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Ecphoric processes in episodic memory

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Ecphory is a process by which retrieval information provided by a cue is correlated with the information stored in an episodic memory trace, thus providing the basis for the subjective experience of remembering and the corresponding memory performance. Particularly relevant to the study of ecphoric processes are experiments in which the material that is to be remembered is held nominally constant and in which both encoding conditions and retrieval conditions are systematically varied. The results of such experiments have imposed certain constraints on theories of retrieval and have led to the revision of several previously popular theoretical ideas. Some illustrative experimental data are described, and one version of a theoretical schema of retrieval is summarized. The schema holds that what a person remembers is a product of a synergistic interaction between the memory trace and the retrieval information, the nature and particular features of the recollective experience being determined by the properties of both the trace and the cue.

Introduction

The process of remembering can be experimentally and theoretically analysed into three successive stages: encoding, storage and retrieval. The retrieval stage can be further subdivided into two separate sets of processes that in this paper will be referred to as ecphory and conversion. Ecphory, a term coined by Richard Semon (1904) to designate activation of latent engrams, in this paper as well as elsewhere (Tulving 1982, 1983) refers to the set of processes by which retrieval information provided by a cue is correlated with the information stored in the memory trace. The product of such correlation, ecphoric information, provides the input into the second stage of retrieval, here referred to as conversion. Conversion makes ecphoric information available to the rememberer in the form of the experience of remembering, or recollective experience, and translates it into corresponding memory performance. The two stages of retrieval and their relation is schematically depicted in figure 1.

Systematic experimental study and theoretical analysis of retrieval processes is of relatively recent origin in the history of the science of memory. Until recently, most theoretical accounts of remembering explained known phenomena in terms of encoding and storage processes and had little to say about the evocation of a response disposition from a latent to a manifest state. The reasons for the neglect of retrieval processes have been discussed by Schacter (1982), in a story of the life and work of Richard Semon, an early but unappreciated advocate of the importance of ecphoric processes in the study of memory.

Although the historical bias toward the explanation of phenomena of memory still exists, a good deal of work has now been done to put the study of retrieval processes on a secure footing. A general picture of retrieval processes is emerging that is accepted by most students of memory. The picture is still hazy, it is lacking in many details, undoubtedly wrong in some others, and it appears in slightly different forms in different theories. But its scope, and experimental

support for it, have advanced it considerably beyond the simple idea that retrieval is activation of dormant associations or 'lifeless memory traces', a notion that Sir Frederic Bartlett (1932) so effectively criticized.

This paper presents some illustrative experimental data, together with a brief summary of a theoretical schema that emphasizes the ecphoric component of retrieval processes. I have discussed one aspect of conversion processes elsewhere (Tulving 1982), and Gillund & Shiffrin (1983) have done the same thing in a much more thorough and precise manner.

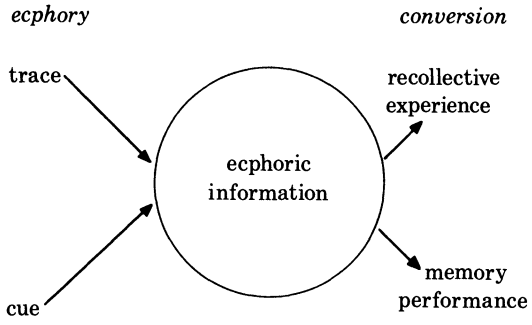

FIGURE 1. Schematic representation of two stages of retrieval: ecphory and conversion.

EXPERIMENTAL EVIDENCE

Episodic memory is concerned with remembering of particular, personal, temporally dated events. The laboratory analogue of such an event is the appearance of a familiar item, such as a word, in a particular experimental list. The word-event experiments that have provided especially relevant evidence to the understanding of retrieval processes have been those in which both encoding conditions and retrieval conditions have been manipulated while the nominal identity of the word to be remembered is held constant (see, for example, Barclay *et al.* 1974; Light & Carter-Sobell 1970; Thomson 1972; Thomson & Tulving 1970; Tulving & Osler 1968). The results of these and other encoding–retrieval experiments have led to the revision of several theoretical ideas of long standing, ideas having to do with the 'strength' of memory traces, the relation between pre-experimental and experimentally established associations between cue and target words, and the reinstatement at retrieval of stimulating conditions present at the time of original study, the so-called principle of reinstatement of stimuli (Melton 1963).

Multidimensional memory traces

One generally accepted idea today is that memory traces are multidimensional constructs (see, for example, Bower 1967; Tulving & Bower 1974; Underwood 1969). The most directly relevant evidence for the proposition comes from experiments in which multiple retrieval cues are successively but independently directed at the same encoded word-event and a pattern of separate and joint cue valences (effectiveness) is obtained (see, for example, Ogilvie 1980; Tulving & Watkins 1975). This pattern has been assumed to reflect the properties of the memory trace, and in a sense it does, but it may be more appropriate to identify it with ecphoric information as defined earlier and illustrated in figure 1.

Two simple experiments, done in collaboration with Michael Watkins, illustrate the method.

In one, subjects studied a list of words presented, one at a time, on a single study trial. The words represented instances of familiar conceptual categories. Recall of each target word was tested twice, once with a cue consisting of the name of the general category (e.g. *a weapon* for the target word PISTOL), and once with the name of a more specific category (e.g. *a firearm* for PISTOL).

In the other experiment, subjects also studied a list of words presented on a single trial, and then, at different times, were given two different cues in the recall test. In this experiment, the cues were semantic associates of the studied target words, adopted from a list used by Bahrick (1969). One type of cue consisted of Bahrick's level 2 associates, words that elicit target words in a semantic free-association test with an average probability of 0.14. The other type of cue were level 4 associates whose normative associative strength to target words was 0.52. (For instance, the level 2 cue for the target word FLOWER was *fragrant*, the level 4 cue was *rose*.)

TABLE 1. TWO-DIMENSIONAL TRACE MATRICES OF WORDS RECALLED TO 'WEAK' AND 'STRONG' CATEGORICAL AND ASSOCIATIVE EXTRA-LIST CUES

general category cue	specific category cue +	−	total
+	0.18	0.02	0.20
−	0.13	0.67	0.80
total	0.31	0.69	1.00

associative level 2 cue	associative level 4 cue +	−	total
+	0.38	0.09	0.47
−	0.24	0.29	0.53
total	0.62	0.38	1.00

The two experiments were similar in that in both one type of cue was 'stronger' than the other. They were different in that in the first experiment the semantic information provided by the 'weaker' cue (general category name) was included in the semantic information of the 'stronger' cue (specific category name), whereas in the second experiment this simple relation did not hold. To the extent that retrieval is governed by informational overlap between the cue and the target as encoded, rather than simply by the 'strength' of the cue–target relation, the patterns of cue valences would be expected to differ in the two experiments.

The results of the experiments, summarized in table 1 in the form of two trace matrices (Tulving & Watkins 1975), confirm this expectation. In both experiments 'stronger' cues were more effective than 'weaker' ones. But more important is the fact that the 'reduced valence' of the 'weaker' cues (the joint probability of successful recall to the 'weaker' cue and unsuccessful recall to the 'stronger' one) was negligible in the category-cue experiment but considerable in the associative-cue experiment.

Thus a 'weaker' cue can succeed where a 'stronger' one fails, depending on the nature of the relation between cues and targets. Our concept of retrieval processes must allow for such a reversal of the effectiveness of 'strong' and 'weak' cues.

Recognition failure of recallable words

Another type of experiment extends the generality of findings that there is no necessary correlation between semantic associative strength and episodic cue effectiveness and clarifies the conditions that determine such effectiveness. In this kind of experiment it is shown that people sometimes do not recognize words that they have encountered earlier in the experiment although they can recall these words perfectly well when other cues are provided. A rather

large number of such experiments have been reported (e.g. those by Bartling & Thompson 1977; Begg 1979; Postman 1975; Rabinowitz *et al.* 1977; Tulving & Thomson 1973; Watkins & Tulving 1975; Wiseman & Tulving 1976). As an example, an experiment that has not yet been published is described here. It was done at Toronto in collaboration with Norman Park.

In the experiment, subjects studied simple three-word sentences, consisting of a subject-noun, a verb, and an object-noun (e.g. *institution lent* MONEY, *boat fired* TORPEDO, and *scientist studied* STARS). The object-nouns of sentences (e.g. MONEY, TORPEDO, STARS) served as target items whose retention was tested in two successive tests: a typical yes/no recognition test followed by a cued-recall test. The treatment of two separate groups of subjects differed only in that the cues in the recall test for one group consisted of the subject-nouns and verbs of sentences (e.g. *institute lent, boat fired, scientist studied*); the cues for the second group consisted of words not seen by the subjects in the experiment but meaningfully related to the studied sentences. These extra-list retrieval cues for the three sample sentences given here were *bank*, *submarine*, and *astronomer*.

TABLE 2. RECOGNITION–RECALL CONTINGENCY DATA FROM THE RECOGNITION-FAILURE EXPERIMENT, USING INTRA-LIST AND EXTRA-LIST RECALL CUES: PROPORTIONS OF TARGET WORDS IN FOUR RESPONSE CATEGORIES

intra-list cues

	recall		
recognition	yes	no	total
yes	0.35	0.11	0.46
no	0.23	0.31	0.54
total	0.58	0.42	1.00

extra-list cues

	recall		
recognition	yes	no	total
yes	0.31	0.11	0.42
no	0.22	0.36	0.58
total	0.53	0.47	1.00

The results of the experiment are summarized in table 2. Both intra-list and extra-list cues produced a level of recall that was higher than the recognition hit rate. More important, however, was the finding that, for both groups of subjects, a sizeable proportion of words that subjects could recall were not recognized. Indeed, the level of recognition failure in both intra-list and extra-list cue conditions was very close to what might have been expected on the basis of the established relation between recognition and recognition failure (Flexser & Tulving 1978; Tulving & Wiseman 1975).

This experiment, as well as many others reported in the literature, thus demonstrates that under certain conditions the 'ultimate retrieval cue' (Darley & Murdock 1971), the 'old' test item in the recognition situation, is ineffective while a previously unseen cue word that embodies semantic information inferred from the study sentences is effective. Since it is well known that under conditions where the words to be remembered are presented for study individually, one at a time, subjects do not recall any words they cannot recognize (see, for example, Watkins & Todres 1978), the reversal of cue effectiveness demonstrated in the recognition-failure situation must be attributable to the study and encoding of the nominal target words in the context of particular meaningful sentences. Thus what a person remembers about a studied item is not only determined by what that item was – a fact that students of memory have always known – but also on how it was encoded when it was presented for study and on the conditions under which its retrieval is attempted – facts that were not quite known only 30 years ago (McGeoch & Irion 1952).

Two other points are worth making about the experiment just described. First, the fact that the extent of recognition failure was approximately the same in the intra-list and extra-list cue conditions is difficult to reconcile with theoretical explanations of recognition failure that attribute the phenomenon to asymmetry of associations between cues and targets, or to failure of 'backward retrieval' (see, for example, Bartling & Thompson 1977; Rabinowitz *et al.* 1977; Salzberg 1976). The concept of asymmetry of associations becomes difficult to interpret in situations in which the cue that may or may not be retrieved has not been explicitly presented.

The second point concerns the principle of reinstatement of stimulus conditions as a determinant of recall (Melton 1963). The recognition-failure experiment just described, along with other similar ones, has produced a clear exception to the principle: retrieval was less effective when the stimulus conditions at study were at least partly duplicated at retrieval, in the form of the 'old' test items in recognition, than in a situation in which the extra-list recall cues had not been encountered at study. It is the information extracted from the cue that matters, not the form in which it is conveyed.

Crossover interactions

The phenomenon of recognition failure, when juxtaposed with the 'normal' state of affairs where all recallable items are recognized, provides one illustration of the interaction between encoding and retrieval conditions in determining recollection: which of two cues X and Y is more effective depends on encoding conditions; conversely, which of two encoding conditions A and B yields a higher level of performance depends on the nature of retrieval information. Absolute statements concerning the 'strength' of either traces or cues cannot be made: properties of the product of encoding processes can be specified only relative to retrieval cues, and vice versa.

Many other experiments have yielded outcomes suggesting the same conclusion. Crossover interactions between encoding and retrieval conditions have been obtained in recall experiments in which external environment is manipulated at encoding and at retrieval (see, for example, Godden & Baddeley 1975; Smith *et al.* 1978), or in which manipulation concerns drug states of subjects (see, for example, Eich *et al.* 1975) or hypnotically induced affective states of individuals (see, for example, Bower 1981). Similar findings in recognition experiments have been described in which the nominal identity of targets and cues is held constant and only their imaginative elaboration at study and physical form at retrieval are manipulated (see, for example, Geiselman & Glenny 1977). Craik (1979, 1981) has reviewed other similar experiments.

As an illustration of an experiment that yields a crossover interaction let us briefly consider one done by Norman Park at Toronto (Park 1980). It was designed as an attempt to clarify the puzzling phenomenon of part-list cueing inhibition originally reported by Slamecka (1968) and studied experimentally and theoretically by others (e.g. Crowder 1976; Mueller & Watkins 1977; Raaijmakers & Shiffrin 1981; Roediger 1974; Roediger & Neely 1982; Watkins 1975). Park's findings replicated the phenomenon of lowered recall in the presence of part-list cues, but they also showed that such inhibition depends on encoding conditions: it occurs only when target items are encoded separately and independently, even if presented together physically. When the items to be remembered are integrated into a coherent higher-order memory unit – for instance, when they form a meaningful sentence, or when the learner forms an interactive image

of the words at the time of study – increasing the number of part-list cues facilitates retrieval, both in recall and in recognition.

A summary of some of Park's data is shown in table 3. Both recall and recognition were higher after interactive-imagery encoding, and lower after separate-imagery encoding, in the presence of three part-list cue words than in the presence of one. Apart from illustrating the crossover interaction between encoding and retrieval conditions with respect to part-list cues, these data underscore the lack of any necessary correlation between the cue–target relation in semantic memory and that in episodic memory tasks.

TABLE 3. PROPORTIONS OF WORDS RECALLED AND RECOGNIZED, AS A FUNCTION OF ENCODING CONDITIONS (INTERACTIVE AND SEPARATE IMAGERY) AND RETRIEVAL CONDITIONS (1 AND 3 PART-LIST CUES)

(Data from the 'attribute' conditions in experiment 4 of Park (1980).)

	recall			*recognition*	
encoding imagery	retrieval: number of cues 1	3	encoding imagery	retrieval: number of cues 1	3
separate	0.21	0.14	separate	0.92	0.77
interactive	0.16	0.72	interactive	0.78	0.92

A THEORETICAL SCHEMA

Synergistic ecphory

A theoretical schema that accommodates some of the salient experimental facts about retrieval is depicted in figure 2. In this schematic diagram, the horizontal axis represents all possible encodings, in an N-dimensional space, projected onto a single continuum. Thus points on the axis represent different ensembles of stored information that share a certain cognitive core but differ with respect to other specifically encoded features. In any particular situation, and at any given moment, only one of the many potential encodings of an event exists, in the sense that it can be ecphorized by appropriate cues. The trace information in the schema in figure 2 represents the state of the episodic system at the moment of retrieval. Changes in the memory trace of an event, or recoding of the trace, brought about by subsequent related events, for instance questioning the rememberer about the original experience (Loftus 1975; Loftus *et al.* 1978), are assumed to be incorporated into trace information.

The vertical axis represents a collection of retrieval cues that are relevant to the situation in that each could potentially ecphorize one or more encodings of the event. This axis, too, represents projections to a single continuum of a large number of N-dimensional interpretations of cues.

The two-dimensional space defined by the two axes represents ecphoric information, all potential products of the process of ecphory. Each point in the ecphoric space designates a potential combination of a particular trace and a particular cue. At the moment of retrieval, one of the ensembles of ecphoric information is actualized and converted into recollective awareness on the part of the remembering individual and, although not necessarily, into corresponding behaviour that is objectively observable and measurable.

The collection of ensembles of ecphoric information that are adequate for a particular form of conversation constitute the conversion space. In the diagram in figure 2, a hypothetical conversion space is surrounded by an elliptical conversion boundary. Ensembles of ecphoric information encompassed by the conversion boundary are sufficient for conversion according to specified criteria, for instance for recognizing a test item as 'old', or for producing a verbal description of the actualized ecphoric information. Points in the ecphoric space outside the conversion boundary are inadequate for the specified conversion, although they may be adequate for some other form of conversion. Thus it is possible to postulate many different conversion spaces within the space of ecphoric information, although in the hypothetical schema in figure 2 only one is shown.

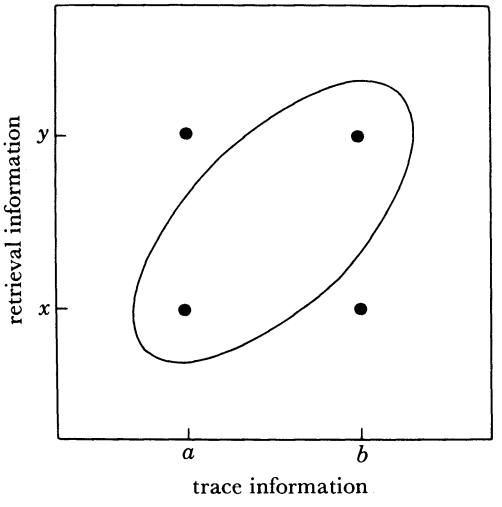

FIGURE 2. Schematic representation of the relation between synergistic ecphory and conversion of ecphoric information.

Retrieval as correlation

The theoretical schema presented here embodies the idea that memory traces are not just activated, not just 'brought to life', but rather that the information they contain is used in the construction of the experience of remembering, as argued by Sir Frederick Bartlett (1932), among others. The use of the episodic trace information takes place in conjunction with the semantic retrieval information, and it is determined by the similarity relations between the traces as specifically encoded and the cues as semantically interpreted. Although the similarity relation can be thought of as referring to the informational 'contents' of traces and cues (see, for example, Flexser & Tulving 1978) or to the similarity of procedures and operations carried out at encoding and at retrieval (see, for example, Kolers & Roediger 1983), it is not yet clear how exactly it should be described and quantified.

The emphasis on the trace–cue interaction in the synergistic ecphory view of retrieval makes it highly compatible with the attractive and mathematically tractable idea that ecphory consists in the operation of correlation. In his recently proposed theory of storage and retrieval, Murdock (1979, 1982) conceives memory traces and retrieval cues as vectors of attributes, and likens storage to the operation of convolution of the cue and trace vectors and retrieval to their

correlation. Eich (1982) has extended very similar basic ideas to the analysis of similarity relations among the items to be remembered in cued-recall situations. The result of the operation of correlation in Murdock's and Eich's theories is the 'retrieved item', a concept that corresponds to that of ecphoric information in the synergistic ecphory schema. The retrieved item provides input into the second, 'decision' stage of retrieval that corresponds to the conversion stage in the synergistic ecphory model. Like ecphoric information, the retrieved item can be 'noisy', and its conversion may produce an outcome that represents a distorted version not only of the original event but also of its encoded and recoded trace.

The synergistic ecphory schema is less compatible with retrieval mechanisms that take the form of a search through the memory store for relevant information laid down there, or of activation of pathways between nodes in an associative network. The metaphor of search seems to be more appropriate as a description of the process of generation of potential retrieval cues (Baddeley 1982), as a prelude to the critical ecphoric event with which the synergistic ecphory schema is concerned. And the idea that retrieval is activation of pathways creates the problem that what a person remembers is determined only by the properties of episodic stored information.

Data and theory

The synergistic ecphory schema can accommodate findings that are troublesome to earlier concepts of remembering. For instance, the phenomenon of recognition failure of recallable words can be schematically depicted by points (a,x) and (a,y) in the ecphoric space in figure 2: with trace information held constant at level a, one cue, y, produces an ensemble of ecphoric information outside the relevant conversion boundary, while another cue, x, produces ecphoric information within it. Similarly, the kind of crossover interaction exemplified by Park's experiment mentioned earlier can be schematically depicted by four points in the ecphoric space: (a,x), (a,y), (b,x) and (b,y). Trace a is ecphorizable by cue x, although not by cue y. On the other hand, trace b is ecphorizable by cue y, but not by cue x. As ecphoric information is defined in terms of the product of trace information and retrieval information it is possible for one encoding to be more readily retrievable under one set of conditions than under another, and for the reverse to hold true for another encoding of the same event.

The schema suggests one way in which qualitatively different N-dimensional bundles of ecphoric information, and corresponding recollective experiences of rememberers, are mapped to quantitative measures of memory performance, such as proportions of 'correct' responses: memory performance reflects the proportion of ecphoric ensembles that lie within the conversion boundary specified by the prescribed memory task.

Finally, it may be noted that the schema suggests a place for the rememberer's subjective experience in the conceptual framework within which objectively observable phenomena of retrieval can be integrated and interrelated. Recollective experience is determined by the 'mix' of episodic trace information and semantic retrieval information that constitutes ecphoric information. It is possible to speculate that it is the contribution of the episodic information to the 'mix' that governs the extent to which the experience is subjectively related to the rememberer's personal past and personal identity.

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Discussion

M. E. Le Voi (*Human Cognition Research Laboratory, The Open University, Milton Keynes, U.K.*). I am unclear as to why Professor Tulving eschews the use of search processes in retrieval. Gregory Jones has shown that the recognition failure function, which Professor Tulving has mentioned in his paper, may be derived from a conception of retrieval that includes a retrieval search for the item (Gregory Jones refers to this as 'extrinsic recall'). Also, in Professor Tulving's first case of multiple-cued recall, my colleagues and I have reported to scientific societies in the U.K. (for example the Experimental Psychology Society meeting, Oxford, June 1981) that those phenomena are as easily handled by retrieval processes involving search as by automatic cue to trace overlapping retrieval. Would Professor Tulving give his reasons why he generally rules out such explanations?

E. Tulving. Alternative interpretations and conceptions of psychological data are always possible. I have no objections to explanations of the extended process of retrieval that entail the notion of search, but I personally find the study of conditions that govern ecphory as an 'instantaneous' process more appropriate at present, as well as more tractable.

D. A. Routh (*Department of Psychology, University of Bristol, U.K.*). I am left feeling a little 'short-changed' by an approach restricted by 2×2 contingency tables. It is reasonable to surmise that there must be an underlying chain of multiplicative factors contributing to the probabilities entering Professor Tulving's contingency tables. I wonder whether progress might not be more rapid if one were to explore the problem of analysing interaction structures within a log probability space, for then we should be dealing with linear additive components, representing row, column and interaction effects.

E. Tulving. The data from a number of experiments that I presented in the form of 2×2 contingency tables, like all other data, represent the end-product of many complex processes. It is quite possible that the approach that Dr Routh describes would aid in the task of understanding the nature of these processes.