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THE ROLES OF INTERFERENCE AND INFERENCE IN THE RETRIEVAL OF AUTOBIOGRAPHICAL MEMORIES

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1. Introduction

Recent work on autobiographical memory has suggested that the representation of an individual experience is encoded within a memory structure containing generalizations about that class of events (Kolodner, 1980; Reiser, Black, & Abelson, 1982; Schank, 1982). In this paper, we examine how retrieval from such a memory category is affected by the number of events encoded within it. We argue that retrieval of personal experiences is a reconstructive process, guided by inference mechanisms that predict features of the target event for utilization as retrieval cues. More frequent events may be easier to retrieve from a category, since the circumstances leading to such an event are easy to predict. Alternatively, one interpretation of interference models of memory suggests that a greater number of events within a category would slow retrieval of one of these events. The effects of frequency of experiences are examined in an autobiographical memory experiment where subjects are asked to recall past experiences in response to verbal cues.

2. Inference in Memory Retrieval

Reconstructive models of memory retrieval have stressed the recursive nature of the search process: search retrieves information useful in constructing new cues for further search, until the target information is retrieved (Kolodner, 1980; Norman & Bobrow, 1979; Williams & Hollan, 1981). In particular, retrieval of an individual personal experience requires search through a memory store containing an enormous number of events. Clearly the success of such a search depends on the selection of the proper search context to restrict the portion of the data base that must be examined. This search context is selected by inference mechanisms which process the generic information in the concepts activated in the query to predict the most plausible location in memory where the target information might reside (Kolodner, 1980). Retrieval of an individual experience from memory is thus an active strategic process, directed by these inference mechanisms.

In recent reformulations of Bartlett's (1932) schema plus correction model, individual experiences are encoded in memory as associations of generic memory structures, indexed by the features on which the event deviated from the generalizations represented for that class of events (Kolodner, 1980; Schank, 1982). Search for an individual experience proceeds by using the generic knowledge about events to infer candidate memory structures for search, and then to generate indices within the structure that specify an individual experience:

Think of a time when you felt impatient.

Felt impatient...I'm trying to think of times when I felt impatient. Impatient always seems to mean when you're waiting in line for something or waiting for something to happen. Um...it's hard for me to think of right now for some reason. I can think of times when I felt frustrated waiting but not really impatient, and I think there's a difference. I remember waiting for someone who didn't show up for 4 hours, and it wasn't really that I was impatient, I was just frustrated with the fact that I didn't know whether this person was going to show up or not.

Was this waiting in line?

No, this was waiting to meet someone in front of a museum in Hartford. And he didn't come for about 4 hours and mostly the reason I was frustrated or maybe it even is impatient is that I didn't know whether he was actually coming...

This protocol demonstrates the use of inference to establish a search context. Here, the subject uses her knowledge about impatience to infer a set of circumstances in which she was likely to have experienced that affect. This process leads to thinking about situations involving "waiting," and ultimately to an experience where she was waiting for someone who was very late. Interestingly, the subjects' hesitation in classifying this experience as "impatience" supports the claim that it was accessed in memory using "waiting" as a search context, rather than simply using "impatience" as a cue.

Essentially, these type of inference processes reformulate a memory query into a set of circumstances in which the target experience might have occurred. The importance of inference in strategic memory retrieval has been

suggested by studies of retrieval protocols (Williams & Hollan, 1981) and computer models (Kolodner, 1980). A recent examination of retrieval times of autobiographical memories may be interpreted as processing evidence for the role of inference in retrieval (Reiser, Black, & Abelson, 1982). In these studies, subjects took longer to recall an experience with an activity (*took a ride on a train*) that contained a goal failure (*couldn't find a seat*) than an experience with the same activity that contained a normative action (*paid at the ticket booth*). We argued that retrieval of an experience containing a normative action typically involves less inferencing, since virtually any of the experiences stored with the activity will contain that action. Retrieval of an experience satisfying a goal failure cue requires more inferencing to find the indices that specify an experience containing the targeted type of goal failure.

In general, the difficulty of a memory retrieval is determined by the type of processing necessary to construct an appropriate search context, and to generate the indices within that context that specify an experience possessing the target attributes. Search within a memory category for an experience satisfying a particular constraint is easier if there are more types of situations in which that type of event occurs. Thus, events that occur more frequently should be easier to find within a category than less frequent events.

3. Interference in Memory Search

Alternatively, one might argue that more unusual experiences will be easier to find in memory, since many similar events may become confused with one another, and interfere during the retrieval process. Anderson has shown that a greater number of associations involving a concept in a memory network slows the retrieval of propositions involving that concept (e.g., Anderson, 1976). Anderson argued that the search is slowed with more associations since the limited capacity process would “fan out” over more paths. Anderson and his colleagues have observed interference in retrieval situations requiring the retrieval of a particular proposition, and have not investigated in situations where any instance of a memory category may be produced as a response. However, one possible application of interference models to this type of production task would predict that retrieval of an instance will be easier for smaller categories than larger ones, which possess more links from the category node to associated subsets and instances. Again, spreading the search over more links reduces the speed of the processing. Furthermore, if the instances possessing a particular attribute form a subcategory of the main category, then a larger number of such instances should slow the search for a category member possessing that attribute.

Although an interference model cannot account for the difference between failure and normative actions found by Reiser et al., it may be argued that this difference is not due to the frequency of the two types of events, but instead to some intrinsic difficulty in recalling goal failure events. In fact, we found retrieval time differences which one might argue support an interference model. Activities (*Going to Movies, Dining at Restaurants*) were found to be better retrieval cues than general actions (*paying, ordering*), which encode abstracted generalizations about an action (or scene) which serves as a component of several activities. We argued that the type of generic information encoded in activities is of greater utility in constructing the right combination of features to specify a unique experience. Retrieval of an experience when presented with a general action such as *waited for your turn* involves first figuring out *where* (i.e., in what kind of activity) one might have waited for something. When a candidate activity such as *Bank* or *Grocery-Shopping* has been inferred, the context-specific knowledge associated with the activity (i.e., features specific to *Bank* experiences) can be used to refine the search context.

An interference model provides an alternative explanation for this result. One might argue that the general actions are poor retrieval cues since they specify more frequent experiences than the activities (most general actions occur in many activities). Search in the category named by the general action must spread over many more links to experiences than search within an activity category, and would therefore take longer to retrieve any of the experiences.

In order to explore the relationship between the number of experiences of a given type and the difficulty of retrieving an experience from memory, we asked subjects to recall events which differed in their average frequency of occurrence. There were two motivations in the present study. First, we hoped to find that more frequent experiences within an activity would be easier to retrieve, to support the importance of inferring a search context and generating indices within that context. By using low frequency events that were not goal failures, we avoid other characteristics of goal failures that may be contributing to their retrieval difficulty. Second, presenting a case where more frequent experiences are *easier* to retrieve provides an argument against interference counter-explanations of our previous finding of retrieval differences between activities and general actions.

4. Retrieval of High and Low Frequency Experiences

Norms collected by Galambos (in press) were used to construct probes about common events which varied in their frequency of occurrence. Each probe consisted of an everyday activity (e.g., *Checked Out Books*) paired with one of its component actions (e.g., *got call numbers*). Galambos' norms enable a test of the effects of event frequency at two levels. The *standardness* rating of a component action measures the within-category frequency of the action -- i.e., how likely one is to perform that action in an execution of the given activity. It is thus an indication of the relative number of experiences encoded within the activity category that involve that particular action. The activity frequency measures the size of the category itself -- a measure of how often one engages in the activity may be considered a rough estimate of the number of experiences stored in memory involving that activity.

Retrieval of experiences for trials involving highly standard actions is predicted to be faster, since it will be easier to infer a context in which this action would have been performed in the activity. For example, most *Going to Movies* experiences involve the action *gave usher tickets*, but fewer involve the action *stood in line*. Virtually any retrieval cue within the category *Going to Movies* would lead to an experience matching the first action. However, more careful consideration of the generalizations about movie-going would be necessary to predict a situation that would involve standing in line. This might lead retrieval to consider "very popular movies", "movies I saw on opening night", "movies I saw on trips to New York", etc. This retrieval thus requires more inferencing to construct a search context. This prediction is contrasted with the interpretation of the interference model suggested above, in which more frequent actions within an activity would be more difficult to retrieve.

The predictions for the effects of activity frequency are less straight-forward. If the generic information encoded in the activity is the principal source of material for inferring the search context, then the frequency of the activity itself may have a smaller effect (or none at all) on the ease of retrieving an experience. That is, if the principal component of retrieval is the inference of indices within the category, then the absolute size of the category may have little effect, and all activities may be equally accessible in memory. However, one might also expect that more frequently executed activities become more richly articulated, and thus the indices within the category may be more easily traversed. For example, recalling a time involving *Eating at a Restaurant* may require less inferencing than a more infrequent event such as *Taking a Photograph*. One is probably familiar with many contexts which include eating at restaurants (*dating, business lunches, grabbing a quick bite to save time, etc.*) while more processing might be necessary to infer a situation that would have included the taking of photographs. This would predict an advantage for more frequent activities. In either case, this prediction can be contrasted with the interference prediction of slower retrieval times for the larger categories.

Method. Two actions, one high and one low in standardness, were selected from each of 18 of the activities presented in Galambos (in press). The high and low standard actions were selected to be equal in "centrality" (the importance of the action to the goals of the activity), since subjects recall the more central actions of an experience more easily than the less central actions (Reiser, in preparation).

The autobiographical retrieval task developed by Reiser, Black, and Abelson (1982) was used to measure the accessibility of the target events in memory. Subjects were told that each trial would consist of two phrases: a description of an activity, and a description of an action that takes place in the activity. Upon initiation of the trial by the subject, the two phrases were simultaneously displayed on a CRT, with the activity phrase presented above the action phrase. Subjects were to recall an experience where they were performing the stated action while doing the stated activity. The subject responded by pressing a *Yes* key on recall of such an experience, or pressed the *No* key if he or she could not recall an experience. We emphasized that the memory be of a specific experience, but that it was not necessary to recall all of the details before responding. Subjects wrote a one or two sentence description of the experience immediately following each *Yes* response. At the completion of the reaction time task, subjects were asked to provide the month and year in which each of their recalled experiences had occurred. Each subject was probed about all 18 activities, but to avoid possible priming effects, a subject was probed only once about each activity. Each subject thus received 9 activity-action pairs containing a high standard action, and 9 activity-action pairs containing a low standard action. Forty-eight Yale undergraduates participated in this experiment for course credit.

Results. Of primary interest are the retrieval times for those trials in which subjects successfully recalled an experience. The mean retrieval times and proportion recalled for *Yes* responses are:

Activity + High Standard Action	2.929 sec; 84% <i>Yes</i> responses.
Activity + Low Standard Action	3.359 sec; 77% <i>Yes</i> responses.

As predicted, subjects were faster to recall an experience involving a high standard action [$\min F(1,64) = 4.19, p < .05$]. This supports the prediction that more processing is required to retrieve an experience involving a less frequent component action.

In order to assess the separate contributions of action standardness and activity frequency, we performed a multiple regression analysis of the mean retrieval times for each activity and action pair. The activity frequency did not significantly affect retrieval time [$F < 1$]. Thus, retrieval from large event categories (frequently executed activities) was no more difficult than from smaller categories.

One possibility is that the high standard actions were easier to retrieve because they had been performed in a more recent experience with the activity. In fact, high standard actions tended to elicit more recent experiences than low standard actions (4.1 vs. 5.5 months), but this difference was not significant ($p > .10$). More importantly, when age of experience is used as covariate in an analysis of covariance of retrieval times, the difference between high and low standard actions remains significant. Finally, the number of experiences recalled by subjects decreased with the elapsed time since the experience, as expected from previous studies (e.g., Crovitz & Schiffman, 1974). Interestingly, a median split on retrieval times for each condition revealed that older experiences were generally slower to retrieve [$\min F(1,54) = 3.63, .05 < p < .10$].

Discussion. This experiment has demonstrated that retrieval of a more frequent experience within a given activity is easier than that of a less frequent experience. This is consistent with a reconstructive model of autobiographical retrieval. Processing first retrieves the category, accessing the generic knowledge encoded about these events. This generic knowledge is utilized to construct retrieval cues consisting of the circumstances likely to have resulted in the target type of experience. Searching for an instance of a frequently executed action is relatively easy, because virtually any context within that activity would involve experiences including the target action. Retrieval of a less frequent event requires greater use of the generic information to infer the *type* of experience within the activity that would include the targeted action.

The failure of category size (i.e., activity frequency) to affect retrieval times suggests that smaller categories are no easier to access than larger categories. The prediction from interference theories of slower retrieval times for larger categories was not supported. Instead, the results support the suggestion that the principal inferencing in retrieval involves constructing the proper path to the event within the category, and that the categories themselves do not differ in their accessibility.

The slower retrieval times for the older experiences conflicts with the curvilinear pattern found by Robinson (1976), where events from 0-5 years and 10-15 years were recalled more quickly than events from 5-10 years ago. Since the data from the present experiment are almost exclusively from the 0-5 year interval, we can not evaluate them for Robinson's curvilinear pattern, and can conclude only tentatively that the older experiences recalled by subjects were less accessible in memory. In fact, the slower retrieval times for the older experiences may be explained by a retrieval strategy that focuses on the subject's current context for retrieval cues. For example, suppose the subject uses knowledge about his or her current job, place of residence, school, social situation, etc. to generate cues for recall. The cues generated in this fashion would be more consistent with recent experiences than with older experiences. If retrieval fails to recover an experience, older contexts may then be tried. Thus, the subject recalls fewer older experiences, and these trials are slower than those retrieving more recent experiences.

Finally, these results argue against an interference explanation of the retrieval differences between activities and general actions. There is no evidence to support slower retrieval times for larger categories; in fact, we have shown that in some situations, more frequent events are easier to retrieve. In combination, these results suggest that structural features such as "frequency" may be inadequate to fully explain memory search. When comparing activities and general actions, more frequent events are *more difficult* to retrieve; when comparing the retrieval of two actions within an activity that differ in frequency, more frequent events are *easier* to retrieve. Clearly, the difficulty of search from a concept is a function not only of the number of associations involving that concept, but also of the type of concept and the type of information encoded within such a category (Reiser & Black, 1982).

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