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Retrieval Blocks in Episodic and Semantic Memory*

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ABSTRACT A retrieval block refers to impaired accessibility in retrieving target information when semantically related information is presented (or retrieved) prior to target retrieval. Research concerning retrieval blocks is reviewed in this paper. Evidence for such blocks occurs in a variety of situations, including both episodic and semantic memory tasks. Retrieval blocks have been most thoroughly studied in the part-list cuing paradigm in episodic recall, but similar principles seem to operate in other situations including the A-B, A-D interference paradigm, episodic recognition, the tip-of-the tongue situation, and other semantic memory tasks. The evidence for such retrieval blocks is problematic for theories postulating automatic spreading activation among associated nodes in memory. We review theories accounting for such retrieval blocks and discuss difficulties with the various approaches. Further research on the nature of retrieval blocks may help illuminate similar phenomena, such as the effects of Einstellung in thinking and problem solving.

RÉSUMÉ Revue de documentation sur les bloquages du processus de recouvrement. Il y a bloquage du recouvrement lorsque l'accès à une information cible est diminué par la présentation (ou le recouvrement), avant le recouvrement de la cible, d'une information qui lui est sémantiquement reliée. De tels bloquages existent dans une variété de situations reliées aux mémoires épisodique et sémantique. Bien que ces bloquages aient été étudiés de manière plus approfondie par l'intermédiaire du paradigme des indices de liste partielle dans le rappel épisodique, des principes analogues semblent être à l'oeuvre dans d'autres situations telles que l'interférence A-B, A-D, la récognition épisodique, les situations de 'mots-sur-le-bout-de-la-langue' et d'autres tâches de mémoire sémantique. L'existence de tels blocages fait problème aux théories qui postulent une propagation automatique de l'activation à travers les différents noeuds associatifs de la mémoire. La revue porte sur les théories qui rendent compte de tels bloquages du recouvrement et la discussion touche aux difficultés soulevées par diverses perspectives. De plus amples recherches sur la nature de ces bloquages pourront aider à la compréhension de phénomènes analogues tel l'effet d'Einstellung dans les situations de résolution de problèmes.

Retrieval blocks refer to experiences in which target information available in the memory store is temporarily blocked from retrieval by the retrieval of

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closely related but erroneous information. The rememberer is often aware that he or she knows the target information, but it cannot readily be called into consciousness. As an anecdotal example, one of us was once trying to recall the name of a small hunting dog with short legs and a smooth coat. The desired name was *beagle* but only *basset hound* came to mind during repeated retrieval attempts. The erroneously retrieved name has the same initial letter as the correct target, and the dogs look similar and share other properties (e.g., both are hounds). This sort of experience suggests that retrieval of erroneous related information can somehow block recall of the correct information. If this is so, recall may be described as having self-limiting properties - recall of some information may inhibit later recall of other information (Roediger, 1974, 1978).

The purpose of the present paper is to review studies in which such retrieval blocks have been experimentally induced. We use the term retrieval block in a descriptive sense to refer to an experimental outcome in which retrieval of target information is slowed or prevented by prior presentation (or retrieval) of semantically related information. Thus our use of the term is theoretically neutral.

The idea that recall of one memory may inhibit retrieval of another is an old one. Ebbinghaus (1885/1964, p. 63, footnote 1) quotes the following passage from Delbouef who explained forgetting 'by the theory that one memory might hinder another from appearing. If one recollection does not actually drive out another, it may be at least maintained that one recollection hinders the other . . . ' Later McGeoch (1942) proposed the hypothesis that response competition accounted for forgetting in the A-B, A-D interference paradigm. As Crowder (1976, p. 225) put it: 'The most important feature of McGeoch's theory . . . is the hypothesis that retrieval failures occur because some unwanted memories are retrieved instead of the information to be remembered . . . forgetting is not a loss in retention or availability but is a blockage of retrieval (accessibility) caused by competing information.' Despite the central theoretical importance of the response competition idea, it was never studied directly by early interference theorists. Direct evidence bearing on response competition (retrieval blockages) has been relatively recent.

The study of retrieval blocks is of theoretical interest because it can potentially help illuminate the structure of memory storage and processes of retrieval. Any experience of remembering can be considered as the interaction or match of information in the retrieval environment to that in the stored trace (Tulving, 1976). When remembering goes awry, as in retrieval blocks, we may ask whether particular storage or retrieval processes are implicated as the source of the difficulty.

Many theories postulate that memory storage should be conceived in terms of a large network of associated nodes that represent features of

experiences. Retrieval is considered to occur via associative paths, and activation of one node is assumed to spread to others (Anderson, 1972, 1976; Collins & Loftus, 1975). Thus one might expect that priming a person with information semantically related to target information should aid retrieval of the target information. However, our anecdote and several lines of experimental evidence show that under certain conditions retrieval is hampered rather than aided by the presence of informaton that is related to the target information. This fact calls for revisions in network models' assumptions about storage and/or retrieval.

In this paper we consider specific theoretical accounts of retrieval blocks in discussing various experimental phenomena. First we consider retrieval blocks in episodic memory, and then turn to similar phenomena in semantic memory. We use the terms episodic and semantic memory in a descriptive sense to refer to situations in which remembering depends on retrieving the spatial and temporal context in which some target event was experienced (episodic memory), or retrieving generic information about concepts (semantic memory) (Tulving, 1972, 1982).

RETRIEVAL BLOCKS IN EPISODIC MEMORY

Inducing retrieval blocks in episodic memory experimentally cannot be accomplished in as straightforward a manner as one might like. Ideally, subjects should recall some information, and the effects of this recall on the recall of other information would be measured. However, in free recall subjects will first recall 'easy' items and then be left with 'hard' ones to recall. Thus, they might perform worse (relative to almost any conceivable control) not because of the act of recalling the earlier items, but simply because they were attempting to recall 'hard' items. To circumvent these problems, experimenters have gained control over the items subjects first recall (or are given) and have measured recall on other critical target items. A comparison is then made to the recall of these same targets in a control condition in which there is no retrieval-block manipulation. One danger in this procedure is that subjects in the control condition (typically free recall) may not recall the critical items well because recall of the critical targets may also occur after other items have been recalled, as in the retrieval-block condition. Thus, the magnitude of the induced retrieval blocks may be underestimated due to the operation of similar uncontrolled factors in the comparison condition.

Recall of Once and Multiply Presented Items

One way to rephrase the notion of response competition is that 'strong items block weak ones' (J. Brown, 1968). In what can be conceived as a test of this idea, Tulving and Hastie (1972) presented subjects with a list of

words in which some words were presented once and others twice. In recall, subjects were required to write down the twice presented words two times and the once presented words once. The results showed that recall of once presented items declined with increases in the number of twice presented items in the list. This observation would seem to support the idea of response competition in free recall, or that strong items block weak ones. However, contrary to this interpretation, later studies by Hastie (1975) and Robbins, Bray, and Irwin (1974) indicated that under conditions in which subjects were not required to keep track of once and twice presented items, the inhibition effect in recall of once presented items disappeared.

Although the Hastie (1975) and Robbins et al. (1974) results dispute a retrieval-blockage interpretation, it should be noted that Roediger, Stellon, and Tulving (1977, Experiment II) reported a similar finding from a paradigm in which there was no requirement to monitor frequency of occurrence. In the relevant conditions of the Roediger et al. (1977) experiment, two groups of subjects studied a list of 64 unrelated words twice. One group then studied 32 of the words again, and then both groups were asked to recall the words. In scoring the set of 32 target words that had been presented only twice to both groups, recall was reliably worse (7.92 versus 9.21 words recalled) for the group that had studied the other 32 words a third time. Although additional evidence is needed, Tulving and Hastie's (1972) general paradigm may be useful for studying how retrieval of strong memories blocks the retrieval of weak ones.

Part-list Cuing Effects in Recall

The largest literature on retrieval blocks comes from the part-list cuing paradigm introduced by Slamecka (1968, 1969). In this paradigm subjects study a list of words and are then given part of the list and told to use these items as cues to recall the remainder of the list. Recall of the target words (those not used as cues) is compared to recall of the same words by free recall subjects. The general finding is that under a wide variety of conditions the part-list cues hurt recall. Although it is beyond the scope of this paper to review exhaustively the extensive part-list cuing literature, such reviews have led to the conclusion that as long as part-list cues do not lead to recall of more higher order units than are accessible in free recall, such cues inhibit rather than facilitate recall (Crowder, 1976, Chapter 10; Raaijmakers & Shiffrin, 1981; Roediger, 1974).

To consider this part-list cuing effect in more detail, we will discuss experiments reported by Watkins (1975) and Mueller and Watkins (1977). In these experiments subjects studied word lists in which the words belonged to common conceptual categories (e.g., birds, kitchen utensils, etc.). In Watkins' (1975) Experiment I, subjects studied lists of six 6-word categories and some unrelated buffer words. When tested, subjects received all

six category names and, for most of the categories, they also received words from the category as retrieval cues. The cue words that usually accompanied the category names were either 2 or 4 category items from the list (intralist cues) or not from the list (extralist cues). Subjects were always required to recall as many list words from the category as possible. To insure that they examined the cues prior to recall, subjects were to put a check by each item they recognized as having come from the list.

The results from the experiment are presented in Table I. As can be seen in the top row, as the number of intralist item cues increased from 0 to 4, the proportion of targets recalled decreased, confirming prior results of Roediger (1973) and Rundus (1973). The novel finding from Watkins' (1975) experiment is the discovery that extralist cues from the target category have the same damaging effect as intralist cues. Since extralist cues from the category produce the same effect as intralist cues, Watkins (1975) refers to these phenomena as 'part-set cuing' effects rather than part-list cuing.

TABLE I

Probability of cued recall of items in categories as a function of the number of intralist or extralist items cues from the category: Data from Watkins (1975, Experiment I)

		Intralist cues		
		0	2	4
	0	.56	.50	.47
Extralist	2	.48	.46	
Cues	4	.46		

Before considering the theoretical implications drawn from these results, we should note that various relatively uninteresting explanations have been proposed to account for the inhibiting effects of cues. The cues may be said to confuse the subjects or, more specifically, to disrupt the normal order of output in free recall, which has a damaging effect (Basden, Basden, & Galloway, 1977). The cues may also be argued to provide some nonspecific interference, or even to delay recall slightly. Although arguments against such artifactual accounts of the part-list cuing decrement are available elsewhere (Raaijmakers & Shiffrin, 1981; Roediger et al., 1977), a control experiment conducted by Mueller and Watkins (1977, Experiment I) also helps lay many of these ideas to rest. They presented subjects with categorized lists of the same type used in Watkins' (1975) earlier experiment, and at the time of test cued subjects with category names and, in some cases, intralist cues. However, the intralist cues presented with the category name were either from the same category as the

one tested (related cues) or from a different category (unrelated cues). (The unrelated cues were also items from the list, though.) Subjects were forced to read the cues by the requirement of checking off each cue word recognized and underlining each one not recognized before recall began.

Mueller and Watkins' (1977, Experiment I) results are shown in Table II. Relative to recall of the same target words under the control condition in which only category names were presented as cues, recall with the addition of related cues was inhibited, but recall with the addition of unrelated cues was unaffected. Of course the unrelated cues should also have served to confuse the subject, delay recall, provide nonspecific interference, and perhaps even alter recall order as the related cues supposedly did. However, only in the case when the intralist cues came from the same category was recall inhibited. This outcome provided additional evidence that the part-list cuing decrement is not an artifact of these sorts.

TABLE II

Probability of cued recall with intralist cues when the cue items are either from the same category tested (related cues) or from a different category (unrelated cues): Data from Mueller and Watkins (1977, Experiment I)

		Probability of recall
Control	.58	.54
3 Related cues	.48	
3 Unrelated cues		.55

Theoretical Implications of Part-list Cuing Effects

One general theoretical conclusion that has been drawn from the inhibiting effects of presenting part-list cues is that theories of memory based on the concept of direct associations among items (e.g., Anderson, 1972; Postman, 1971) are in need of modification (Roediger, 1973, 1974; Rundus, 1973; Slamecka, 1968, 1972; Watkins, 1975). If there were direct associations among items in memory, then presentation of some of the items as cues should aid recall of others via activation of associative pathways. Indeed, a computer simulation of one such theory, Anderson's (1972) influential FRAN (Free Recall by Associative Nets) model of free recall, showed that FRAN predicts that part-list cuing should produce a substantial increase in recall rather than the decrease that is actually obtained (Anderson, 1972, p. 362.) However, as will be discussed in more detail shortly, Raaijmakers and Shiffrin (1981) have shown that inhibitory part-list cuing effects can be accommodated by at least one model which assumes that direct associations are formed among list items during study and are used

to guide retrieval during recall. We turn now to consider three explicit theories of the part-list cuing decrement. (These theories can also account for the observation that 'strong' multiply-presented items inhibit the recall of 'weak' items that occurred fewer times during list presentation.)

Watkins Cue Overload Approach: Watkins (1975) accounts for the inhibiting effect of part-list (or part-set) cues by relating it to another well-established phenomenon, the relation between list length and item difficulty. As the length of a list (or the number of items from a category in a list) is increased, the probability of recalling a random item from that list (or category) decreases (e.g., Murdock, 1962; Tulving & Pearlstone, 1966). Watkins (1975, 1979) argues that these pheonomena are manifestations of cue overload - the more overloaded a retrieval cue becomes in terms of the number of items subsumed under the cue, the worse is recall of any one of those items. Watkins accounts for inhibitory part-list cuing effects by assuming that despite their temporal separation the list words and the cue words are integrated into the same higher order unit. Since the cues are functionally members of the list, they add to its length and reduce the recall of other list items through cue overload.

Several observations are congruent with this cue overload interpretation. First, as already discussed, extralist cues from the same category as the target items have the same damaging effect on target item recall as do intralist cues from that category (Watkins, 1975, Experiment I). Second, presenting additional list items at either study or test inhibits recall, though the effect is greater when they are presented at test (Watkins, 1975, Experiment II). Third, other experiments have shown part-list cuing effects in paradigms other than the typical categorized list paradigm with semantic categories. For example, using rhyming sets of words or sets of words that subjects sorted into groups, Mueller and Watkins (1977, Experiments II and III) found retrieval interference when part-set cues were presented during the test.

The cue overload approach of Watkins (1975, 1979) points to the similarity between inhibitory part-set cuing effects and list length effects, and his experimental work extends his analogy. However, Watkins does not provide a molecular account of mechanisms that might be producing these effects. The two approaches to be discussed next each provide such an account.

Rundus' Sampling-with-Replacement Model: Rundus (1973) has proposed an account of the part-list cuing effect that is based on Shiffrin's (1970) search model. The same approach has also been used by Roediger (1973, 1974, 1978) to account for recall interference in several situations. Following the lead of others who have assumed that memory structures are hierarchically organized (e.g., Mandler, 1967), Rundus proposed a three tiered hierarchy for representing a categorized list. The highest level represents

the list-wide context and subsumes the second level which represents the names of the categories that appeared in the list. These category representations can be called control elements (Estes, 1972), because they control access to the third level of representation which is that of the individual elements, the words in the list. Instead of assuming direct associations, Rundus (1973) assumed that representations occupying the same level in the hierarchy are associated to one another through the control element they share at the next highest level in the hierarchy. In Wickelgren's (1976) terms, the associations assumed by Rundus are vertical rather than horizontal associations.

Rundus' (1973) primary assumptions about retrieval were: (a) Recall of an element in the hierarchy is determined by its strength of association to its superordinate control element; (b) Retrieval occurs via a probabilistic sampling-with-replacement process; (c) The act of retrieving an item strengthens its association to its control element so that it is more likely to be retrieved again; and (d) Recall stops after repeated retrievals fail to yield a new item. Since there are no direct associations among list words, the only way part-list cues can facilitate recall is to allow access to an otherwise inaccessible control unit. As noted earlier, reviews of the literature indicate that part-list cues improve recall only when they permit access to more higher order (control) units than can be recalled unaided (e.g., see Roediger, 1974).

To handle inhibitory part-list cuing effects, Rundus (1973) assumed that presenting a list item as a cue strengthens its association to its control element just as the act of recalling it does. Hence, part-list cues inhibit recall because the 'strengthening' of the cue items produced by their presentation results in their repeated retrieval before the critical items are recalled. This repeated retrieval of the cue items leads to a premature cessation of memory search (cf. Crowder, 1976, p. 350). In sum, in Rundus' (1973) model the inhibiting effects of part-list cues arise from special properties of the way information is retrieved from memory. Specific mechanisms are provided to support the notion that strong items block weak items, and the model can also account quite naturally for the fact that list length reduces probability of recall. With increased list length, there is a smaller probability of sampling any particular item.

A good deal of evidence is consistent with Rundus' (1973) model, based as it is on Shiffrin's (1970) general model of search processes in memory. The model can also nicely accommodate data reported by Roediger (1978), who used only category names as cues in obtaining a result analogous to the typical inhibitory part-list cuing effect. In Roediger's experiments subjects studied categorized lists in which the words were grouped according to category. In Experiment II subjects studied 10 categories and at test were given either free recall instructions, or were given 2, 4, or 7 ca-

tegory names and were instructed to recall as many words as possible from both cued and non-cued categories. Conditions were arranged so that all subjects could be scored on recall of items from three critical categories, those that no subjects received as cues. Relative to performance of free recall control subjects, those given category names recalled more words from the cued categories, but fewer words from the noncued categories.

Recall of words from the critical categories is presented in the top panel of Figure 1, in which R-2C, R-4C, and R-7C indicate the number of category names presented as cues in the three conditions. Recall of the critical items was plotted cumulatively, to show that subjects were at asymptotic levels of performance. Thus the decrement in recall of non-cued categories was not simply due to having limited time and devoting it to recall of items for which cues were provided. As can be seen in Figure 1, recall of items from the three critical noncued categories declined with increases in the number of category names given as cues.

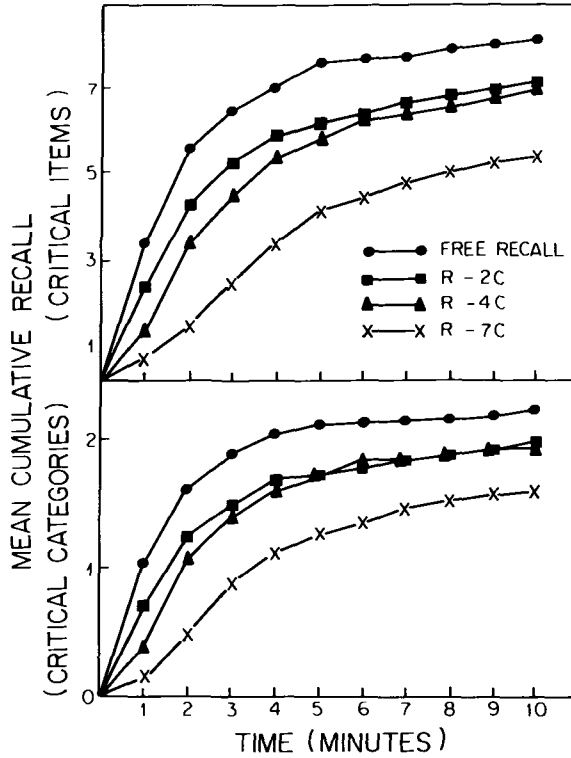

Figure 1 Mean cumulative recall of critical items (top panel) and critical categories (bottom panel) in the four conditions of Roediger's (1978) Experiment II.

These results can be interpreted in a straightforward manner by Rundus' (1973) model. Presenting category names permitted access to those categories and hence better recall than under free recall conditions. However, the associations between the general 'list' control element and the cued category representations was strengthened, so that these category control elements were repeatedly retrieved to the relative exclusion of the noncued categories. As with part-list cues, the greater the number of categories presented, the worse was recall of the other categories. The model also leads to the prediction that the detrimental effect of category cuing should be in recall of other categories rather than in recall of words from categories. Cumulative recall of categories is portrayed in the bottom panel of Figure 1, where subjects were given credit for recalling a category when one word was recalled from that category. It is evident that the recall of categories parallels the overall recall of words. It is also worth noting that it is not necessary to ask subjects to recall words from cued categories to find inhibition in recall of other categories. Roediger and Tulving (1979) found that simply presenting category names to subjects with instructions to recall words from other categories from the list produced a similar, though attenuated, inhibition in recall of noncued categories, relative to free recall.

The Rundus (1973) model provides a good account for the inhibiting effect of part-list cues, as well as for other phenomena. Thus it serves as an explicit account of how the act of recall or presentation of part-list cues can produce retrieval blocks. A central structural feature of the model is that there are no direct associations between representations of the list words. However, as Anderson (1978) has argued with respect to distinguishing imaginal from propositional representational systems, it is difficult to draw conclusions about the nature of mental structures on the basis of behavioural results. The reason is that the prediction made by a theory with a particular set of structural assumptions depends on the assumptions made about the retrieval processes that operate on that structure. If evidence is provided against the theory, it is always possible to modify it by altering either the structural assumptions or the retrieval assumptions. Hence, Anderson's (1978) analysis poses a general challenge to the widely held view that inhibitory part-list cuing effects cannot be encompassed by a theory such as Anderson's (1972) FRAN model, which postulates direct interitem associations. It may be that the retrieval assumptions (rather than the structural assumptions) of such a theory can be changed to accommodate the part-list cuing effect. The basic idea is that an inhibition in retrieval processes produced by part-list cuing would override any positive effect expected from these cues due to interitem associations. This general approach is embodied in Raaijmakers and Shiffrin's (1981) SAM model.

Raaijmakers and Shiffrin's SAM Model: Raaijmakers and Shiffrin (1980, 1981) have proposed a general model for memory and retrieval referred to

as SAM, for Search of Associative Memory. The model assumes that memory contains a large network of both horizontal and vertical associations, an assumption shared with Anderson's FRAN model. However, the retrieval assumptions are quite different from those in FRAN, since they are based on Shiffrin's (1970) search model, which also served as a basis for Rundus' model. As the authors comment, it 'is not too difficult to see that this retrieval model [SAM] is at least potentially able to explain a variety of data in free recall, especially if one recognizes that the model combines features of two powerful models, namely the model of Shiffrin (1970) and the FRAN model of Anderson (1972)' (1980, p. 222). Raaijmakers and Shiffrin's (1981) article was largely devoted to explaining how SAM can ac-

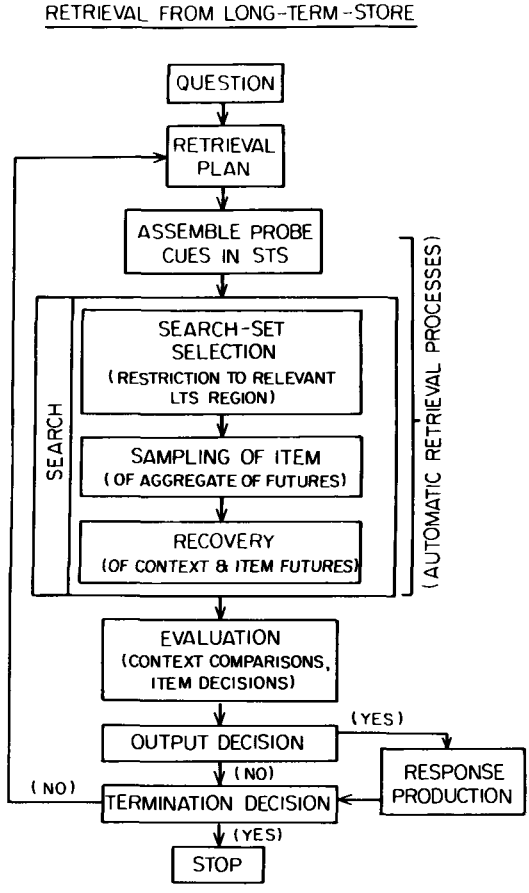

Figure 2 An overview of the various phases of retrieval in SAM. From J.G.W. Raaijmakers and R.M. Shiffrin, Search of associative memory. *Psychological Review*, 1981, 88, 93-134 (Figure 2). Copyright (1981) by the American Psychological Association. Reprinted by permission of the authors.

count for an inhibitory part-list cuing effect. Since all of SAM's ten parameters do not play a role in accounting for this effect, we will limit our remarks here to those aspects of the theory that are relevant to the mechanics of how the retrieval process acts to cancel out any positive cuing effects due to interitem associations.

A general picture of SAM's search processes is given in Figure 2. Specific probe cues are used to initiate a search in memory for information relevant to the particular memory query at hand. In list-memory experiments, these probes may be general context cues associated with the list's presentation, specific items that are recalled or, in the case of cued recall, words presented by the experimenter as cues. To begin free recall a person utilizes only context cues, associations formed between the list context and the to-be-remembered items. As items are recalled, the probe cues are changed to include the recalled items in addition to the context cues. A probe cue is used for recall until it fails to produce recall of new material on a certain number of occasions, represented within the model as the L max parameter. The act of recall increases the strength of the context-to-item association through a process referred to as incrementing. After cues have been exhaustively employed, there is a rechecking process by which each cue is used again in combination with context cues to search for additional targets. Eventually, when K failures to retrieve a new item have occurred, a stopping rule is invoked and recall ceases. (This somewhat oversimplified rendition of the model will do for present purposes.)

To understand how SAM accounts for inhibitory part-list cuing effects, one must determine which of SAM's several retrieval processes nullify and override the positive effect of part-list cuing due to interitem associations. Because of SAM's complexity, this requires that computer simulations be performed. Taking this approach, Raaijmakers and Shiffrin (1981) showed that changes in the parameters corresponding to two of SAM's retrieval processes did not eliminate the inhibitory part-list cuing effect. These processes not responsible for the part-list cuing effect are the incrementing assumption (increase in strength between the part-list cues and the context) and the stopping rule (the number of retrieval attempts resulting in no new recovered items). It is quite interesting that these two retrieval processes are not responsible for SAM's predicting the inhibitory part-list cuing effect, since they play a central role in Rundus' (1973) model's prediction of the effect.

Why, then, does SAM predict an inhibitory part-list cuing effect? The basic reason is that cued subjects begin memory search with the list items they are given as cues, whereas free recall subjects begin with context cues. Since free recall subjects begin with context cues alone, the first list items they recall and then use as cues are those with the strongest context-to-item associations. Since these items are the ones that were processed

most during study, they are also the items that have the strongest associations to other items in the same higher order unit. Furthermore, since part-list cued subjects will have, by definition, at least one cue item (and possibly more) in the cluster in which they begin their memory search, free recall subjects will begin their memory search in a cluster that is, on the average, relatively richer in critical items than the one used by the cued subjects. Hence, free recall subjects will tend to recall more critical items than cued subjects.

Although Raaijmakers and Shiffrin's (1981) SAM model provides a recent and novel solution to the part-list cuing problem, designing independent tests of the model may be difficult, since its ten parameters and numerous countervailing processes make unambiguous predictions hard to come by. But even more problematic are the difficulties SAM has in accounting for two findings reported in Watkins (1975) and Mueller and Watkins (1977). One problem is Watkins' (1975) finding that extralist and intralist cues from the to-be-recalled category have an equivalent damaging effect on recall (see Table I). Thus one might expect the same underlying mechanism to be responsible for both effects, which is the case in Watkins' (1975) approach to this problem, and would be the case in a reasonable extension of Rundus' (1973) model. However, in SAM two different sets of mechanisms must be enlisted to account for the equivalent effect of intralist and extralist cues. Thus, the fact that the two types of cues have the same effect must then be seen as merely a coincidence. Such an interpretation seems unparsimonious at best.

A second problem for SAM is that those of its mechanisms that produce the inhibitory extralist cuing effect lead to the prediction that intralist cues from a category other than the one being tested should also produce the inhibition. Mueller and Watkins (1977) have shown that this is not the case in the experiment cited earlier (see Table II). Raaijmakers and Shiffrin (1980, 1981) acknowledge this problem and argue that items from a category other than the to-be-recalled category are probably not used by subjects as cues. (However, Mueller and Watkins used a recognition test of their cues to insure that subjects at least read them.)

Conclusions: Storage and Retrieval Assumptions in Explaining Part-list Cuing

The part-list cuing effect has been the most popularly studied case of a retrieval block. Although the paradigm was originally introduced to test for the structural assumption of direct associations among memories, the basic part-list cuing phenomena can be accounted for either by theories that postulate direct interitem associations (SAM) or those that do not (Rundus, 1973). The parsimonious conclusion would then seem to be that

the effect should be explained by properties of the retrieval system, with the encoding and storage assumptions made being relatively unimportant.

Experiments reported in a recent doctoral thesis by Park (1980) indicate, however, that encoding and storage factors cannot be ignored in the part-list cuing situation. Park (1980) has shown in three experiments that whether or not part-list cues help or hinder recall depends on the way information is encoded. In Experiment I Park (1980) found that when people studied words embedded in sentences, part-list cues aided recall; however, when the same words were embedded in categorized lists, recall was damaged by cues. In other experiments subjects studied three word sets either by forming coherent interactive images or separate images of the referents of the words. At test subjects received either one cue for each set (the category name) or three cues (the category name plus two items). The probability of correct recall in these conditions is shown in the two panels of Figure 3. (The Location and Attribute designations refer to different classes of material and need not concern us.) As can be seen, under interactive imagery instructions recall improves greatly with the addition of part-list cues to the category name, but under separate imagery instructions part-list cues inhibit recall.

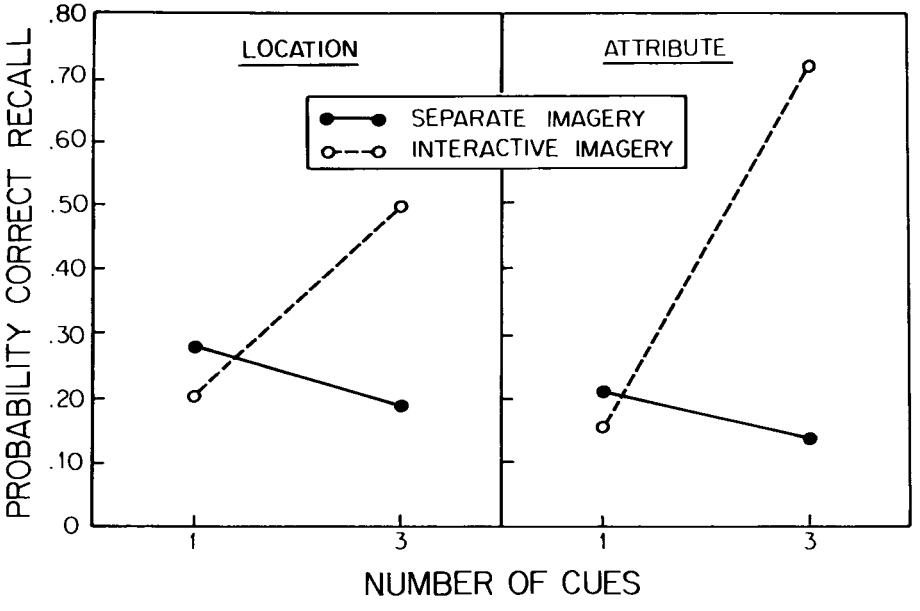

Figure 3 Probability of correct recall as a function of number of cues and encoding conditions in Experiment II of Park's (1980) dissertation.

Park's (1980) work points up the critical role of encoding and storage factors in determining whether or not part-list cues will be effective. The simplest interpretation of his results is that when words are embedded in sentences or when interactive images are formed among their referents, direct (horizontal) associations between representations of the words are formed. In this circumstance, cues aid recall. However, when separate images are formed or when typical categorized lists are presented, no direct interitem associations are formed and part-list cues have an inhibiting effect. This conclusion creates the need for changes in Rundus' (1973) model, and may call for changes in the SAM model of Raaijmakers and Shiffrin (1981). The Rundus (1973) model could be changed to allow more flexible encoding. Horizontal associations in addition to vertical associations might be formed under certain conditions, with part-list cuing producing facilitation rather than inhibition in those circumstances in which horizontal associations are formed. Exactly how Park's (1980) results could be accounted for by SAM is more difficult to see, since rich horizontal associative connections are already assumed even in situations in which intralist cues produce inhibition. Indeed, Raaijmakers and Shiffrin (1981, p. 114) argue that 'the reason for the cue condition disadvantage in SAM is the presence of the very associations that previous theorists have tried to rule out' (i.e., horizontal associations). Thus, it is unclear why encoding conditions that would seem to lead to even stronger horizontal associations should then lead to facilitation from part-list cues, although Raaijmakers (Note 1) has suggested that the stronger associations may affect the recovery process (see Figure 2).

Effects of Semantic Primes on Recognition

Under a variety of conditions part-list cues have been found to inhibit recall relative to free recall. Does one obtain the same sort of part-list cuing effect with recognition? This issue takes on some importance since Rundus' (1973) model has been interpreted by Slamecka (1975) as predicting no effect of part-list cues on recognition. In this section, we review the data relevant to whether the presence of semantically related information affects recognition. For the sake of convenience and of stressing the similarity that some of these studies have to semantic memory studies, we will adopt a terminology in which semantically related 'cues' are called primes. This shift in nomenclature is also appropriate because in recognition tasks subjects are not explicity told to use the semantically related primes as 'cues' that will aid their performance.

In two experiments employing forced-choice tests of recognition, Slamecka (1975) found no effects from presenting either zero, one, or three intralist semantically related primes. He concluded that while part-list cuing may damage recall, it has no effect on recognition. However, since

Slamecka's (1975) results were reported, at least three other groups of researchers have all found evidence that semantically related primes can interfere with episodic recognition.

Todres and Watkins (1981) employed a forced-choice recognition test for memory of categorized lists. Prior to the recognition test, subjects were exposed to either intralist or extralist semantically related primes. Relative to a control condition in which only unrelated primes were presented, extralist related primes had a small but reliably damaging effect on recognition whereas intralist related primes had no effect at all. Todres and Watkins (1981) explained the absence of inhibition from the related intralist cues by assuming that they helped to reinstate the target's study context. Presumably, this reinstatement provided a source of facilitation that nullified the inhibition produced by the related intralist cues.[1] To test this, in Experiment IV Todres and Watkins attempted to reduce the facilitation from reinstatement of the study context by making it less likely that the intralist primes occurred near the target in the study list. This was done by using a random presentation of the list items rather than the blocked-by-category presentation that was used in the other experiments. Todres and Watkins did indeed find inhibition from related intralist cues under these conditions.

Results from two other sets of experiments both extend and limit the generality of Todres and Watkins' (1981) results. Park (1980, Experiments III and IV) tested forced-choice recognition with varying numbers of intralist related primes following the blocked presentation of categorized materials under either interactive or separate imagery instructions. His effects in recognition were like those he found in recall: Under interactive imagery instructions, increasing the number of the intralist related primes aided recognition, but under separate imagery instructions, increasing the number of primes reduced performance. This latter finding is somewhat problematic for Todres and Watkins' analysis, since he found an inhibition effect with intralist primes using blocked presentation of the study list. However, it could be argued that under separate imagery instructions subjects functionally studied each list item in isolation. Thus there would be no study context for the related intralist primes to reinstate. This interpretation could also explain the finding that intralist related primes facilitated recognition

[1]It should be noted that Todres and Watkins' (1981) reasoning concerning context reinstatement by intralist primes leads one to expect that related intralist cues should have less of an interfering effect on recall than do related extralist cues. Contrary to this expectation, Watkins (1975) using randomly presented categorized lists found equivalent inhibitory effects on recall from related intralist and extralist cues. Also, with unrelated word lists, Roediger et al. (1977) actually found less inhibition from extralist cues than intralist cues. Exactly why the intralist vs extralist priming difference in recognition is not also obtained in recall must at present remain unexplained, but see Todres and Watkins (1981, p. 98).

when subjects had studied the items under interactive imagery instructions. With such instructions, subjects would have studied one item in the context of (in the same image as) other adjacent related items in the list. The presentation of these list items as primes should then serve to reinstate the study context of their related target item, thereby facilitating recognition.

Neely, Schmidt, and Roediger (Note 2) tested speeded yes/no recognition following the presentation of blocked categorized lists. In the conditions of interest for present purposes, subjects were tested on a critical item from a category (either a target or a lure) after they had been tested on either two or six other 'priming' items from that category (half targets and half lures). When the critical item was a target, reaction times (RTs) were slower when six related items preceded the critical test item than when two related items preceded it. Although subjects made more errors on lure critical items after six rather than two related primes, there was no RT difference.

There is one further qualification of the Neely et al. (Note 2) findings: The inhibition effect of having been tested on six rather than two prior related items was more consistent when the priming item prior to the target was a lure (extralist cue) rather than another target (intralist cue). Thus, as in the Todres and Watkins' (1981) experiment, the magnitude of the inhibition in recognition produced by semantically related primes was modulated by the intralist vs. extralist nature of the last-presented prime.

One other aspect of the data from experiments on priming effects in episodic recognition must be discussed. Macht and O'Brien (1980) have reported that the presence of extralist related primes facilitates the speed with which targets can be recognized. It is important to note, however, that in such cases the priming manipulation consists not of how many semantically related primes have occurred prior to the target, but rather of how recently the related prime has occurred. In such cases, the more recently a related prime has occurred, the more quickly the target item is recognized. In two of their experiments, Neely et al. (Note 2) manipulated both the recency of priming and the number of primes. They found that the magnitude of the inhibitory effect from increasing the number of semantically related primes was not influenced by the recency of occurrence of the last related prime. However, RTs to targets and lures were facilitated considerably when the last related prime occurred as the immediately preceding test item rather than occurring two items previously. Thus, in interpreting the effects of primes on recognition, one must be mindful of the fact that there are two different ways in which priming can be manipulated. One of these manipulations, variations in the recency of a related prime's occurrence, yields facilitation in the speed with which target recognition occurs. The other, variations in the number of semantically related primes, yields inhibition in both the speed and accuracy of target recognition.

The experiments of Todres and Watkins (1981), Park (1980), and Neely et al. (Note 2) show that recognition, like recall, is inhibited under certain conditions by the presentation of related items either from within or outside the to-be-remembered list. Although a detailed explanation of these findings has not been worked out, one general theoretical conclusion is that the mechanism producing retrieval blocks is not specific to recall, but rather is common to both recall and recognition.

Response Competition in Paired-Associate Learning

As noted previously, the first factor of the two-factor theory of interference was response competition (McGeoch, 1942). For example, in the A-B, A-D interference paradigm, when subjects are presented A and asked to recall the associated response from the first or second list, performance suffers, relative to a single list control, because of competition between the B and D responses. Retrieval of one response was considered to inhibit recall of the other.

Given its central role as an explanatory device, it is interesting that response competition as a source of retrieval difficulty was not explicitly manipulated in experimental tests of classical interference theory. Also, the concept seems to have lost much of its force since the important work of Barnes and Underwood (1959). Their research demonstrated large effects of interference under conditions believed to remove the possibility of response competition. Specifically, Barnes and Underwood (1959) introduced the procedure of Modified Modified Free Recall (MMFR), which allowed subjects to respond during a test following A-B, A-D learning with either or both responses associated with A. This was believed to relieve any competition that might exist between the two responses, because according to Barnes and Underwood's (1959) view, competition between responses occurs only under 'standard' conditions when subjects are asked to recall the one response appropriate to a particular list. However, if response competition is conceived as a retrieval inhibition in calling to mind a response when another has already been retrieved, then it is obvious that such inhibition is not overcome even by the MMFR procedure. Retrieval of one response may still make recall of the other less likely.

Direct evidence that this is the case has been reported in the studies of Mueller and Watkins (1977, Experiment IV), although a similar finding was also reported by Postman, Stark, and Fraser (1968, Experiment III). Mueller and Watkins (1977) presented subjects with six lists of 16 pairs of items corresponding to an A-B through A-G interference paradigm. At the time of test subjects were given either only the A term or the A term plus three of the response terms with MMFR instructions to recall as many items associated with the A terms as possible. The results showed that when response terms were presented along with the A stimulus term, recall was impaired.

This can be taken as evidence for response competition in the MMFR paradigm. Activation of some responses serves to inhibit recall of others. Thus, the notion of part-set cuing inhibition extends quite well to the paired-associate paradigm.

RETRIEVAL BLOCKS IN SEMANTIC MEMORY

Semantic memory may be thought of as a person's general store of knowledge (Tulving, 1982). In retrieval from semantic memory one need not recall the time or place in which the information was first iearned, which distinguishes such tests from those of episodic memory. Tulving (1982, Chapter 5) argues that, based on the evidence accumulated thus far, the episodic and semantic memory systems should be considered as functionally distinct. However, we will use the term semantic memory in a descriptive sense to refer to a class of tasks in which pre-experimental knowledge is tested without any requirement for the subject to retrieve where or when the information was acquired.

The discovery of retrieval blocks in semantic memory produced by related information is as problematic for several associative theories of semantic memory as are the part-list cuing results in episodic memory. For example, Collins and Loftus' (1975) influential theory postulates spreading activation throughout a semantic network, as does Anderson's (1976) ACT theory. A considerable body of evidence supports the notion of automatic spreading activation (Collins & Loftus, 1975; Neely, 1977a; Schvaneveldt & Meyer, 1973), but there are also instances of retrieval blocks produced in semantic memory. We organize our view of this research around different types of tasks: recall tasks, lexical decision tasks, categorization tasks, and perceptual recognition tasks.

Recall Tasks

The best known instance of retrieval blocks in semantic memory is the tip-of-the-tongue phenomenon first studied experimentally by R. Brown and McNeill (1966). When students were given definitions of low frequency words that occasionally precipitated a tip-of-the-tongue state, they exhibited partial knowledge for the target concept by producing similar sounding and meaning words, estimating the number of letters better than chance, and guessing the initial letter better than chance. One view of how people overcome the retrieval block and eventually recall the target word is that activation from the related concepts spreads to the target, thus activating it. (Brown and McNeill proposed a similar idea.) However, if the related information primes the target, the question remains as to what produced the retrieval block in the first place.

Roediger (1974) suggested that the difficulty represented by the tip-of-the-tongue phenomenon may actually be due to retrieval of the related

information blocking recall of the target. This idea can be tested experimentally by asking subjects to retrieve information from semantic memory and priming them with different sorts of information beforehand. Most semantic memory tasks require retrieval of only one fact or word, with RT as the dependent variable. However, J. Brown (1968) performed the first experiments manipulating retrieval blocks in semantic memory with a free recall test of a whole set of material. He presented one group of subjects with 25 randomly selected states and instructions to study them for five min, while a control group spent the time reading. At the end of the 5 min period all subjects were required to free recall all 50 states. The group that studied the 25 states recalled these states better than the control group. However, the control group recalled more of the other 25 states (the complementary set) than did the experimental group. Brown (1968, Experiment II) replicated the effect with British students using the 40 counties of England as targets. Karchmer and Winograd (1971) also replicated Brown's (1968) results using states as materials.

One possible difficulty with these studies is that subjects were given only 5 min for recall. Since subjects who have studied some material tend to recall it before they attempt the other material, the recall period may not provide enough time for subjects to reach asymptotic levels of recall. Roediger and Payne (Note 3) repeated Brown's (1968) experiment, but allowed 10 min for recall and measured recall cumulatively. They still found a slight but reliable inhibition effect in recall of those subjects who had studied half the states prior to recalling the entire set, even at the end of the 10 min period when recall was near asymptote.

These inhibition results are not easily accommodated by theories postulating spreading activation in semantic memory. Presentation of half the states should have activated their representations in semantic memory, and this activation should have spread to related concepts, making their recall more likely at test. Thus the problem is the same one posed for unelaborated associative theories by part-list cuing inhibition in episodic memory. Roediger and Payne (Note 3) performed two other semantic memory experiments analagous to part-list cuing experiments. Students were asked to free recall category members for 10 min and were given varying numbers of items from the category to serve as cues. These cues produced slight but reliable inhibition in recall of the target items, and this inhibition increased with an increase in the number of cues given. Although these results are inconsistent with unelaborated associative theories postulating automatic spreading activation, it is possible to modify these theories with retrieval assumptions such as those embodied in SAM to permit postdiction of these results.

A.S. Brown (1979, 1981) has reported a number of experiments in which semantically related primes were found to slow retrieval from semantic

memory relative to several control conditions. In the first set of studies Brown (1979) presented subjects with definitions preceded by one of several prime types. For present purposes we can consider three prime types, correct, related, and unrelated. The correct prime was the target word, in which case subjects were simply to respond 'yes'. In the other cases the prime was either semantically related or unrelated to the target and subjects were to produce the target. In his experiments Brown found that subjects were generally slower to retrieve the target following related than unrelated primes, which he attributed to automatic spreading inhibition in semantic memory.

A difficulty with Brown's (1979) procedure is created by his use of correct primes on some trials. In this procedure, subjects must first compare the prime to the definition on all trials to determine if there is a match. If there was a match, subjects were to respond 'yes'. Thus, only if the prime and definition did not match would subjects attempt to retrieve the target. It seems reasonable from other evidence (e.g., Schaeffer & Wallace, 1969) that subjects would take longer to reject related than unrelated primes as being incorrect. Thus subjects would be slower following related than unrelated primes, not because the related prime inhibited the retrieval process once it began, but because it delayed initiation of the retrieval attempt. Brown (1979, Study III) presents some indirect evidence against this account, but Roediger, Neely, and Blaxton (Note 4) examined the issue more directly. They measured the reaction time of subjects to answer simple questions. ('Who was President during the Civil War?') after receiving various primes. One group of subjects was tested with one of four different types of primes on each trial: correct (Abraham Lincoln), related (George Washington), unrelated (Colorado), and neutral (the word 'ready'). In all cases the subjects' task was to respond with the correct target. Under these conditions Roediger et al. (Note 4) replicated Brown's (1979) results: Subjects were fastest following the correct prime, intermediate following the neutral and unrelated primes (which did not differ), and slowest following related primes. However, a second group of subjects was tested with only three prime types: related, unrelated, and neutral. Since no prime was ever the correct answer, there was no need for subjects to compare the prime to the question before attempting retrieval of the correct answer. Under these modified conditions the semantically related prime produced reliable facilitation rather than inhibition, at least when compared to the unrelated prime condition. Thus they concluded that the inhibition Brown (1979) found was likely a result of the particular procedure he adopted and not a true retrieval block.

Brown's (1981) other studies of retrieval blocks in semantic memory used a different methodology. In Experiment I he had subjects repeatedly retrieve words from categories when given initial letters (e.g., Fruit-a), a

task first used by Freedman and Loftus (1971). When subjects repeatedly retrieved words from the same category, they became increasingly slow. On the other hand, Loftus and Loftus (1974) found that people were faster on a second category-letter retrieval if they had retrieved an item from the same category on the prior trial. The difference between their finding and Brown's may be that in Brown's experiment subjects knew that they would be repeatedly retrieving items from the same category, while in the Loftus and Loftus experiment repeated tests were more rare. In other experiments Brown (1981) required subjects to name a series of pictured objects belonging to the same category, and found that RTs increased with the number of prior related pictures tested, although this inhibition in naming built up more slowly than that in the Freedman and Loftus (1971) paradigm used in Experiment I. It is arguable as to whether picture naming involves retrieval in the same sense as applies to the other tasks reviewed here, but the picture-naming results are similar to those obtained in these other tasks.

In summary, several lines of evidence suggest retrieval blocks in recall from semantic memory. Such blocks have been less thoroughly studied than those in episodic recall tasks, but even these first results would seem to argue that theories of semantic memory postulating automatic spreading activation are in need of revision. Several general approaches might be taken. One is to postulate spreading inhibition in semantic memory under certain circumstances (Brown, 1979; Martindale, 1981); another is to introduce retrieval assumptions to the models that would override the facilitation to be expected from spreading activation (Raaijmakers & Shiffrin, 1981). In fact, Brown (1981) interprets his results from the Freedman and Loftus (1971) and picture naming paradigms within the framework of Raaijmakers and Shiffrin's (1981) SAM model.

Lexical Decision Task

One popular paradigm for studying the effects of related primes is the lexical decision task in which subjects must decide whether or not a string of letters is a word. When a subject makes a lexical decision about two words in succession, the relatedness between the words affects RT to the second word. For example, Schvaneveldt and Meyer (1973) found facilitation between semantically related words such as *doctor-nurse*, and Neely (1977a) found facilitation with category names and their exemplars (*bird-robin*).

Although facilitation from the recent presentation of a single semantically related prime is the typical result in the lexical decision task, there are two sets of studies that are pertinent to whether 'multiple' semantically related primes produce inhibition. In one such set of studies, investigators have looked for the phenomenon of semantic satiation employing the lexical decision task. Semantic satiation refers to a hypothesized loss of meaning of

a word through repeated massed presentations (e.g., Esposito & Pelton, 1971). For present purposes we can think of the procedure as one of repeated priming of the same concept. Neely (1977b) and Cohene, Smith, and Klein (1978) compared RTs to a target item after it or its associates had been presented numerous times (satiated) or once or twice (nonsatiated). Neither study showed an increase in RTs to the target due to numerous prior massed presentations of the target or its associates.

The second set of studies involving multiple semantically related primes in the lexical decision task appears to provide evidence for retrieval blocks in semantic memory. Schmidt (1976) found more errors following eight semantically related primes than following one such prime in a lexical decision task. But since subjects were faster in the case of the multiple related primes, a speed/accuracy tradeoff, rather than a retrieval blockage, may account for these results. In sum, there is no evidence for true retrieval blocks within the lexical decision paradigm.

Categorization Task

Rosch (1975), using a categorization task, has reported a curious finding that is often cited as demonstrating retrieval inhibition from a semantically related prime. She presented subjects with pairs of words and their task was to decide whether or not the words belonged to the same semantic category. In conditions of interest, subjects were primed either with the category name ('furniture') or a neutral prime ('ready') before deciding whether the two words belonged to the same category. She found that when the words were the same and were atypical members of the category (e.g., rug rug), people were slower to respond that they belonged to the same category following the category name prime than following the neutral prime. Although this is an interesting effect, its generality is quite limited. When the task is varied so that subjects decided whether or not the two words matched in terms of physical characteristics instead of category membership, the inhibition effect disappeared. Also, in the category judgment task, if the two words are typical category members (chair chair or chair table) or even atypical members but different words (rug stove), one finds facilitation from the category name prime. Thus the inhibition from semantic priming occurs only when atypical members are presented twice (rug rug). Although this inhibition may represent an instance of a retrieval block, its limited generality reduces its theoretical interest.

Perceptual Tasks

Although we recognize that there is no firm boundary separating the study of perception from that of memory, some tasks revealing retrieval blocks involve brief presentations of information and do not necessarily require subjects to access the meaning of concepts. We discuss these tasks together

under the rubric of perceptual tasks. For example, Egeth and Santee (1981) investigated a phenomenon, first reported by Bjork and Murray (1977), called the repeated letter inferiority effect. Bjork and Murray (1977) presented subjects with two letters very briefly (e.g., AE) and then cued them to report one of the two (e.g., A). They found that report of the letter was better when two different letters appeared in the display than when the same letter was repeated (AA). They explained this effect by appealing to inhibition of perceptual processing of similar visual features. Since more features match when the letters are the same, there should be greater interference. However, Egeth and Santee (1981) found that the repeated letter inferiority effect is also found under conditions in which the two repeated letters do not match in terms of physical features (e.g., Aa). Although the effect was somewhat diminished with mixed case letters, it was still quite reliable. Such a finding argues that interference is at a more abstract conceptual level, involving either a phonological or semantic code. Thus it may well be related to the other forms of retrieval blocking we have discussed. In fact, Underwood (1981) has reported a similar phenomenon in which the parafoveal presentation of words interferes with the categorization of a foveally presented target word when the parafoveal words and the target word belong to the same semantic category.

Another possible example of a retrieval block in a perceptual task can be found in work by Neill (1979). In his experiments, subjects decided if two visually presented target letters or digits were nominally or physically identical or were different. Different groups of subjects were told to emphasize either speed or accuracy. Under accuracy instructions, a prime from the same category as the targets (e.g., F as a prime for Aa or 5 as a prime for 22) hurt the accuracy to 'same' target pairs in comparison to a prime from the opposite category (e.g., 5 as a prime for Aa or F as a prime for 22). However, this inhibition from a categorically related prime did not occur under speed instructions. Under speed instructions, a categorically related prime facilitated 'same' RTs, compared to a categorically unrelated prime. Neill (1979) argues that in order to identify items from a category under accuracy instructions, subjects must suppress the codes for other items from that category. If a nontarget item from the category has been recently primed, the code for that item is difficult to suppress, thereby inhibiting the subject's identification of the target. The same mechanism producing this inhibition in target identification might also be mediating the inhibition from semantically related primes in recognition paradigms such as Brown's (1981) picture naming task and Neely et al.'s (Note 2) and Todres and Watkins' (1981) episodic recognition tests.

The final perceptual task we will consider in relation to retrieval blocks is the Stroop (1935) interference task. In this task, subjects are slower to name the color of ink in which a word is written when that word is the name

of some other color rather than being an unrelated word. One theory of this Stroop effect postulates a race between processes involved with naming the word and those involved with naming the ink color in which the word is written. The overpracticed word naming response 'wins' and thus blocks the color naming response (e.g., Dyer, 1973). A similar sort of interference occurs in naming a picture that is simultaneously presented with a to-be-ignored word (e.g., Smith & Magee, 1980), and this interference is greater when the picture and word are related than when they are unrelated (Lupker, 1979; Lupker & Katz, 1981). These results seem inconsistent with the notion of spreading activation, since simultaneous activation of semantically related codes (those of color names, or a related picture and word) might be expected to facilitate processing. However, theorists postulating spreading activation have attempted to account for these Stroop-like effects by arguing that response competition overrides the facilitation that is due to spreading activation (Posner & Snyder, 1975).

SUMMARY AND CONCLUSIONS

We have summarized a great deal of evidence about retrieval blocks from a variety of paradigms. In episodic memory tasks, retrieval blocks have been found both in recall and in recognition, in the part-list cuing paradigm, in the A-B, A-D interference paradigm, and in poorer recall of 'weak' items when mixed in lists with 'stronger' ones. In semantic memory tasks, retrieval blocks have been found in recall tasks resembling those used to produce the tip-of-the-tongue phenomenon, as well as in miscellaneous classification and perceptual tasks. Interestingly, no evidence for retrieval blocks has been found with the lexical decision task.

It may be objected that the phenomena from the diverse tasks we have catalogued here - especially those in the last few pages - are only superficially related. Although the inhibition found from presenting semantically related information in these different tasks does fit our definition of retrieval blocks, the mechanisms producing the inhibition may be quite different in the various cases. This line of reasoning may well turn out to be correct. However, in the past we believe an error has been made in not seeking commonalities across disparate tasks and phenomena. We would prefer to assume that common mechanisms underlie the various manifestations of retrieval blocks until evidence convinces us to abandon this assumption. In short, we hope that a general theory of retrieval blocks can be developed.

The nature of such a general theory cannot be specified at the moment. In fact, since many of the phenomena we have included here have received so little experimental attention, it may not even be profitable to begin constructing a general theory until more is known about the basic variables that determine retrieval blocks. A major challenge is simply to uncover why presentation of semantically related information induces retrieval blocks in

certain tasks while similar manipulations produce facilitation in other tasks. This puzzle will be solved only with a good deal more empirical work. Nonetheless, two general theoretical approaches to explaining retrieval blocks seem worth pursuing.

One approach is to apply the theories developed to explain the part-list cuing phenomenon, the most studied example of retrieval blocks, to the other tasks that produce similar blocks. For example, Raaijmakers and Shiffrin's (1980, 1981) SAM model provides a potentially powerful theory that can be applied to many tasks. Brown (1981) has already attempted to apply it to his study of retrieval blocks in semantic memory.

A second approach is to borrow ideas concerning inhibition that have been well worked out in other biological systems and apply them to memory phenomena. The notion of lateral inhibition worked out in the study of neural networks underlying vision may be one serviceable analogy. Crowder (1978) has pressed the idea into service to account for inhibitory phenomena in auditory memory, and the idea has been expanded by Walley and Weiden (1973) to account for 'cognitive masking' effects. In fact, Martindale (1981, pp. 196-200) has even tried to apply this approach to understanding some cases of retrieval blocks that we have reviewed here.

In order for these two approaches to be workable, a theorist must specify precise mechanisms to allow unambiguous predictions of facilitation and inhibition in a given situation. Obviously a theory that has opposing processes that facilitate and inhibit performance can 'explain' any pattern of data (facilitation, inhibition, or a null result) at some level of generality.

An understanding of retrieval blocks in perceptual, episodic memory, and semantic memory tasks may also aid our understanding of similar phenomena in the study of higher processes of thinking and problem solving. In several different problem solving tasks the effect of prior experience produces difficulty for a person in solving a new problem. For example, Luchins (1942) had subjects solve problems that had one solution and thus led them to build up a set way of attacking the problem. When presented with a new problem that had a simpler solution, subjects often persevered with their set way of solving the problem, rather than using the more straightforward method that control subjects easily discovered. Rees and Israel (1935) studied similar effects of set in solving anagrams. Also, it has been reported that when anagrams are presented in nonsense form (ERTEN for ENTER) they are easier to solve than when presented as words (CAUSE for SAUCE) with other factors held constant (Beilin & Horn, 1962; Ekstrand & Dominowski, 1965). Apparently receiving the letter string as a word blocks retrieval of the second word containing the same letters (but see Mayzner & Tresselt, 1965). It may be that Einstellung (set) effects and other related phenomena (e.g., Duncker, 1945) involve similar processes to

those underlying retrieval blocks, since in both cases priming by related information damages later performance. As Posner (1973, p. 166) comments in discussing Einstellung and similar effects, 'The tendency of thought to follow paths similar to ones that have recently been activated is an important and pervasive one.' Such a statement may capture the essence of retrieval blocks of all sorts.

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