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EPISODIC MEMORY

Memory is a mental phenomenon, but it is usually conceptualized from what is, broadly speaking, an artificial intelligence perspective. Thus the objective of virtually all contemporary memory theorizing is to devise a system, or model, that will simulate selected aspects of memory-based behavior. The model may take the form of a computer program that can actually produce simulations, but more often it is merely a schematic or verbal description of some critical component of the system.

Episodic memory is usually contrasted with knowledge, or semantic memory. The distinction, which was brought to the fore by Tulving (1972, 1983), takes a variety of forms but is perhaps most readily appreciated in a phenomenological way: episodic memory refers to the recollection of a particular event and is characterized by a definite awareness that the event was personally experienced, whereas an item of knowledge is usually more abstract in the sense that it is brought to mind with no recollection of the event or events from which it was derived.

Most theorists are uncomfortable about such a key distinction being made in phenomenological terms, and

somewhat less subjective criteria have been proposed. According to some of the more prominent of these, episodic memory (1) is of an event rather than a fact, (2) is temporary rather than permanent, (3) is related to other contents of mind in a temporal rather than a conceptual way, (4) has a veracity that is arbitrated by the rememberer rather than by experts, and (5) originates from a particular occasion rather than from many different occasions.

Such criteria are not entirely satisfactory. As an example, the occasion of hearing the news of President Kennedy's assassination might seem to constitute an excellent example of episodic memory, and yet it could be argued that it violates each of these criteria, in that it may (1) serve as a source of knowledge adequate for responding to factual questions, (2) endure until the rememberer dies, (3) be brought to mind in association with conceptually related events, (4) be shown to be at variance with objective evidence, and (5) be thoroughly fused with memory for the many occasions on which the incident has been thought about or pictures or replays of it seen. Conversely, knowledge of the assassination of President Lincoln is unlikely to be regarded as the product of episodic memory, and yet it (1) is about a particular event, (2) may have lost much of its detail during the time immediately following its acquisition, (3) may be organized in a way that reflects its temporal relation to other historic events, (4) could appropriately be judged for veracity by the knower (as when the knower happens to be an authority on the subject), and (5) could conceivably be entirely attributable to a single occasion even though the occasion as such may be beyond recollection. At a more general level, disentangling episodic memory and semantic memory is complicated by the need that each has of the other: knowledge, or at least the bulk of it, has its origin in events, and events require knowledge to be understood.

The strong interrelation of episodic memory and semantic memory and the lack of clear objective criteria for distinguishing between them have led some to conclude that the distinction is not of fundamental significance (McKoon and co-workers, 1986; Neely, 1989). But, regardless of its theoretical status, the distinction remains useful as a descriptive device, and for present purposes episodic memory will be used in reference to those experimental procedures in which, loosely speaking, subjects respond on the basis of their memory for specific events rather than of their general knowledge.

It is perhaps worth noting that the definition of an event is necessarily arbitrary. A vacation in Europe, an excursion to Paris during the vacation, a visit to the opera during the excursion, a particular aria in the opera, or a particular note in the aria could each be considered an event. In most episodic memory experiments events are typically defined as presentations of specific items, such as numbers, words, pairs of words, sentences, or pictures. Memory for these item presentations is usually referred to simply as memory for items. The conditions of item presentation, the number of items presented, and the study-to-test delay vary according to the purpose of the experiment. Most memory tests are of one of three forms: unaided recall, aided recall, or recognition. In an unaided recall test the set of to-be-recalled events is specified, al-

beit usually implicitly, and the subjects report as many events as they can. This test usually requires either serial recall, in which case the items have to be reported in their exact order of presentation, or free recall, in which case the items can be reported in any order. In an aided recall test, subjects are given hints, or cues, to facilitate recall. More often than not a separate cue is presented for each item, although sometimes more than one cue is presented for each item or one cue serves for more than one item. A cue may take many forms: for the word *eagle*, it may be a fragment of the word (eg, *-ag-e*), a context item (eg, *emerald* if the presentation item had been the word pair *emerald-eagle*), or something that had not formed part of the study list (eg, "a kind of bird" or "rhymes with beagle"). In a recognition test the to-be-remembered items are intermixed with new items, referred to as lures or distractors, and the subjects' task is to decide whether each item occurred in the study list. The proportion of items given a positive response is sometimes left up to the subjects and is sometimes specified by the experimenter. In addition, the subjects may be required to rate the confidence they have in each decision. A comprehensive account of these and other procedures for studying memory can be found in Puff (1982).

In discussing the issues and findings of episodic memory research, it is useful to distinguish between primary and secondary memory. The distinction was originally formulated by James (1890) in phenomenological terms. Specifically, primary memory refers to the remembering of events that have never left consciousness and that, therefore, belong to the psychological present. Secondary memory, or memory proper, refers to memory for events that, although represented in consciousness immediately after their presentation and again on recollection, are not continuously maintained in consciousness between these times; they belong to the psychological past. In more contemporary usage, primary and secondary memory are generally thought of in a more conceptual way: they are often cast as separate memory stores or systems. In any case, primary memory refers to events that have occurred most recently, and secondary memory to events from further back in time.

PRIMARY MEMORY

Most of what has been learned about primary memory concerns its qualitative nature and its capacity, and these topics form the basis of the present discussion. The dominant form of inquiry has been objective experimentation, but introspection, however informal, has also played an essential role.

Nature of Primary Memory

Objective experimentation and introspection both show that primary memory takes on the character of the perceptual-motor world. It assumes an auditory, visual, or some other sensory quality or, as when a manual task is mentally rehearsed, a proprioceptive quality. Depending on whether it preserves the sensory quality of the event

that gave rise to it, primary memory might be said to be direct or indirect.

A strong argument for direct auditory primary memory, or echoic memory, is given by the very fact of speech perception. Of its nature, speech is spread out over time and, in order to be understood, information occurring at any one instant must be integrated with a precise record of information that occurred immediately beforehand. Introspection confirms the existence of such a record. At each successive instant that speech is being heard, memory for the immediately preceding few words has a freshness far more original than does memory for earlier words. Not only is it plain exactly what these words were but it is almost as though they could still be heard, with such details as tone of voice, intonation, and accent clearly preserved. Memory of this sort is difficult if not impossible to sustain through further speech; subsequent words are apt to take their place in echoic memory whether or not the rememberer wishes it.

Much of the experimental research on echoic memory has involved the serial recall of spoken lists of about eight digits or words. Serial position functions, obtained by determining the probability of recall for each within-list position, show that level of recall increases sharply over the last two or three positions (Murdock, 1968). The echoic nature of this recency effect, as it is called, is indicated by its virtual absence when the items are presented visually (Conrad and Hull, 1968) or when they are acoustically similar to one another (Crowder, 1971). The vulnerability of echoic memory to the effects of additional auditory information is illustrated by a sharp reduction in the recency effect when the list items are followed by an additional, nominally irrelevant item (Morton and co-workers, 1971).

Direct visual primary memory, known as iconic memory, has a fidelity even more striking than that of echoic memory. Indeed, it is of such a quality as to create the illusion that the information is still present. The illusion occurs in watching a film, for it is through iconic memory that a picture shown in one frame continues to be seen during the time required to replace the frame by the next one, with the result that the film is seen not as a flickering sequence of still pictures but in the same smooth way that *the real world is seen*. The useful life of iconic memory depends on the prevailing conditions, although it is typically no more than a fraction of a second (Sperling, 1960; Haber and Standing, 1970).

An example of indirect primary memory can be found in the verbatim retention of material just read. The material was perceived visually, but introspection reveals its conscious representation to be more auditory or articulatory in nature, a sort of silent speech. Experimental confirmation of this impression comes from a study by Conrad (1964) in which subjects were given serial recall tests on short sequences of letters. To avoid extraneous difficulties, Conrad was interested in only those sequences in which subjects erred on just one letter. He found that the incorrect letter was often acoustically similar to the letter that should have been reported. Given that acoustically similar letters do not tend to be visually similar, the implication is that the visually presented letters were coded in a

speechlike form. Not only can information be recoded for representation in conscious mind, but it can be rehearsed and otherwise manipulated in the service of a mental task. Such willful processing of information is commonly said to constitute working memory (Baddeley, 1986).

Capacity of Primary Memory

How much information can be retained in conscious mind at any one instant? What, in other words, is the capacity of primary memory? This question raises a number of unresolved issues, not the least of which is the appropriate unit of measurement. It is perhaps to minimize this particular difficulty that the question of capacity has been raised almost exclusively with respect to verbal material, because this can be broken into discrete units in a relatively objective fashion. The relevant research falls into two categories: one concerned with memory span, the other with the recency effect.

Memory span refers to the number of items for which there is an even chance of perfect reproduction after a single presentation. Roughly speaking, this turns out to be seven items. This fact suggests a model whereby primary memory is likened to a store containing seven distinct locations. Such a model may be adequate for some purposes, but it does not account for the modest variations in memory span that do occur between types of items or conditions of presentation. Thus memory span is about an item greater for letters than for words and about an item less for letters than for digits (Crannell and Parrish, 1957) and about half an item greater with auditory than with visual presentation (Drewnowski and Murdock, 1980). According to one theory, memory span corresponds, not to a fixed number of items, but rather to the number of items that can be recited within a fixed time, estimated to be between 1.5 and 2.0 s (Baddeley and co-workers, 1975; Schweikert and Boruff, 1986). This theory accounts for several puzzling findings, including the relative spans for letters, words, and digits (letters can be recited more quickly than words but not as quickly as digits), although it leaves other findings unaccounted for (Brooks and Watkins, 1990).

Apart from these empirical puzzles, there are reasons to doubt that memory span is, even in principle, a valid measure of primary memory capacity. For instance, memory span has been shown to be greater for words that have a high frequency of everyday occurrence than for words that occur less often, and because this variable is generally assumed to affect secondary memory but not primary memory, the implication is that memory span may include one or two items from secondary memory. Also, even if memory span were entirely the product of primary memory, it may reflect more its upper limit than the capacity typically used in attending to a continuous stream of information.

This latter possibility suggests that the capacity of primary memory might be more appropriately ascertained by using a list length substantially in excess of memory span and focusing on recall of the last few items. A great many studies of this sort have been conducted, most of them using lists of 12–20 randomly selected words and a

free recall test. Serial position functions reveal a recency effect spanning the last six or seven positions (Murdock, 1962), and this is generally attributed to primary memory. Of particular interest are findings that list length, the rate at which the words are presented, the concreteness of the words (or rather of their referents), the frequency of the words in everyday usage, and many other variables have an appreciable effect on recall of prerecency items but little if any effect on the recall of recency items (Glanzer, 1972). Although there has been much discussion of precisely how the capacity of primary memory should be estimated from the serial position function, the area under the recency part of the function (ie, the sum of the recall probabilities for the last few positions) can be taken as a first approximation, and this turns out to be about 3.5 items. Note that this is substantially less than the estimate given by memory span.

One or two variables have been shown to distinguish between prerecency and recency portions of the serial position function in just the opposite way—that is, they affect recency positions but not prerecency positions. Specifically, the recency effect is reduced slightly if the items are presented visually rather than auditorily (Murdock and Walker, 1969), and is largely eliminated if subjects engage in a verbal task (such as simple arithmetic or copying down several other words) between presentation and recall (Glanzer and Cunitz, 1966). Neither of these exceptions seriously undermines a primary memory interpretation of the recency effect. Thus it is not unreasonable to suppose that primary memory could be of slightly greater capacity when of a direct echoic form than when of an indirect phonological form and that an interpolated verbal task diverts conscious mind from the recency items. More serious are findings of a recency effect when subjects are distracted after the presentation of each individual item (Tzeng, 1973), simultaneous recency effects for more than one set of items (Watkins and Peynircioglu, 1983), and substantial recency effects over intervals spanning several weeks (Baddeley and co-workers, 1977). Plainly, recency effects can arise for reasons other than retention in primary memory. The implications for the measurement of primary memory capacity remain a matter of debate.

SECONDARY MEMORY

The dominant sense of the term memory, which James called secondary memory, refers to the remembering of events that have passed from current awareness. It is discussed in two parts, the first dealing with the events as experienced and the second with their recollection.

Events as Experienced

Events vary in how long they are remembered; some are remembered only fleetingly, others for most of a lifetime. Yet, as obvious as this is, very little effort has been made to identify and systematize the variables that control memory persistence. For present purposes, these variables are organized into seven factors: duration, meaningfulness, vividness, distinctiveness, organization, emotionality, and primacy and recency. These factors are not

tion decision, whereas the success in aided recall indicates that it was.

In light of such difficulties, some theorists have abandoned the generate-recognize model and embraced instead the ideas of encoding specificity and transfer appropriate processing (Tulving, 1976; Morris and co-workers, 1977), whereby an experience is recollected or in one way or another subsequently manifested in behavior whenever cognitive processing matches sufficiently closely the processing that occurred at the time of the experience. No crucial distinction is drawn between recall and recognition. A recognition test is usually more successful than a recall test because the re-presentation of a central component of that experience as a test item (or copy cue) is likely to induce processing similar to the processing that defined the target experience. That a context word may under some conditions be more effective than the copy cue means merely that it is more successful in recreating the processing of the target event.

These ideas have considerable generality. For example, they provide a plausible account of why information learned under the influence of alcohol is often better remembered in the same inebriated state than in a sober state (Eich, 1980). The transfer appropriate processing ideas have also been applied to prose learning and education (McDaniel and Einstein, 1989). One problem is that the notions of specific encoding and test appropriateness are fuzzy and apt to lead to circular reasoning.

Part of the difficulty in formulating an adequate account of event recollection is that, at least for events involving complex material, such as lectures or conversations, recollection is likely to take the form of a summary rather than an unabridged verbatim reproduction. Moreover, it is likely to be expressed largely in the rememberer's own words. The implication is that such recollection is substantially a matter of reconstruction, of using knowledge of the world [perhaps conceptualized as schemata or scripts (qv) (Bower and co-workers, 1979)] to piece together an account faithful to the gist, or perhaps just to the tenor (Neisser, 1981), rather than to the details of the episode.

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