 1973, 9, 189-197.
- Paris, S. G., & Lindauer, B. K. The role of inference in children's comprehension and memory for sentences. *Cognitive Psychology*, 1976, 8, 217-227.
- Paris, S. G., & Lindauer, B. K. Constructive aspects of children's comprehension and memory. In R. V. Kail, Jr. & J. W. Hagen (Eds.), *Perspectives on the development of memory and cognition*. Hillsdale, N.J.: Erlbaum, 1977.
- Paris, S. G., Lindauer, B. K., & Cox, G. L. The development of inferential comprehension. *Child Development*, 1977, 48, 1728-1733.
- Paris, S. G., & Upton, L. R. Children's memory for inferential relationships in prose. *Child Development*, 1976, 47, 660-668.
- Paul, I. H. Studies in remembering: The reproduction of connected and extended verbal material. *Psychological Issues*, 1959, 1(2, Whole No. 2).
- Perfetti, C. A., & Goldman, S. R. Thematization and sentence retrieval. *Journal of Verbal Learning and Verbal Behavior*, 1974, 13, 70-79.
- Pichert, J. W., & Anderson, R. C. Taking different perspectives on a story. *Journal of Educational Psychology*, 1977, 69, 309-315.
- Postman, L., & Underwood, B. J. Critical issues in interference theory. *Memory & Cognition*, 1973, 1, 19-40.
- Potts, G. R. Memory for redundant information. *Memory & Cognition*, 1973, 1, 467-470.
- Potts, G. R. Artificial logical relations and their relevance to semantic memory. *Journal of Experimental Psychology: Human Learning and Memory*, 1976, 2, 746-758.
- Potts, G. R. Integrating new and old information. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 305-320.
- Potts, G. R., Keller, R. A., & Rooley, C. J. Factors affecting the use of world knowledge to complete a linear ordering. *Journal of Experimental Psychology: Human Learning and Memory*, 1981, 7, 254-268.
- Prawat, R. S., & Cancelli, A. Constructive memory in conserving and nonconserving first graders. *Developmental Psychology*, 1976, 12, 47-50.
- Reitman, J. S., & Bower, G. H. Storage and later recognition of exemplars of concepts. *Cognitive Psychology*, 1973, 4, 194-206.
- Royer, J. M. Remembering: Constructive or reconstructive? Comments on chapter 5 by Spiro. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge*. Hillsdale, N.J.: Erlbaum, 1977.
- Royer, J. M., & Cable, G. W. Facilitative transfer in prose learning. *Journal of Educational Psychology*, 1975, 67, 116-123.
- Royer, J. M., & Cable, G. W. Illustrations, analogies, and facilitative transfer in prose learning. *Journal of Educational Psychology*, 1976, 68, 205-209.
- Royer, J. M., & Perkins, M. R. Facilitative transfer in prose learning over an extended period of time. *Journal of Reading Behavior*, 1977, 9, 185-188.
- Royer, J. M., Perkins, M. R., & Konold, C. E. Evidence for a selective storage mechanism in prose learning. *Journal of Educational Psychology*, 1978, 70, 457-462.
- Rubin, D. C. Very long-term memory for prose and verse. *Journal of Verbal Learning and Verbal Behavior*, 1977, 16, 611-621.
- Rundus, D. Analysis of rehearsal processes in free recall. *Journal of Experimental Psychology*, 1971, 89, 63-77.
- Sachs, J. S. Recognition memory for syntactic and semantic aspects of connected discourse. *Perception and Psychophysics*, 1967, 2, 437-442.
- Sachs, J. S. Memory in reading and listening to discourse. *Memory & Cognition*, 1974, 2, 95-100.
- Schallert, D. L. Improving memory for prose: The relationship between depth of processing and context. *Journal of Verbal Learning and Verbal Behavior*, 1976, 15, 621-632.
- Schank, R. C. Conceptual dependency: A theory of natural language understanding. *Cognitive Psychology*, 1972, 3, 552-631.
- Schank, R. C. The role of memory in language processing. In C. N. Cofer (Ed.), *The structure of human memory*. San Francisco: Freeman, 1976.
- Schank, R. C., & Abelson, R. *Scripts, plans, goals, and understanding*. Hillsdale, N.J.: Erlbaum, 1977.
- Schustack, M. W., & Anderson, J. R. Effects of analogy to prior knowledge on memory for new information. *Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 565-584.
- Schweller, K. G., Brewer, W. F., & Dahl, D. A. Memory for illocutionary forces and perlocutionary effects of utterances. *Journal of Verbal Learning and Verbal Behavior*, 1976, 15, 325-337.
- Segal, M. A., & Mandler, G. Directionality and organizational processes in paired-associate learning. *Journal of Experimental Psychology*, 1967, 74, 305-312.
- Shaughnessy, J. J., & Mand, J. L. How permanent are memories for real life events? *American Journal of Psychology*, 1982, 95, 51-65.
- Singer, M. A replication of Bransford and Franks' (1971) "The abstraction of linguistic ideas" *Bulletin of the Psychonomic Society*, 1973, 1, 416-418.
- Singer, M. Processes of inference during sentence encoding. *Memory & Cognition*, 1979, 7, 192-200.
- Singer, M. Verifying the assertions and implications of language. *Journal of Verbal Learning and Verbal Behavior*, 1981, 20, 46-60.
- Small, D. W. The abstraction of arbitrary categories. *Memory & Cognition*, 1975, 3, 581-585.
- Smiley, S. S., Oakley, D. D., Worthen, D., Campione, J. C., & Brown, A. L. Recall of thematically relevant

- material by adolescent good and poor readers as a function of written versus oral presentation. *Journal of Educational Psychology*, 1977, 69, 381-387.
- Smith, D. A., & Graesser, A. C. Memory for actions in scripted activities as a function of typicality, retention interval, and retrieval task. *Memory & Cognition*, 1981, 9, 550-559.
- Smith, M. E. Delayed recall of previously memorized material after twenty years. *Journal of Genetic Psychology*, 1935, 47, 477-481.
- Soli, S. D., & Balch, W. R. Performance biases and recognition memory for semantic and formal changes in connected discourse. *Memory & Cognition*, 1976, 4, 673-676.
- Spear, N. E. *The processing of memories: Forgetting and retention*. Hillsdale, N.J.: Erlbaum, 1978.
- Spilich, G. J., Vesonder, G. T., Chiesi, H. L., & Voss, J. F. Text processing of domain-related information for individuals with high and low domain knowledge. *Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 275-290.
- Spiro, R. J. Remembering information from text: The "state of schema" approach. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge*. Hillsdale, N.J.: Erlbaum, 1977.
- Spiro, R. J. Accommodative reconstruction in prose recall. *Journal of Verbal Learning and Verbal Behavior*, 1980, 19, 84-95. (a)
- Spiro, R. J. Prior knowledge and story processing: Integration, selection, and variation. *Poetics*, 1980, 9, 313-327. (b)
- Stein, N. L., & Glenn, C. G. An analysis of story comprehension in elementary school children. In R. O. Freedle (Ed.), *New directions in discourse processing* (Vol. 2). Hillsdale, N.J.: Erlbaum, 1979.
- Stein, N. L., & Nezworski, T. The effects of organization and instructional set on story memory. *Discourse Processes*, 1978, 1, 177-193.
- Sulin, R. A., & Dooling, D. J. Intrusion of a thematic idea in retention of prose. *Journal of Experimental Psychology*, 1974, 103, 255-262.
- Taylor, S. E., & Crocker, J. Schematic bases of social information processing. In E. T. Higgins, C. P. Herman, & M. P. Zanna, (Eds.), *Social cognition: The Ontario Symposium* (Vol. 1). Hillsdale, N.J.: Erlbaum, 1981.
- Thorndyke, P. W. The role of inferences in discourse comprehension. *Journal of Verbal Learning and Verbal Behavior*, 1976, 15, 437-446.
- Thorndyke, P. W. Cognitive structures in comprehension and memory of narrative discourse. *Cognitive Psychology*, 1977, 9, 77-110.
- Thorndyke, P. W., & Yekovich, F. R. A critique of schema-based theories of human story memory. *Poetics*, 1980, 9, 23-49.
- Tulving, E. Subjective organization in free recall of "unrelated" words. *Psychological Review*, 1962, 69, 344-354.
- Tulving, E., & Pearlstone, Z. Availability versus accessibility of information in memory for words. *Journal of Verbal Learning and Verbal Behavior*, 1966, 5, 381-391.
- Tulving, E., & Thomson, D. M. Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 1973, 80, 352-373.
- Tzeng, O. J. L. Sentence memory: Recognition and inferences. *Journal of Experimental Psychology: Human Learning and Memory*, 1975, 1, 720-726.
- Underwood, B. J. False recognition produced by implicit verbal responses. *Journal of Experimental Psychology*, 1965, 70, 122-129.
- Underwood, B. J. Stimulus selection in verbal learning. In C. N. Cofer & B. S. Musgrave (Eds.), *Verbal behavior and learning*. New York: McGraw-Hill, 1963.
- Underwood, B. J. Attributes of memory. *Psychological Review*, 1969, 76, 559-573.
- Underwood, B. J., & Freund, J. S. Errors in recognition learning and retention. *Journal of Experimental Psychology*, 1968, 78, 55-63.
- Underwood, B. J., & Schulz, R. W. *Meaningfulness and verbal learning*. Philadelphia: Lippincott, 1960.
- Vipond, D. Micro- and macroprocesses in text comprehension. *Journal of Verbal Learning and Verbal Behavior*, 1980, 19, 276-296.
- Walker, C. H., & Meyer, B. J. F. Integrating different types of information in text. *Journal of Verbal Learning and Verbal Behavior*, 1980, 19, 263-275.
- Walsh, D. A., & Baldwin, M. Age differences in integrated semantic memory. *Developmental Psychology*, 1977, 13, 509-514.
- Wanner, H. E. On remembering, forgetting, and understanding sentences: A study of the deep structure hypothesis. Unpublished doctoral dissertation, Harvard University, Cambridge, Mass., 1968.
- Waters, H. S. Superordinate-subordinate structure in semantic memory: The roles of comprehension and retrieval processes. *Journal of Verbal Learning and Verbal Behavior*, 1978, 17, 587-598.
- Wilkes, A. L., & Alred, G. Prose and prejudice: Some effects of priming context on the immediate recall of information. *British Journal of Psychology*, 1978, 69, 123-133.
- Wood, G. The knew-it-all-along effect. *Journal of Experimental Psychology: Human Performance and Perception*, 1978, 4, 345-353.
- Yekovich, F. R., & Manelis, L. Accessing integrated and nonintegrated propositional structure in memory. *Memory & Cognition*, 1980, 8, 133-144.
- Yekovich, F. R., & Thorndyke, P. W. An evaluation of alternative functional models of narrative schemata. *Journal of Verbal Learning and Verbal Behavior*, 1981, 20, 454-469.
- Yekovich, F. R., Walker, C. H., & Blackman, H. S. The role of presupposed and focal information in integrating sentences. *Journal of Verbal Learning and Verbal Behavior*, 1979, 18, 535-548.
- Zangwill, O. L. Remembering revisited. *Quarterly Journal of Experimental Psychology*, 1972, 24, 123-138.

Received June 3, 1982

Revision received August 23, 1982 ■