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Recognizing: The Judgment of Previous Occurrence

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Several suggestions for a class of theories of recognition memory have been proposed during the past decade. These models address predictions about judgments of prior occurrence of an event, not the identification of what it is. The history and current status of one of these models is discussed. The model postulates the detection of familiarity and the utilization of retrieval mechanisms as additive and separate processes. The phenomenal experience of familiarity is assigned to intraevent organizational integrative processes; retrieval depends on interevent elaborative processes. Other current theoretical options are described, and relevant supportive data from the literature are reviewed. New tests of the model involving both free recall and word pair paradigms are presented. The dual process model is extended to the word frequency effect and to the recognition difficulties of amnesic patients.

In general English usage the verb *to recognize* usually is defined as the act of perceiving something as previously known. It is an apparently clear as well as etymologically correct usage, that is, to know again. In this article the process of recognizing will be analyzed, but it will be restricted to the recognition of the prior occurrence of an event. This restriction follows psychological rather than common usage. Experimentation that addresses problems of recognition has typically required subjects to make judgments about prior encounters with some target event. Subjects have been asked to judge whether a particular item or event has been seen or heard before in a particular experimental context. In fact, knowledge, in the wider sense of asking exactly what the event is or requiring some identification, has rarely been assessed in the typical recognition experiments.

This article addresses this "psychological" problem as a necessary first step toward a more general theoretical approach to "previous knowledge." The present problem is to ascertain how people come to make judgments that an item or event has been previously encountered. More exact knowledge about the event (the what and the where), of course, will often be attained in the course of such judgments, but it is not usually required. The process of arriving at a decision about prior occurrence is defined here as *recognizing*. In the extreme case such a process will sometimes produce a context-free judgment, particularly in everyday life situations. Consider seeing a man on a bus whom you are sure that you have seen before; you "know" him in that sense. Such a recognition is usually followed by a search process asking, in effect, Where could I know him from? Who is he? The search process generates likely contexts (Do I know him

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from work; is he a movie star, a TV commentator, the milkman?). Eventually the search may end with the insight, That's the butcher from the supermarket!

The initial sense of knowing the man is apparently context free. However, this example is an unusual case, occurring infrequently in everyday life, and seems to be absent in the laboratory. The context-free recognition example is used here merely to illustrate the operation of the following two processes: recognition by familiarity and identification as a result of a retrieval process. In the normal course of events, the two separate processes occur conjointly; recognition involves the additive effects of familiarity and retrieval.

The search for identification seems to be a search for contexts. It is more likely, however, that this search for contexts is only the first step in a retrieval process; the final result is the recovery of the required identification. For example, a context such as "Do I know him from work?" restricts the search set but is unsuccessful as a retrieval cue. On the other hand, the context "Do I know him from the supermarket?" together with the physical characteristics of the man, produces enough cue specificity to recover the memory (representation) of the butcher. Contexts are addressed and used, but only to provide more adequate cues or descriptors of the target event (cf. Norman & Bobrow, 1979).

To identify an event implies, in the context of this discussion, that the event is located within the relational network of long-term memory. Identification involves the recovery of such features and attributes as the functional significance of the event, its name, the contexts in which it is usually or has recently been encountered, and its relation to other subordinate and superordinate concepts. Specific identification of an event is not possible on the basis of its familiarity alone. The butcher-in-the-bus is one intuitive demonstration of such an assertion; I shall present additional evidence from more restricted experimental contexts.

We originally proposed a dual process model in 1969, when we found, to our surprise and contrary to conventional wisdom, that organizational variables affected recognition performance and, also, that the effect of those variables increased with a test delay of up to 5 weeks (Mandler, Pearlstone, & Koopmans, 1969; see also Mandler, 1972).

The relevant observations were based on the sorting/recall paradigm. Subjects sorted sets of unrelated words into a number of categories of their own choosing. Subsequently they were given recall and/or recognition tests for the sorted items. Previous research had shown that the number of categories used in sorting was highly correlated with the number of items subsequently recalled. Thus, the correlation between recall and number of categories (r) was used as an index of the dependence of recall on the organizational effects of sorting. If recognition performance were independent of organization, then no correlation would have been found between recognition scores and the number of categories used in sorting. The variance of recall and recognition performance accounted for by the organizational variable can be described in terms of the correlation between performance and number of categories used in sorting (r^2, based on r). The phenomenon we encountered is illustrated in Figure 1, which shows the variance accounted for by the organizational variable in both recall and recognition performance as a function of the interval between sorting and test. The organizational variable decreased in effectiveness over time as far as recall is concerned, and it was also relatively uninfluential as far as immediate recognition performance went. However, the effect of organization on recognition increased dramatically over time.

To accommodate these data we proposed that the recognition judgment depended, in the first instance, on occurrence information about the target event. If that information reached some specified criterial value, the event or item was called *old*. If it did not reach the critical value, then a "retrieval check" was performed that tested whether the target event was retrievable. If so, the item was called old. The underlying assumption, shared by others in a variety of con-

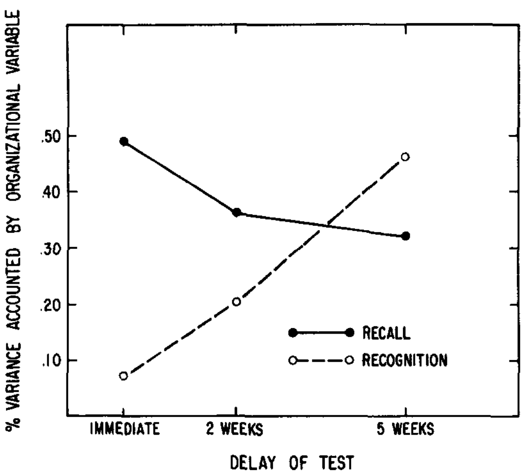

Figure 1. Summary data from Mandler, Pearlstone, and Koopmans (1969) showing, separately for recall and recognition performance, the variance accounted for by the number of categories used during previous sorting; the abscissa shows the delay between the sorting task and subsequent tests.

texts, is that occurrence information (or familiarity, as I prefer to call it now) decays more rapidly over time than do organizational, structural effects. Consequently, the organizational information that provided access for the retrieval check became increasingly important in determining the recognition judgment.

It may seem paradoxical to claim that an item that is currently perceived and registered is checked for retrieval; it is, after all, already present. How does one perform a retrieval check on an item that is already held in consciousness? Can one retrieve something that, in a sense, one already knows? An everyday example might illustrate the process. In reading a passage in a book, one comes across a word that looks familiar but the meaning of which escapes one for the moment. In this situation a retrieval is performed, using the context of the target word as cues. Frequently such a search ends successfully; one eventually locates the word in semantic memory and understands it. The retrieval search for words in a list is similar; the organization of the list both defines list membership and provides the retrieval processes that make it possible to access a member of the list. Once again, even though the word is currently present, its retrieval results in a different cognitive state than its mere presence has before; its successful retrieval identifies it as a member of the list.

In 1971 Juola, Fischler, Wood, and Atkinson independently proposed a similar model. They started with a modification of Kintsch's (1967) position that subjects base their judgment of prior occurrence on the evaluation of an item's familiarity. Juola et al. assumed that the familiarity measure is a value on a continuous scale, and that all items whose familiarity values fall above a specified high criterion are called old, those that fall below a low criterion are called new. When the subjective familiarity value of an item lies between the two criteria, the subject "will check the memory list before responding. Checking the list results in a slower response" (Juola et al., 1971, p. 12). Both in their original paper and in later elaborations, Juola et al. assumed, just as we did, that the second (search) process is only initiated after the familiarity judgment has failed to provide an unequivocal decision. In 1976 Tiberghien named the model the *conditional search model* to stress the fact that a search or retrieval process is contingent on the failure of the familiarity test.

This approach was subsequently extensively elaborated and empirically tested by Atkinson and his associates (e.g., Atkinson & Juola, 1973, 1974; Atkinson & Wescourt, 1975). Most of the research coming from this group of investigators has been concerned with quantitative predictions of response latencies to items from limited, and usually well-memorized, word lists. The general finding in these extensive studies has been that repetition of target items increased hit rate and reduced reaction times, and repetition of distractors increased false alarm rates and slowed reaction times. On the other hand, reaction times were slowed as the size of the search set (the set of items from which the target item was drawn) increased, showing the operation of the slow, retrieval component involved in the recognition judgment. A similar finding was presented by Mandler and Boeck (1974), who showed that organizational (retrieval) variables were related to recognition performance for slow responses but unrelated to fast recognition judgments, which were presumably made primarily or entirely on the basis of the familiarity component. Cooper and Monk (1976) investigated the transfer from recall–test phases to a delayed recognition and recall test. They interpreted their latency result within the framework of the Atkinson and Juola model. Cooper and Monk also commented that "there is no *a priori* reason why . . . [the familiarity value] . . . should always be sampled first" (p. 155). I shall return to this point later.

Wolford (1971), also independently, presented data on paired-associate recognition and proposed a model that is similar in structure to the dual process model, except for the fact that he replaced the occurrence or familiarity factor with a guessing parameter.

I will next review the current status of the model. Following the Atkinson convention, occurrence information is now referred to as familiarity. Whereas other suggestions, such as presentation code, perceptual information, and item information, all appeal to the same basic process, the notion of familiarity best embodies both the intuitive and the theoretical implications of the concept. It still leaves open the question of the underlying psychological processes that generate the phenomenal and empirical aspects of familiarity.

I have suggested previously (Mandler, 1979) that the phenomenal experience of familiarity can best be assigned to a process of intraitem integration. Repeated exposures of an event focus organizational processes on the perceptual, featural, and intrastructural aspects of the event; intraitem organization involves sensory and perceptual integrations of the elements of the target event. This increasing integration or organization of the event itself, independent of its relations to other events and representations, is perceived as the familiarity of the event. Atkinson and Wescourt (1975), in elaboration of the dual process model, have introduced the notion of perceptual (p) and conceptual (c) codes. They conclude that it is the former that contribute to the familiarity value of an event, and they note that "p-codes . . . are produced when a table is seen, when the printed word 'table' is seen, when the auditory word 'table' is heard, etc." (p. 490; cf. also Juola, 1973). It seems to be both intuitively and theoretically reasonable to assign the psychological processes underlying the experience of familiarity to a perceptual process. A scene, a word, a face, all appear to be familiar if the particular concatenation of perceptual features they represent has been previously examined. Events become increasingly familiar the more frequently their identifying perceptual/featural combinations have been encountered. A detailed discussion of the variety of integrative mechanisms can be found in Mandler (1979), but several aspects need to be emphasized for present purposes.

In the first instance, the term *integration* is used to refer to a continuous, not on all-or-none, process. Integration refers to the stability and invariance of structural relations among the featural constituents of an event. Integrative processes occur with a well-practiced word, as they do with a novel event or a newly constituted set of perceptual features. In the case of the well-known previously practiced event, these processes may focus more on the general reactivation of the relations among the constituent features, rather than on the registration of new intra-event relationships.

Since sheer repetition seems to be an important occasion for the occurrence of these integrative processes, what is it that may happen during the attentive repetition of an event, a word, an item? Repetitions make possible "attention to [an item's] internal structure . . . [and] draw attention to its spelling, its phonemic constitution, pronunciation, etc." (Mandler, 1979, p. 298). Furthermore, to the extent that the event has to be matched to some stored internal representation, additional structural information will make such a match more likely. Since it is assumed that much of the integrative process has perceptual rather than conceptual consequences, integration will produce increased salience by providing a more coherent and unitary perceptual event. General activation of the representation of an event as a result of repetition is a more automatic process. Such activation of the relations among the features may, by itself, provide greater coherence and salience on subsequent encounters. The phenomenon that familiarity values increase with repeated presentations or recalls has been demonstrated in a wide variety of experimental contexts by Atkinson and his associates. Such increments occur independent of the identification of the item as part of the target set. For example, Atkinson, Hermann, and Wescourt (1974) report that if subjects are given task-irrelevant instructions, and if those instructions include some of the words used in later recognition test as distractors, these items show the effect of incremented familiarity. This is an important demonstration that familiarity affects recognition *independent* of the context in which the familiarity is incremented.

If familiarity is due to intraitem organization, then recognition should be affected by perceptual modality-related aspects of the prior experience with the target event. If any of the perceptual aspects of an item are changed (e.g., by presenting auditorally and testing visually), then familiarity effects should be less than when the perceptual features of the target stay constant. A direct demonstration of this kind has been provided by Geiselman and Bjork (1980) in several studies that tested recognition as a function of the speaker's voice used during presentation and recognition. Recognition performance improved as a function of primary (maintenance) rehearsal "only if the speaker's voice at test matched the rehearsal voice" (p. 188). When recognition of an auditory target was tested visually, primary rehearsal "had no effect on recognition performance unless the original voice context was reinstated mentally at test" (p. 188).

I have reviewed the available literature on the effects of repetition on recognition elsewhere (Mandler, 1979). The general conclusion is that different kinds of processing affect familiarity/integration and retrieval/elaboration differentially. The same general argument has been advanced by Tversky (1973), who demonstrated that performance on recognition and recall tests is affected differentially, depending on the kind of test people expect. In discussing the locus of that effect, she noted that "recognition is enhanced by integration of the details of each item while recall is enhanced by interrelating the items within a list" (p. 285). In other words, integrative activity is apparently called for by the very act of preparing for a subsequent recognition test, whereas preparing for recall involves elaborative organizational activity.

Retrieval processes involved in recognition are essentially the same as those used in recall tasks. However, the particular retrieval process used in a specific recognition task depends on the task requirement. For example, the retrieval process involved in the recognition of a B item from an A–B pair requires the retrieval of the holistically encoded pair; recognition of a line from a poem may require retrieval of preceding and following lines; and recognition of a football player may require identification of his team and retrieval of his membership in that team. In discussing the model I shall assume that retrieval subsumes all those mechanisms that make access to some stored event or item possible. Although overt recall is the primary index available for a retrieval process, the latter may subsume a large variety of mechanisms and strategies. I assume, of course, that retrieval processes depend, in the first instance, on the structured, organized nature of long-term memory. It is organization that is embodied in the many interevent and interitem relations that define a target event's meaning. What particular retrieval processes and mechanisms are appropriate and relevant in a particular task or situation is determined by task requirements. As I indicated earlier, retrieval cues may be provided in some situations by contexts, in others by the organization of a list or the holistic "image" of a scene. Similarly, direct-access retrieval must be distinguished from other kinds of memory searches. Sometimes we need to generate and subsequently recognize items to complete a memorial task successfully. However, the retrieval cues for generating all female names, for example, in order to recognize the one that is currently required are very different from the cues used to retrieve the name directly. Generation–recognition is not, as we have shown elsewhere (Rabinowitz, Mandler, & Barsalou, 1979), the primary or preferred memory strategy. The conjoint use of retrieval and familiarity in recognition is quite different from the sequential application of generation and recognition in recall. However, it may well be the case that in the latter, the generation of candidate events or items is followed by a choice that is determined to a large extent by the event's familiarity value.

Concerning the effect of retrieval processes on recognition performance, I have discussed the evidence for this argument extensively elsewhere (Mandler, 1972), and demonstration of the effect has been continued in several studies. In the context of list learning, Rabinowitz, Mandler, and Patterson (1977) considered the effects of item accessibility on recall and recognition. An item is accessible in storage if it can be retrieved, and the accessibility of items, as determined by their retrieval in free recall, predicts the likelihood of their being recognized, independent of whether accessibility was determined before or after the recognition test.

In the case of word pairs (paired-associate acquisition), we considered the important finding by Tulving and his associates (e.g., Tulving, 1968; Tulving & Thomson, 1973) that subjects may be able to recall items that they cannot recognize, that is, recognition failure. They demonstrated that for a word pair *A–B*, *B* may be recalled given *A*, but the same *B* items may not be recognized. An analysis of the retrieval processes involved in the recognition of *B* led to a series of studies (in Rabinowitz, Mandler, & Barsalou, 1977) arguing that the recognition of *B* involves a judgment of familiarity and the retrieval of the encoded *A–B* pair, given *B*. Thus recognition of *B* depends on the retrieval of *A* (given *B*), and the recall of *B* involves the retrieval of *B* (given *A*). We found that recognition failure depends to a large extent on the failure to retrieve the *A–B* pair given *B*. Tiberghien, Cauzinille, and Mathieu (1979), using a variant of the dual process model, showed that Tulving and Thomson's (1971) related demonstration of contextual effects on recognition was primarily dependent on retrieval processes.

The Formal Model

I use the following definitions:

$F =$ the probability that an event will be called *old* on the basis of its familiarity value; $R =$ the probability that an event will be called *old* as a result of retrieval processes; $Rg =$ the probability that an event will be called *old*.

In this discussion I do not address the problem of the criterion of familiarity that is used by different subjects in different experimental situations. None of the data reported involve any manipulations of response criteria, and I assume that within any single experiment, the criterion stays constant.

The original formulation of the model was

$$Rg = F + (1 - F)R. \qquad (1)$$

The probability that an event will be recognized is the sum of the probability that it can be recognized on the basis of familiarity plus the probability that it can be retrieved if it is not recognized on the basis of familiarity. It is the sequential implication of this particular formulation that has dominated the use of this class of model and has led to the locution of the conditional search model. For the present it is not necessary (nor is the relevant evidence unequivocal) to choose between a sequential process, with familiarity sampled first, and a parallel process, with a fast familiarity and a slower retrieval process. Equation 1 can obviously be rewritten as

$$Rg = R + (1 - R)F, \qquad (2)$$

which is a form that will be useful for some later analyses. The general form of the equation becomes

$$Rg = F + R - FR, \qquad (3)$$

which best conveys the central postulate that recognition of prior occurrence is the result of two additive and separate processes.

The variant originally proposed by Juola et al. (1971) has frequently been used and found useful. It assumes that the familiarity judgment involves a low as well as a high criterion. Whenever the familiarity value of an item falls below the lower criterion, it is called *new*. Thus there are two probabilities associated with the familiarity continuum, F_h and F_l, such that a recognition probability would be computed as follows:

$$Rg = F_h + (1 - F_h - F_l)R. \qquad (4)$$

The new evidence reported below uses the simpler version of the dual process model. Specifically, analysis of the data available to us indicated little or no need or evidence for familiarity judgments based on the lower criterion. At no point did the analyses indicate that subjects were rejecting either old or new items on the basis of low familiarity judgments; when estimated these probabilities were at or near zero. The use of the low criterion familiarity check has usually arisen in cases in which subjects were under time pressure, as in reaction time experiments, to make their yes/no responses (Atkinson & Juola, 1974). It is reasonable to assume that under such time pressure, fast rejections based on a low familiarity criterion might occur, whereas under the more leisurely conditions of written or spoken yes/no judgments, it is more likely that retrieval attempts would be initiated whenever an event failed the high criterion familiarity cutoff.

Finally, the possibility must be considered that people do not usually respond to the raw familiarity/integration value of an event but, rather, are sensitive to the increment in familiarity (the additional integration) provided by the presentation in the experimental setting. I shall introduce an incremental variant in later discussion of the word frequency effect. For present purposes we need only consider some net value of familiarity, particularly when the experimental situation does not require judgments among events that differ systematically in their baseline familiarity value.

Theories of Recognition

The past 10 years have seen fairly intense activity toward the theoretical explanation of recognition phenomena. In this section I briefly review the most prominent approaches, primarily to identify similarities and differences within the class of models favored in this aritcle. I do not discuss more ancient theories, such as the single strength model that arrays recall and recognition along a dimension of response strength or its equivalent. (But see Anderson & Bower, 1972; Tulving, 1976, for critiques of these positions.)

Several theoretical discussions, including Anderson and Bower (1972), Norman (1968), and — historically — Hollingworth (1913), have been attracted by an apparent asymmetry of recall and recognition processes. In the former, the context is present and a missing event is sought; in recognition, the event is given and the appropriate context (setting, list) needs to be found. These discussions are often puzzling, and often not pursued theoretically (except by Anderson and Bower). At the basis of the confusion seem to be the two uses of the term *recognition,* indicated earlier. The search for a context is, in the first place, probably a search for a better specification of retrieval cues, as I have indicated earlier.

Even the successful search for such a context, with the subsequent identification of the target event, is not what is usually required from subjects in the typical recognition experiment. The typical request is to make a judgment about whether the event has been previously presented, sometimes with a detailed specification of the context in which it was presented. As illustrated earlier in the butcher-in-the-bus example, such judgments may even be achieved without any reference to the original context of encounter or presentation. Recognition as search for context focuses on the exact identification of the target event and ignores powerful effects of familiarity on recognition decisions. For example, when Norman (1968) says that the task in recognition is "whether the context surrounding the item is appropriate" (p. 533), he requires the subject to recognize what or which it is that is encountered, not simply whether it has been encountered before. Conversely, it is, of course, often possible to state what or who the target event is in addition to making the judgment of prior occurrence.

There is one current position related to the familiarity dimension. Underwood (1971) has suggested that recognition judgments are made mainly on the basis of the frequency attribute of words. Judgments of prior occurrence reflect the judged frequency of prior occurrence of the items. Underwood starts with the demonstration available in the literature that people are, in fact, quite sensitive to the prior frequency of words, letters, and letter combinations. Further, Underwood suggests that differential judgments of frequency (and by implication of prior occurrence) are based on frequency ratios, rather than frequency differences. Retrieval or recall variables are not considered to play any role in recognition performance. Finally, Underwood makes the distinction between background and situational frequency, the former being a function of long-term acquaintance with the target event, and the latter, a function of experimental manipulation of item frequency. However, it is assumed that judgments about situational frequency can be made independent of the background frequency of an event.

To the extent that frequency of prior exposure is one of the major variables contributing to what we have called the familiarity (or integration) of an event, Underwood's theory and data are both consistent with the present model. We differ, of course, about the role of retrieval variables. In addition, there are two theoretical problems with a pure frequency theory. First, it is difficult to conceptualize the psychological mechanism that mediates the phenomenal frequency judgment. The closest Underwood comes is the implication of some frequency counter that increments with each presentation of some specified event (Underwood, 1971, p. 319). How such a counter operates and what it is sensitive to are not specified, which leads to the second problem, what is the occurrence that increments the counter? Does the occurrence of a word or phrase that is seen for some few hundred milliseconds increment the counter by as much as the extended inspection of the same event? It seems necessary to postulate a theoretical variable that is differentially incremented by long or short, incidental or attended occurrences of events. The familiarity/integration dimension serves exactly that purpose. We assume that frequent occurrences increment the integration of an event and result in higher familiarity (and frequency) judgments, but it is not postulated that frequency per se is mapped linearly into the integration/familiarity value.

The most impressive and elaborated theory of recognition outside the familiarity/retrieval models has been presented by Anderson and Bower (1972, 1974). They identify the following four kinds of retrieval processes: (a) the generation of representations (ideas), searching for senses of words that occurred in a list; (b) the determination of whether a particular representation (sense or idea) accessed includes list markers or contextual propositions that identify that representation as having been a list (context) member; (c) the production of a lexical realization of the representation (idea or sense); and (d) the access to a representation (sense or idea) from a word. Free recall is supposed to involve a, b, and c, in that order, whereas recognition involves d followed by b. Anderson and Bower (1972) have argued that Step b is similar to the retrieval check proposed in the early version of the familiarity/retrieval model (Mandler et al., 1969). The only difference appears to be whether the search is for the event or for a context, and Anderson and Bower (1972) note that the "two views would appear difficult to distinguish in practice" (p. 121).

This position apparently excludes any familiarity/integration judgments from the recognition process. It seems to have difficulty handling such phenomena as the butcher-in-the-bus example given earlier. In fact, the theory seems to apply more to the problem of recognition in the sense not used here; that is, what is the object and where has it occurred before? It is probably in that extension of the theory beyond the usual psychologists' sense of prior occurrence that it will be most useful.

Another theory that stresses retrieval processes in the process of recognizing is Tulving's encoding specificity position (Tulving, 1976; Tulving & Thomson, 1971, 1973). The basic assumption is that at presentation and encoding, a unique trace of the target event is established. That trace is a function of a multitude of variables, including, but not restricted to, semantic markings and contextual features. Successful search for the event depends on two events, the properties of the trace and the total information available to the individual in the course of retrieval. This position leads to the conclusion that the processes involved in recall and recognition are not "inherently different" (Tulving & Thompson, 1971, p. 123). They differ only to the extent that "the retrieval information that is present at the time of recall is different from that at the time of recognition" (Tulving, 1976, p. 67). I do not believe that there exists today any fundamental disagreement with that general statement. What needs to be added, however, is the next step, namely that "the *types* of retrieval must be distinguished" (Anderson & Bower, 1974, p. 411). I would argue that what must be available at the time of recognition is information about the familiarity/integration of the target event, as well as information about its retrieval/elaboration. Recognition and recall differ in the kind of information that must be retrieved to lead to successful performance.

A position similar to the distinction between familiarity and retrieval processes has been advocated by Humphreys (1976, 1978). Here, the distinction is made between item information and relational information. Item information is similar to integrative information (familiarity) in that it is specifically a feature of the target event alone; relational information is, of course, coextensive with the present use of elaborative processes. Humphreys's use of this distinction has been in the context of paired-associate tasks, in which his data generally support the arguments made here.

Evidence: Direct and Indirect

In this section I first review a variety of studies that provide some evidence or theoretical support for the dual process model. Following that, I present a summary of recent experimental evidence from my laboratory.

A study by Estes and Da Polito (1967) is relevant, not only because its data are consistent with our model but also because it provided one of the earlier indications of different processes operating for recall and recognition. Intentional and incidental instructions produced no variations in recognition probabilities (presumably because familiarity is equally affected by sheer presentation under the two conditions), but did produce significant advantages of intentional instructions for recall (presumably because these instructions encourage the formation of relevant elaborations). Estes and Da Polito concluded that recognition involved low level information storage, whereas recall required the availability of a retrieval process. Their appeal to information storage as adequate for recognition is similar to more recent labels for the familiarity/integration dimension, such as perceptual encoding, item information, and occurrence information.

One of the more interesting empirical problems facing the dual process theory is that rejection of distractors is affected by their semantic status (Hermann, McLaughlin, & Nelson, 1975; Reynolds & Goldstein, 1974). In a recognition test for a categorized list of words, correct rejection latencies for distractors unrelated to the categories used are usually faster than correct rejection latencies for category-related distractors. Hermann, Frisina, and Conti (1978) have discussed four alternative models that claim explanatory power for this effect. The first relies entirely on the categorization process; the second rests entirely on a familiarity effect derived from spread of activation; the third assumes that familiarity is checked prior to a categorization process; and the fourth postulates a categorization process that precedes the familiarity check. A test of all four models led Hermann et al. (1978) to conclude that the data were consistent with the presence of both the familiarity check and categorization, with the latter preceding the familiarity check.

In addressing the same problem, Rabinowitz (1978) elaborated the dual process model to take into account the effects of categorization. He assumed that the familiarity value of an item is affected not only by the familiarity of the item per se but also by the familiarity value of its category, if category membership is accessed. He also tested the set size effect (Atkinson & Juola, 1974) in a design in which strong categories (semantic categories) and weak categories (rhymes) varied in the number of items per category presented for study. The assumption was that with increasing instances per category, subjects were presented with an increasing number of presentations of the category. This procedure would increment the familiarity value of the category and, to the extent that items are identified as members of a category, increment the familiarity value of all of the items from that category (including both targets and distractors). This category-familiarity effect was expected to be less effective for categories whose membership is not automatically accessed (e.g., rhyming categories). Rabinowitz's data were consistent with this model. Hit latencies decreased and correct rejection latencies increased as a function of category size. The slope of this function for semantic categories was steeper than the slope for rhyming categories, both for hits and for correct rejections.

The model proposed by Rabinowitz is consistent with the fourth model discussed by Hermann et al. (1978), if it is assumed that the incremented familiarity value derived from the categorization process during presentation is available only if the category of an item is properly evaluated before the familiarity check is performed, or at least if the categorization process and the familiarity access occur in parallel. These studies extended the dual process model to categorization effects in recognition and further support the general utility of the model. It is interesting to note that in this context, the categorization of an item has two separate effects: on the one hand, it increments an item's familiarity, and on the other, it has the well-known effect of increasing its retrievability.

In a related series of experiments derived from Underwood's frequency theory, Ghatala, Levin, Bell, Truman, and Lodico (1978) were particularly interested in the effect of prior exposure on false alarm rates. The distractor items used were compounds of words previously presented. Briefly, they found that compounds of previously presented words produced greater false alarm rates than the same compound words when there had been no prior presentation, and that false alarm rates increased with increasing similarity between the single words originally presented and the compounds used as distractors. They concluded that "situational frequency can accrue independently to nonsemantic and semantic features of words" (p. 655). This conclusion is consistent with the finding that category membership independently increments familiarity values. At the same time sheer presentation should increment the familiarity values of the individual words, that is, their nonsemantic aspects.

Hogan and Kintsch (1971) showed that item exposure as such increased recognition probabilities, whether the exposure was manipulated by preceding study trials or by recognition tests of the entire list. Study trials and recognition tests were more effective than recall tests because in the latter, "only those items that [are] actually recalled can gain frequency increments" (p. 563). It might be noted that for recall, prior recall tests were more effective than study trials or recognition tests. These data are consistent with the dual process theory, but they are also consistent with the two-stage theory of recall (Kintsch, 1970), which postulates frequency (familiarity) as determining recognition and recall as involving item retrieval followed by a recognition (familiarity) decision. The dual process approach to recognition also recognizes the importance of familiarity for recognition, but it assumes that retrieval is an inevitable adjunct and not, as Hogan and Kintsch suggest, an optional process during recognition.

I have previously discussed the relation between repetition (various kinds of rehearsal) and the integration/elaboration dimensions. Sheer maintenance rehearsal affects familiarity, but not retrieval, probabilities (Mandler, 1979). In that context Glenberg and Adams (1978) showed that maintenance rehearsal (Type 1 rehearsal in Craik & Lockhart's, 1972, terminology) affected primarily the acoustic–phonemic components of a to-be-remembered item, rather than semantic or contextual components. Thus, this study provided additional evidence for the conclusion that properly conducted primary or maintenance rehearsal works to enhance the integration of the target event in terms of its physical, perceptual characteristics. Such integration would be expected to improve hit rate but leave recall unaffected.

Given that the presentation of an item increases its familiarity value (or increments its integration) and that we can show such effects with a few seconds of presentation and after several days of delay, can a similar effect be shown to exist over very short periods of presentation and testing? A positive answer comes from an extensive theoretical and empirical investigation of the Sternberg paradigm (see, e.g., 1969) by Monsell (1978). The task involves the presentation of sets of items (letters or words), followed immediately by a probe item to which the subject makes a response indicating whether the probe item was or was not a member of the immediately preceding set. Set size and delay of the test probe were varied; item presentation time was 700 msec with a 100-msec interitem interval. The maximum delay before tests was of the order of a few seconds. Monsell concluded that "some form of direct discrimination of recency is . . . used in performing the item recognition task" (p. 491).

Using the Atkinson and Juola (1974) model as representative of familiarity-with-search models, Monsell found no evidence for a search effect. However, he noted that search processes may not be very effective at the very short delays tested. More important, perhaps, is the fact that with item presentations of 700 msec/item and 100-msec interitems, it is unlikely that the proper and necessary organization of the list could have been established. In the absence of some such organization, search processes not only will not be effective but may, in fact, not occur. This finding underlines the need to define the search process as well as the familiarity process, rather than to assume that a search process will take place and will be a linear function of set size.

What is directly relevant to the present arguments is that Monsell concluded that some sort of activation model probably best represents the data and ancillary observations. He assumed that "activation" may be seen as distributed over diverse memory elements, ranging from sensory ones to more abstract lexical and semantic ones. In general the data suggest that item integration could be substituted for the notion of activation. The data show that integration increments with presentations as short as a few hundred milliseconds and persists over some time period (at least a few seconds and possibly minutes) thereafter.

Another set of evidence for the separability of familiarity and retrieval factors comes from the study of anterograde amnesic patients. It has generally been accepted that the deficit shown by these patients is a long-term memory deficit, since their ability to retrieve material from short-term memory is generally intact (Baddeley, 1976).

If it is the case that the amnesic primarily has a problem with long-term retrieval, then we would expect recognition (in our sense) to be impaired because the R part of the $Rg = F + R - FR$ (Equation 3) function would be depressed. How about the familiarity decision; is that also impaired in amnesics? The question is not easy to answer because we rarely know how to assess the decision based on familiarity in the absence of some estimates of the retrieval probability. However, the preponderance of the evidence suggests that the problem resides primarily, if not solely, in the retrieval part of the function and that amnesics are generally able to respond to the familiarity aspect of events. Whenever a significant retrieval requirement enters into the recognition task, recognition performance deteriorates badly.

Some interesting evidence from experiments by Warrington and Weiskrantz (1970, 1974, 1978) appears to provide access to a more or less "pure" familiarity phenomenon. It has been shown that amnesics are at least as good as, if not better than, normals in completing partial cues for previously seen words or in using partial information. For example, although patients may not be able to recall the word *table* seen in a list or to recognize very well that the presented word *table* was in fact part of the list, they are very good at completing the cue *ta*— with —*ble* when asked to do so following presentation of the list. Note that the latter task is not a retrieval task in the present sense, since the organization of the episodic input is not required. In fact, no retrieval that involves the structure of the initial presentation is involved. The subject is asked to complete the partial cue without reference to a prior presentation. To be sure, there is retrieval required to complete the word, but it is a nonsemantic perceptual task, rather than a long-term memory task. If we assume that the familiarity of *table* was incremented in the prior presentation, then the completion task simply benefits from the greater perceptual familiarity of *table* over other possibilities such as *tasks*. It might even be argued that the worse performance of normals in this task is due to the fact that normals probably do attempt the additional retrieval task; that is, they complete the word and then try to remember whether it was in fact part of the previously presented list. The amnesics neither remember the prior lists nor, often, the fact that there even was a prior experimental task; instead, they act on the basis of familiarity (integration) alone.

Another piece of evidence comes from a study by Huppert and Piercy (1976), which showed that in comparison with normals, amnesics were severely impaired in their recognition performance when they had to make judgments about the temporal occurrence of a previously presented item (did it occur 10 minutes or 24 hours previously?). Thus the addition of a retrieval requirement (i.e., find the temporal context) seriously impairs recognition performance in amnesics. These data and analyses suggest that the recognition as well as the recall performance of amnesics is impaired because of their difficulties with retrieving stored events. In contrast to Gaffan's (1976) arguments, these patients may not have any difficulty in assessing the familiarity (integration) of previously presented material.

Experimental Tests of the Model

We have recently concluded a series of studies in the word-pair paradigm that addesses the parameters of the model directly (Mandler, Rabinowitz, & Simon, Note 1). We first collected normative data on the recall and recognition of word pairs. The data obtained were the following: *recognition*—*A* alone, *B* alone, *A–B* pairs; distractors of all three types; *recall*—*A* given *B* (*A/B*), *B/A*, and free recall of *A–B* pairs.

We built up a large data base using random pairings of high frequency nouns that were presented for 3 sec. Recall and recognition tests were between-subjects variables, and different kinds of items tested were within-subjects variables. Each data point reported is based on 144 subjects, with six relevant items per subject.

Using the basic formulation of the model (Equation 3), the following three equations show its adaptation to the paired associate task. For the recognition of an *A* item, we assume that the recognition probability is the sum of the probability that *A* is recognized on the basis of its familiarity value (*F*), plus the probability that *A–B* is recovered given *A* (the *R* value), less the product of the two values. Thus,

$$RgA = F_a + R_{a-b/a} - F_a R_{a-b/a}, \qquad (5)$$

where *a* and *b* subscripts indicate the individual items and *a–b* the complete pair. Thus, for example, the retrieval probability (*R*) for *a–b/a* refers to the probability that the *a–b* pair can be retrieved, given *a* as a cue. Similarly, for the recognition of *B* items,

$$RgB = F_b + R_{a-b/b} - F_b R_{a-b/b}. \qquad (6)$$

For the recognition of *A–B* pairs, we assume that the familiarity value reflects the probability that both items are familiar, that is, that the probability of a positive recognition response for the pair is the product of the *F* values for the two items that constitute it. The *R*, or retrieval value, should reflect

Table 1
Observed and Predicted Recognition Probabilities for Word Pair Items

Items	Hits			False alarms		
	Observed	SE_M	Predicted	Observed	SE_M	Predicted
A	.76	.11	.79	.18	.10	.23
B	.77	.11	.79	.23	.11	.22
AB	.86	.10	.81	.06	.01	.04

the independent additive probability of retrieving the pair given either of the two items as a cue. Thus,

$$RgA\text{–}B = F^2 + R_{a-b} - F^2R_{a-b}, \qquad (7)$$

where

$$R_{a-b} = p(A/B) + p(B/A) - p(A/B)p(B/A).$$

We make the additional assumption that F will be identical for all items presented equally often; that is, that $F_a = F_b$. We can then estimate F from Equations 5–7 using the observed values for the recognition of A, B, and A–B and for the cued recall of A (A/B) and B (B/A). For false alarm rates the same calculations apply for an independent measure of F, using probabilities of false alarms as the recognition scores and the probabilities of cued intrusions for the retrieval estimates.

The estimate for the F value of old items was .63, and for distractors it was .19. Given these estimates of F, we substitute them in Equations 5–7, separately for hits and false alarms, and arrive at the predicted values. These are shown in Table 1, together with the standard error of the mean of the observed values. In general the result is rather reassuring, and it is particularly interesting that the model predicts both the high hit rate for old A–B pairs and the very low false alarm rate for new ones.

Another test of the model is to look at the recognition of items that have been presented equally frequently, but which, for reasons other than presentation frequency, show differential recognition performance. In that case the estimates of F should be the same for items presented with equal frequency. For this analysis we used data available in Rabinowitz, Mandler, and Barsalou (1977), who tested the recognition of B items and cued recall (following recognition) for both A and B. It is the case that for those cases in which B is not recalled (given A), the recognition of B is lower (as is the recall of A given B) than in those cases in which B has been recalled. In the present analysis we examined these two kinds of B items, those that are recalled when A is presented and those that are not. It is also the case that the recognition scores for the former are much higher than the latter. On the other hand, since they were presented equally often, the two kinds of B items should have the same familiarity values. We estimated the F values for three different studies (Studies 1, 2, and 3 listed here were Experiments 4, 5, and 6 in Rabinowitz, Mandler, & Barsalou, 1977). Table 2 shows the recognition values for the two kinds of B items, as well as the estimated F value for each of the obtained recognition probabilities.

Thus with presentation frequency held constant, we obtain constant estimates of F values, despite large differences in recognition probabilities. We have presented similar data in Mandler and Barsalou (Note 2), in which subjects were given 10 different paired-associate tasks over a period of 6 weeks. Since the new pairs for each of the successive lists were presented for the same amount of time, the familiarity values should also have been the same for each of the sessions. The data are shown in Figure 2. Despite increases in recall and recognition over successive sessions, the estimated F value stays constant.

These sets of data also permit another test,

Table 2
Recognition Probabilities and Estimated F *Values for B Items*

Study	Recalled items		Nonrecalled items	
	Recognition	Estimated F	Recognition	Estimated F
1	.69	.40	.41	.39
2	.70	.35	.40	.39
3	.85	.42	.48	.46

that is, of the prediction that recognition probabilities should be near unity when the appropriate R (recall) value is estimated to be near unity, and the recognition probability should be at or near the estimated F (familiarity) value when R is expected to be absent or near zero. Given the variability of recognition scores, fairly reliable estimates of recognition performance should be used for this test. Such estimates are available from Experiment 5 in Rabinowitz, Mandler, and Barsalou (1977) (Study 2 in Table 2 above).

In that experiment subjects were given two successive recognition tests, and success and failure on *both* tests provides a fairly reliable estimate of recognition and nonrecognition. In fact, these estimates were used for the data in Table 2. Given our assumption that the retrieval task in the recognition of B items from A–B pairs is the retrieval of A, given B, we can examine those B items that show successful retrieval of A and those that do not. The recognition probability for B items producing successful retrieval of A is .93, that for B items that fail to be effective in retrieving A is .42. As indicated earlier, the recognition probability for the former (with an R value at or near 1) should be near unity, that of the latter (with an R value at or near 0) should be at or near the estimated F value.

Since all items were treated identically up to the recognition test, we can compare the estimated F value from Table 2–Study 2 with the obtained value. The former is .37 (mean of .35 and .39), and the latter is .42. The conclusion, consistent with the model, is that items providing access to the appropriate retrieval process are nearly perfectly recognized. On the other hand, items providing no access to retrieval or identification information are recognized only to the extent of their familiarity/integration information. One interesting implication of such a finding is that such events might be judged as previously encountered, but they should not be identifiable in terms of the nature or characteristics of the context in which they have been encountered. Conversely, whenever a retrieval process is required in order to arrive at a

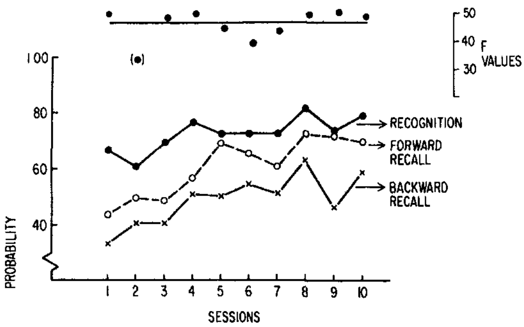

Figure 2. Recognition, cued recall, and estimated F values for 10 successive açquisitions of different paired-associate lists. (Data and figure from Mandler and Barsalou, Note 2.)

positive recognition judgment, some elaborative, contextual information will be available about the target event.

Another test of the model examines the effect of a prior recall on recognition. Data for this test come from Rabinowitz, Mandler, and Patterson (1977), in which categorized lists were used and recognition was tested either immediately following a recall test or a week later. Retrieval probabilities were obtained by a recall test following the recognition task. Thus F values could be estimated for items that had or had not been recalled in the original recall test. The F value for recognition immediately following the recall test was .97 for recalled items and .72 for nonrecalled items. When the recall test occurred a week prior to the recognition test, the F values were .75 and .73, respectively, for recalled and nonrecalled items. These F values are relatively high in comparison with other results reported here. We can assign this increase to the categorized nature of the lists and to the incremental familiarity due to category identification discussed above. For the same reason, these estimates do not provide any clues to the decay of familiarity over time. But they do indicate that an immediately preceding recall boosts the familiarity value of an item; an unsuccessful intervening recall test does not change the F value, regardless of when the recall test occurs. The increase in F as a function of a successful recall apparently decays over a week to the same level as that achieved by unrecalled, but presumably categorized, items.

We have recently developed additional evidence on the effect of item repetition on recognition in an experiment on the recognition of categorized words in a repeated test condition (Mandler & Rabinowitz, Note 3). The model provided an excellent fit for the hit and false alarm rates of items that had or had not been presented in a prior test. In adapting the model to the repeated test situation, we assumed (as have Atkinson and Juola, 1974, e.g.) that the first test incremented the familiarity value of the tested item. The estimates were consistent with the values reported above. The F value for items tested 1 week previously was .80, of which .28 could be assigned to the increment due to the prior test. In addition the familiarity value varied with the accessibility of the categories, consistent with the previous argument concerning the effect of category identification on familiarity. Estimates of F values for old and distractor items also showed, as expected, that the presentation in the first (prior) test incremented the familiarity value of old items less than that of the new distractor items (which were, of course, presented for the first time in the prior test).

We also compared items that were presumably recognized primarily on the basis of their familiarity value with those that were recognized on the basis of both retrieval and familiarity. The data were obtained from Studies 1 and 2 in Rabinowitz, Mandler, and Patterson (1977) and from various subgroups in Rabinowitz et al. (1979). These groups involved items from categorized lists that had been tested for recall both before and after a recognition test, or twice following the recognition test. We assume that items that cannot be recalled on either of those two tests have a retrieval probability that is close to zero. We can assume that the Rg probability of those items is a reasonable estimate of the F value in this experiment. On the other hand, successive retrievability of recalled items is more variable. Therefore the retrieval estimate (R) for these recalled items can be expected to be less than unity.[1] Using Equation 2,

$$Rg = R + (1 - R)F,$$

we represent the relationship between the recognition of recalled items and of nonrecalled items (presumably primarily due to F) by letting F equal Rg for nonrecalled items. Specifically, the slope $(1 - R)$ and the intercept (R) of the function relating the two kinds of items should sum to 1.00.

Using data from 30 independent subgroups from five different experiments, we tested the prediction. Figure 3 shows the plot of this relationship. The solid line shows the empirical slope; the dotted line is the theoretical function that is the least-square solution that satisfies the requirement that slope and intercept add to zero. The empirical slope and intercept were .428 and .606, respectively, with the sum of 1.034. (The correlation was .896.) Testing this function against the theoretical function, the variances accounted for by the two did not differ significantly, $F(28, 28) = 1.12$, $p = .38$. Again we have a successful test of the model.

The Word Frequency Effect

The fact that more frequent words are easier to identify than less frequent ones has been known at least since Howes and Solomon's (1951) experiment. They showed that the visual duration threshold is a linear function of the log frequency of words, with frequency determined by the Thorndike-Lorge word count. Thus, for purposes of arriving at a lexical identification, the more frequent words are superior to the less frequent ones. Findings such as this one have given rise to an active area of research on word perception that asks not whether an item has been seen before, but specifically what it is. The central import here is, of course, a practical one; how do people recognize words; that is, how can they read and understand them?A sum-

[1] Independent tests showed the probability of subsequent recall of nonrecalled items to be .05 or less; that of recalled items varied from .70 to .95 under various conditions.

mary of current theories has been presented by Adams (1979).

The most popular models of word recognition fall into two classes, the sophisticated guessing models and the response bias models. The former generally assume that partial information is picked up from the stimulus array and restricts the set of possibilities from which a reasonable guess is made (e.g., Rumelhart & Siple, 1974; Solomon & Postman, 1952). The response bias model assumes that on the basis of available stimulus information, the probability of a particular output (decision) is biased toward some small subset of possible responses (e.g., Broadbent, 1967; Morton, 1969). Whether these two sets of models are critically different is not important to this discussion (cf. Adams, 1979; Nakatani, 1970, 1973). In fact, one of the most impressive current models (Rumelhart, 1977) is difficult to assign to one or the other of these two categories. Do these models significantly contribute to the problem of the recognition of prior occurrence? Briefly, they do not because they start invariably with an analysis of letter concatenations and dependencies and inevitably arrive at the "what is it" judgment, a topic deliberately beyond the scope of my intent here. More important is the fact that recognition of prior occurrence reverses the previous basic phenomenon; now low frequency words are more easily recognized.

The notoriety of the word frequency effect relies on the well-established laboratory finding that subjects are more likely to recognize a low frequency word as having been previously presented than a high frequency word. Free recall follows the more expected pattern, of course, in that high frequency items are easier to recall than low frequency ones. There has been much speculation about the locus of the recognition advantage for low frequency words (Glanzer & Bowles, 1976; Kinsbourne & George, 1974; Shepard, 1967; Underwood & Freund, 1970).

There is no doubt that the word frequency effect is an important challenge to the familiarity–retrieval model of recognition. One can easily tell high frequency from low frequency words as such; the former are rated as more familiar, as having been previously encountered, as being "words." But given one presentation, subsequent judgments about their having been presented are easier for low than for high frequency words. It is not the case that the unfamiliarity or uniqueness of low frequency words makes them stand out. Glanzer and Bowles (1976) have shown that false alarms demonstrate the dominance of high frequency words; that is, hit rates are higher for low frequency words, but false alarm rates are higher for high frequency words. In other words, in the absence of retrievability the recognition judgment (for distractors) depends on the familiarity of the item.

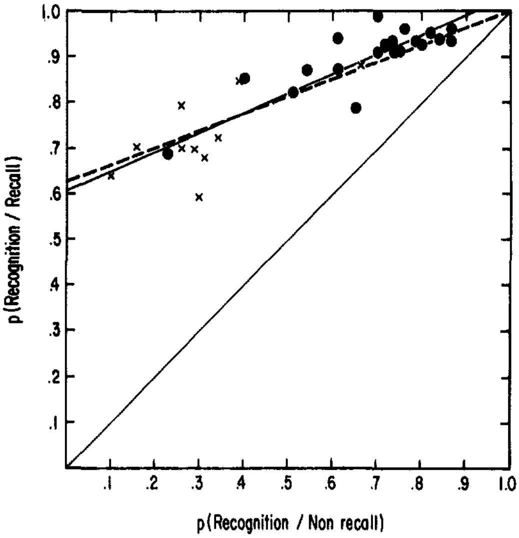

Figure 3. Relation between the probability of recognizing recalled versus nonrecalled items for 30 different groups from various free recall experiments. (Circles are data for hit rates and crosses for false alarm rates. The solid line is the empirical slope and the dotted line the theoretical prediction. See text for detail.)

On the basis of familiarity alone, the best explanatory candidate is an incremental explanation; that is, the additional presentation produces a larger relative increment for low than for high frequency words. The incremental view assumes that each additional presentation and processing of an event adds some specified degree of integration to the target. If that amount of incremental integration is some constant d, then the ratio of d to the sum of the base familiarity value of the event plus the constant d will be larger for low frequency than for high frequency words. Specifically, the operative F value for a word would be $d/(d + F)$, where F is the preexperimental base familiarity value of the word. Such a position requires that people be quite sensitive to both incremental and baseline frequencies (familiarity) of words, and they are, as Underwood (1971) and Hintzman (1976) have shown extensively.

Given the argument that what is evaluated is the increment due to the additional presentation, the word frequency effect is represented in the following inequality:

$$\frac{d}{(d + L)} + r - \frac{rd}{(d + L)} > \frac{d}{(d + H)} + R - \frac{Rd}{(d + H)}, \quad (8)$$

where d = increment in familiarity due to the presentation; H and L = the original familiarity value of the high and low frequency words, respectively; R and r = retrievability of the high and low frequency words.

Since d is a scale parameter we can set it equal to 1 and simplify Equation 8 to the single inequality

$$H > \frac{L(1 - r)}{(1 - R) - (R - r)L}.$$

This formulation helps to identify some limits of the word frequency effects. For example, if retrieval of the two sets of words is equally probable (i.e., if $R = r$), then low frequency words will be more easily recognized only to the extent that the base familiarity of the high frequency words is higher than the base familiarity of the low frequency words. For two sets of words of equal frequency (or base familiarity), differences in recognition probabilities will depend on the difference between the retrieval probabilities. This latter consequence restates the basic formulation of the model (Equation 3) and shows that the incremental formulation leads to conclusions identical to the simpler formulation used earlier.[2]

The incremental model assumes, at least implicitly, that the increment in familiarity (integration) for all words is a constant function of the amount of time that the item is presented. However, it seems reasonable to assume that the amount of attention to the item and its internal structure will vary as a function of its baseline familiarity value. Consider instructions to remember the words *happy* and *frantic.* It is likely that the response to the former would be to assume that one "knows that well" and needs to exert little effort to examine it, whereas the latter would receive at least some additional attention. Particularly when the exposure to the items is longer than a few seconds, such differential attention and, consequently, differential incrementing of their integration would not be unexpected.

Summary and Problems

I have summarized theory and research from a variety of sources stretching over 10 years. Support has been adduced for the notion that the recognition of previous occurrence is adequately captured by a theory that assumes that two processes are invoked when somebody is asked to make a judgment of prior occurrence. The first process retrieves the familiarity value of the event, or, more precisely, evaluates the intraevent state of integration. The second, slower mechanism engages in a search and retrieval process that attempts to determine whether the target item was originally presented.

Most theoretical formulations have assumed that the two processes occur in serial fashion; that is, the retrieval process does not start until the familiarity evaluation fails to reach criterion. However, assuming that the retrieval process is in fact slower, and a variety of data support this contention, I find it more reasonable to suggest that both processes are initiated upon event presentation. A similar suggestion was made by Cooper and Monk (1976), and it is consistent

[2] We have some preliminary data suggesting that the word frequency effect can be adequately modeled within this formulation.

with the notion of the operation of two separate and additive processes.

Changes in recognizability over time and trials have been treated implicitly rather than specifically. At the present time the model does not make any explicit predictions about the dynamics of change. I have assumed that the familiarity value of an item decays more rapidly than does its retrievability. Some relevant data were shown in the changing relationship among recognition, recall, and organizational variables (cf. Figure 1 and discussion). Presumably, familiarity changes more rapidly because it involves the interactive activation of perceptual features, whereas the loss of retrievability is more likely due to the often temporary loss of appropriate retrieval cues. Conversely, the work of Atkinson and our own research have shown that repeated recognition tests (presentations) not only prevent loss of familiarity but actually increment it. Retrievability of specific events apparently improves only if new elaborative structures (additional retrieval cues) can be recruited. The specific interaction of these various mechanisms still needs to be defined before we can arrive at a detailed description of the change in recognition over time and exposures.

I have repeatedly had occasion to note that the retrieval process involved in a recognition task depends on the structure and interpretation of the task. In the case of free recall the process is probably an attempt to retrieve the target item by sampling from some specified search set. In the case of paired-associate tasks, the retrieval process is a search for a holistically encoded pair of which the target item is a member. More generally, the search for contexts appears to be a search for more adequate descriptors of and retrieval cues for the target event. In any case the proper identification of the retrieval process involved in any particular recognition task depends on a careful analysis of the original encoding operations and the requirements posed to the recognizing individual. To make any kind of reasonable predictions about the judgment of prior occurrence, one needs to analyze the strategies and processes used during encoding and retrieval to identify appropriate mechanisms that might influence both integrative and elaborative processes.

I have left aside problems of the criteria used by subjects in coming to decisions based on the familiarity values of items. These questions need to receive adequate attention in subsequent work on the dual process model. Both situational and instructional variables, as well as interindividual differences, may contribute to wide variations in the criteria set and used.

The word frequency analysis has suggested that what is perceived in most cases is not the raw integration (familiarity) of an event but, rather, its incremental integration as a function of experimental exposure. If that is the case, some of the simpler recognition tasks, that is, simpler than differential word frequency problems, need to be analyzed in terms of an incremental process. Such a program would involve experimental methods for investigating the baseline familiarity value of events.

Finally, the present analysis has been restricted to the recognition of words and concatenations of words. To prove its worth, the dual process model should be applicable to other, often more interesting, events. For example, face recognition seems to be consistent with the model, but adequate ways must be found to estimate the two theoretical processes as they operate in the recognition of complex visual (and auditory) stimuli. The notion of intraevent integration seems to be particularly relevant to the investigation of complex situations.

For the time being, this model is offered as an explanation of a restricted domain. The complete and accurate recognition of an event, beyond the judgment of its prior occurrence, will require a familiarity judgment and also precise retrieval processes that can produce the complete identification of the event. The model should be seen as opening the door to more complex investigations as well as to the problem of how things are recognized in the wider sense, that is, recognizing what they are, not just that they have been encountered before.

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