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The concept of episodic memory

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Over the last half century, the experimental study of human memory has departed from the earlier concept of a unitary faculty, with the increase in knowledge leading to differentiation between subsystems of memory, often based on the study of neuropsychological patients.

Although foreshadowed by the classic work of William James (1890), the current approach to the fractionation of memory probably began with Hebb's (1949) proposal of a distinction between short-term memory (STM), based on temporary electrical activity within the brain, and long-term memory (LTM), based on the development of more permanent neurochemical changes. He even proposed a learning mechanism, a concept that continues to be influential in neurobiological theorizing (see Burgess *et al.* 2001). Experimental evidence for a distinction between STM and LTM began to appear a decade later with the demonstration by Brown (1958) and Peterson & Peterson (1959) of the rapid forgetting of small amounts of material when ongoing rehearsal was prevented. They proposed that this forgetting reflected the decay of a short-term trace, a process they distinguished from long-term forgetting, which was attributed to interference among long-term memory representations. This view was resisted, with the counter claim made that all forgetting could be interpreted within a single stimulus–response association framework (Melton 1963). The question of whether short-term forgetting reflects trace decay or interference remains unresolved (Cowan *et al.* 2000; Service 1998).

During the 1960s, however, experimental evidence from a range of sources seemed to point increasingly strongly to the need to distinguish between STM and LTM on grounds other than type of forgetting. Neuropsychological evidence was particularly influential, with patients suffering from the classic amnesic syndrome showing grossly impaired LTM, coupled with total preservation of performance on a range of tasks associated with STM (Baddeley & Warrington 1970). Anatomically, the amnesic syndrome has most strongly been associated with damage to the hippocampus (Milner 1966), although it could result from damage to a series of structures that broadly make up the Papez circuit (see Aggleton & Pearce 2001). The STM–LTM distinction was further supported by patients showing the opposite dissociation, with STM performance impaired and LTM preserved (Shallice & Warrington 1970).

By the late 1960s, a range of two-component models was being proposed, of which the most influential was that of Atkinson & Shiffrin (1968). In this model, information was assumed to come in from the environment, be processed by a short-term storage system and then fed into LTM. Probability of learning was assumed to depend on time held within the short-term store. STM was also assumed to act as a working memory, a system responsible for the temporary maintenance of information demanded by the performance of such complex tasks as reasoning and comprehension. Amnesic patients were assumed to have a deficit in LTM, while the second type of patient was assumed to have an STM deficit.

Although it appeared to give a good account of the available data, and still figures prominently in many cognitive psychology textbooks, the Atkinson–Shiffrin model rapidly encountered major problems. The simple unitary STM proposed had difficulty accounting for the neuropsychological evidence. The model would suggest that patients with STM deficits should have substantial further problems in using LTM and, moreover, should have extensive further problems in complex information processing. In fact such patients often have remarkably few problems outside the range of their specific STM deficit (Vallar & Shallice 1990). Baddeley & Hitch (1974) therefore proposed replacing the concept of a unitary STM with a multicomponent working memory (WM) model. This attributed the STM patient's deficit to a subcomponent of WM, the phonological loop, suggesting that other components of WM were intact in these patients, hence allowing their comparatively normal cognitive function. The phonological loop, on the other hand, was proposed to function principally as a mechanism to facilitate the acquisition of language through its impact on phonological LTM and vocabulary learning (Baddeley *et al.* 1998), although it probably also has a further role in the verbal control of action (Baddeley *et al.* 2001; Luria 1959*a*,*b*; Vygotsky 1962).

The Atkinson–Shiffrin model also encountered problems as a result of its simple assumption that the longer an item was held in STM, the more likely was its transfer to LTM. Simply maintaining an item in short-term store is a very poor method of long-term learning. Craik & Lockhart (1972) showed LTM to be dependent on the nature of the processing of the incoming material, with 'deeper' and more semantically based processing leading to much better subsequent learning than 'shallow' visual or phonological processing.

At about this time, computer scientists were attempting to programme machines to understand language. They rapidly encountered the problem of how meaning might be stored, a problem that was tackled by a Massachusetts Institute of Technology (MIT) graduate student, Ross Quillian, who developed a program he called TLC (the teachable language comprehender). At the heart of the

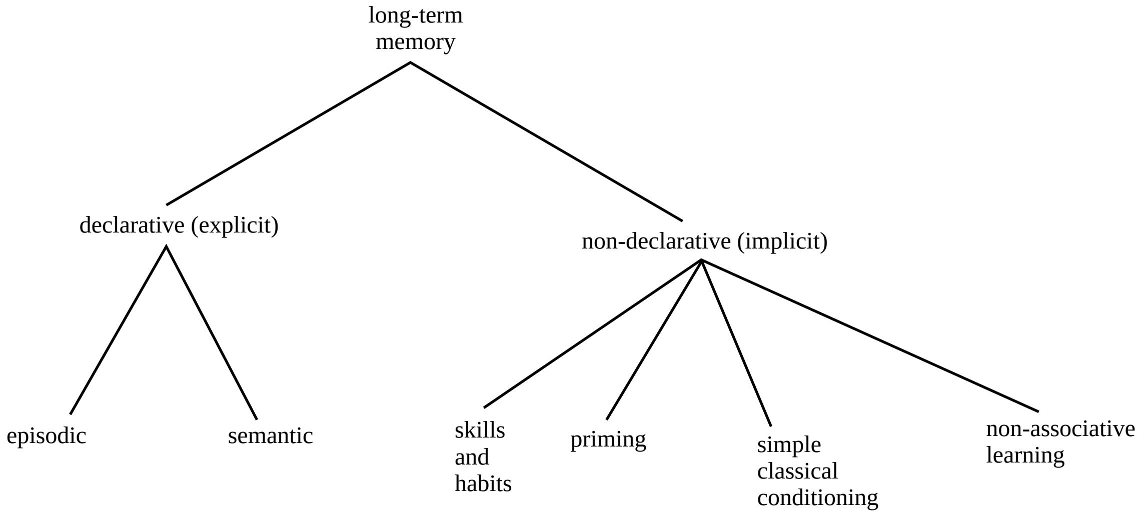

Figure 1. Classification of long-term memory. Declarative (explicit) memory refers to conscious recollection of events (episodic) and facts (semantic). Non-declarative (implicit) memory refers to a heterogeneous collection of abilities whereby experience alters behaviour non-consciously without providing access to any memory content. (Based on Squire (1992).)

system was a series of assumptions about the way in which meaning was stored, using hierarchical organization to minimize storage demand. Psychologists began to use this model in order to investigate the way in which humans store knowledge, resulting in a series of experimental investigations into the speed at which statements or features of the world can be accessed and verified (Collins & Quillian 1969; Landauer & Freedman 1968).

This new line of research was well represented in a conference organized by Tulving & Donaldson (1972) on the role of organization in human memory. The conference prompted Endel Tulving to ponder the relationship between this new approach to human memory and the more traditional approach reflected in the remaining conference papers, resulting in his writing a concluding chapter to the proceedings in which he proposed to distinguish between what he termed 'semantic memory' and 'episodic memory'.

Semantic memory was assumed to reflect our knowledge of the world; knowing the meaning of the word 'bottle', how many yards there are in a mile, or what is the colour of a ripe banana. Semantic memory held generic information that is probably acquired across many different contexts and is able to be used across many different situations. The term episodic memory, in contrast, was assumed to refer to the capacity to recollect individual events, for example, meeting an old sea captain on holiday last year, or remembering what you had for breakfast. The essence of this type of memory is its specificity, its capacity to represent a specific event and to locate it in time and space. The proposed distinction was widely accepted, though principally I suspect because it allowed the separate conceptualization of knowledge of the world, an important area of investigation that had hitherto been largely neglected by experimental psychologists. At this point, most people probably regarded the term 'episodic memory' as applying to virtually everything else, although, as we shall see, Tulving himself developed a much more specific interpretation.

At first sight, the neuropsychological evidence also appeared to support a clear distinction between semantic and episodic memory. Amnesic patients clearly have a gross deficit in their capacity for storing new episodic memories in the absence of any obvious semantic memory deficit; they can use language perfectly normally, and typically can answer questions about the world and its ways. However, this is not a fair comparison as it involves contrasting new episodic learning with old semantic knowledge. Subsequent research de-confounded these two variables; Baddeley & Wilson (1986) and Wilson & Baddeley (1988) showed that densely amnesic patients could have well-preserved and apparently normal episodic memories of incidents in their earlier lives, while such patients would experience considerable difficulty in adding to their store of semantic knowledge. Such densely amnesic patients would, for example, typically be unaware of who is the current prime minister or president, and fail to know the meaning of words such as AIDS that were introduced into the language after the onset of their amnesia (Gabrieli *et al.* 1988). While the possibility remains that semantic and episodic memory reflect different storage systems, perhaps relying on a common episodic input system, it seemed simpler to assume that semantic memory merely represents the residue of many episodes. Features that the episodes hold in common would be well learned, in contrast to the individual features of an episode that allow one experience to be separated from another, presumably by its association with a specific context.

A third important dissociation began to be emphasized during the 1970s, namely that between implicit and explicit memory. Once again the strongest evidence came from neuropsychology, where it became increasingly clear that densely amnesic patients were capable of certain types of learning, including priming, the acquisition of motor skills, classical conditioning and habit learning. An example of priming is the capacity to enhance the perception of stimuli under degraded conditions by prior presentation (for a review, see Squire *et al.* 1993). In all these cases, learning is reflected through enhanced performance of the task in question, with the amnesic patient typically denying ever having encountered that task before. Although this array of tasks was initially interpreted as reflecting a unitary capacity, it now seems likely that they reflect a range of different learning mechanisms dependent upon different brain systems, and having in common the fact that they do not depend upon the recollective or episodic system that is typically impaired in amnesic patients. By the 1990s, there was growing agreement for fractionation in LTM along the lines shown in figure 1, based on Squire (1992) but also supported by a range of other theorists (see Baddeley 1997, ch. 20).

The classic amnesic syndrome therefore played a major role in the conceptual fragmentation of the human memory. However, attempts to understand amnesia in more detail proved less satisfactory. A number of attempts were made to attribute the amnesic deficit to cognitive failures of one type or another, including failure to encode sufficiently deeply (Cermak & Reale 1978), excessive sensitivity to interference between memory traces (Warrington & Weiskrantz 1968) and failure to use environmental context adequately (Huppert & Piercy 1978). None of these, however, has been convincingly shown to be responsible for the amnesic syndrome, leaving a more basic neurobiological interpretation in terms of some function such as trace consolidation as a plausible baseline hypothesis (Baddeley 2001).

Attempts to fractionate amnesia into a number of subtypes have also had little sustained success. The proposal that patients with amnesia resulting from temporal lobe damage forget at a different rate from those in which the deficit is diencephalic (Parkin 1992) was not supported by subsequent research, while the proposal that some patients showed impaired recall but preserved recognition memory (Aggleton & Shaw 1996; Hirst *et al.* 1986) was criticized on the grounds that the recognition tests were simply intrinsically easier than those testing recall (Shallice 1988; Reed & Squire 1997).

By the 1990s, there was broad, although not universal, agreement that it was valuable to distinguish between LTM and working memory, that working memory itself was fractionable, and that a broad distinction should be made between implicit and explicit LTM. Anatomically, it seemed well established that episodic memory depended crucially on the hippocampus, while working memory reflected systems in the temporo-parietal and frontal lobes. There was general agreement that semantic memory served a different function and operated in a different way from episodic memory, although there was disagreement as to whether the two depended upon fundamentally different learning and memory systems. Other unresolved issues concerned the question of whether recall and recognition reflected different retrieval mechanisms applied to the same memory systems, or were basically different processes. Although a number of single case studies hinted at the possibility of a range of different types of amnesia (Aggleton & Brown 1999), there was no generally accepted subcategorization. Finally, the concept of episodic memory itself was showing signs of potential fractionation.

The core of the potential separation stemmed from a feature of episodic memory that was increasingly emphasized by Tulving himself, namely the central importance of the phenomenological experience of remembering. This did not play an important role in the general use of the concept in its initial years, when the term episodic memory was commonly used to refer to all memory other than semantic or working memory. Indeed, in the 1970s, suspicion of phenomenology was such that emphasis on this aspect might well have militated against its general use. Increasingly, however, Tulving began to emphasize what he referred to as the 'autonoetic' character of episodic memory, with the recollective experience being regarded as a *sine qua non* of episodic memory (Tulving 1985). He suggested that subjects be questioned as to whether an item recognized or recalled was 'remembered' or simply 'known'. 'Remembering' requires the capacity to recollect some specific feature of the learning experience. For example, when remembering the word 'dachshund', a subject might recollect that, when shown the word, it evoked the memory of a particular dachshund belonging to a friend, or perhaps that it suggested the possibility of an association with an earlier word such as 'sausage'. Other words could confidently be attributed to the previously presented list but had no such specific recollected experience. Tulving suggests that this capacity to 'relive' the experiences associated with the initial episode is crucial in allowing us to reinvestigate our past and use it to predict the future; 'episodic memory does exactly what the other forms of memory do not and cannot do—it enables the individual to mentally travel back into her personal past' (Tulving 1998, p. 266). As the contribution by Gardiner (2001) indicates, despite its phenomenological nature, a regular and meaningful pattern of empirical results has resulted from asking subjects recognizing a previously presented item whether they 'remember' it, in that they recollect the circumstances under which it was previously encountered, or simply 'know' that it was presented.

The remember–know distinction is only one of a series of techniques suggesting that explicit recognition and recall memory may reflect more than one underlying system or process. Mandler (1980) suggested that recognition may be based on at least two separate processes, one analogous to recollection, while the other is based on a feeling of familiarity. Jacoby (1994) has developed a series of ingenious techniques for separating such components of memory using what has come to be known as the 'process dissociation procedure'. The extent to which this procedure and the remember–know distinction reflect equivalent underlying systems has been a topic of some controversy in recent years (Baddeley 1997; Joordens & Merikle 1993; Jacoby *et al.* 1993). Yonelinas (2001) describes some elegant work that attempts to resolve this issue.

Mayes & Roberts (2001) describe a range of new findings resulting from increasingly sophisticated methods of investigation that are questioning earlier interpretations of the amnesic syndrome, while the application of new technology and novel methodology is throwing fresh light on the nature of normal memory—and of the ways in which it breaks down, as is well illustrated by Schacter & Dodson (2001).

A crucial feature of the concept of episodic memory is the role of the rememberer. The concept therefore bears very centrally on theorizing about the self, and the extent to which one's self concept is based on the accumulation of episodic experience. This problem forms the focus of the contribution by Conway (2001), who makes a distinction between the term 'episodic memory', which he limits to relatively recent recollective experience, and the longer-term accumulation of personal knowledge that he refers to as 'autobiographical memory'. The next two chapters use data from neuropsychological patients to investigate further the nature of the accumulated memories that play such an important role in allowing us to function. Kopelman & Kapur (2001) provide a valuable review of the area of retrograde amnesia, the loss of memory for events preceding a memory deficit. In this review they examine the range of factors that influence retrograde amnesia at the level of both recollecting specific episodes and retrieving knowledge about one's early life, sometimes known as semantic autobiographical memory (Kopelman *et al.* 1989).

Despite the excitement generated by the concept of semantic memory in the 1970s, research on normal subjects proved frustratingly inconclusive (Kintsch 1980) in that the experimental methods available, based principally on the complex task of sentence verification, did not appear able to decide between the various models proposed. A breakthrough in this area came from the observation that certain dementia patients showed a progressive deterioration in the knowledge of the meaning of even common words (Warrington & McCarthy 1987). The decline was typically lawful in that detailed information was lost first. Hence a patient who had had an accident, when asked to name a picture of a greyhound, might first of all lose the specific term but still know that it was a dog, subsequently only being able to classify it as an animal and eventually potentially losing even this capacity. This syndrome became known as 'semantic dementia' (Snowden *et al.* 1989) and, as Hodges & Graham (2001) illustrate, is beginning to throw considerable light not only on semantic memory but also on its relationship to episodic and autobiographical memory.

The contributions so far can be described as stretching and elaborating the status quo, rather than challenging it directly. In my own view, the greatest challenge to the status quo is offered by the group of patients described by Vargha-Khadem *et al.* (2001). In particular the case of the young man 'Jon' challenges received wisdom in that despite being amnesic, apparently from birth, he has nevertheless acquired normal intelligence, language and semantic memory. If semantic memory is simply the accumulation of episodes, then his impaired episodic memory surely ought to have led to substantial developmental deficits. A second challenge to the status quo is the observation that his recognition memory appears to be entirely normal, whereas his recall capacity is seriously impaired. This may provide a clue as to how he has been able to acquire normal knowledge of the world but the underlying principles remain obscure. Interestingly, Jon appears to lack the normal capacity to 'remember', in the sense of failing to recollect the experience of learning, the autonoetic component that is central to Tulving's concept of episodic memory. It is, of course, difficult to argue strongly from a failure of the experimenter to elicit a particular type of introspective response. Fortunately, the great strides made recently in functional brain imaging offer a possible solution. Maguire (2001) gives an excellent overview of this development, and has in fact used such techniques to study Jon's episodic memory, producing evidence suggesting that he is capable of episodic recollection but that this does not occur under standard recognition conditions. Neuroanatomically, Jon's memory deficit appears to be associated principally with reduced hippocampal volume. This again casts doubt on the status quo, since hippocampal damage was typically regarded as associated with the classic amnesic syndrome, which shows impairment in both recall and recognition. Indeed, Squire and co-authors have demonstrated very clearly a deficit in recognition in a group of their own patients whose damage is principally associated with the hippocampus (Manns & Squire 1999; Reed & Squire 1997).

As Aggleton & Pearce (2001) illustrate, however, the development of increasingly sophisticated neurobiological techniques has cast doubt on the earlier assumption of the simple and central role of the hippocampus. They present a convincing case for the need to assume a much more complex relationship between the various anatomical structures whose damage is classically associated with the amnesic syndrome in humans and impaired learning and memory in animals.

Animal studies clearly allow a much wider range of investigative techniques than those applicable to the study of either normal human subjects or neuropsychological patients. The question therefore arises as to whether it is possible, or even conceivable, to study episodic memory in animals. Certainly, using Tulving's definition, episodic memory would only be possible if animals were assumed to have consciousness, something that is very difficult to establish. However, as Aggleton and Pearce point out, one feature of episodic memory is the pulling together in a single episode of 'what', 'where' and 'when' something happened, and its subsequent recall. This issue is taken up and discussed in much more detail by Morris (2001), while the capacity for such episodic-like memory is elegantly illustrated by Clayton *et al.* (2001), who study the remarkable capacity of scrub jays to store food (the 'where') while successfully remembering the nature of the food (the 'what') and allowing for its perishability in deciding which to eat first (the 'when').

Finally, one important aspect of recent work in this area is its interdisciplinary nature. This is illustrated particularly well by Burgess *et al.* (2001), who combine neurophysiological and behavioural evidence from animals with neuropsychological and neuroradiological evidence from humans to develop and elaborate a computational model that attempts to give an account of how episodic memories are acquired, and lost following brain damage.

In the 30 years since the concept of episodic memory was first proposed, it has proved to be highly durable, suggesting its inherent usefulness as a theoretical concept. At the same time, it has also proved to be extremely productive in raising important questions and stimulating new research, a characteristic that is well illustrated by the contributions in this issue that follow. Indeed, since this Discussion Meeting was planned, the concept has spread to working memory, in the form of a fourth component, the 'episodic buffer' (Baddeley 2000). This is assumed to be a temporary storage system that binds together information from the phonological and visuo-spatial subsystems of WM with information from LTM. As such, it provides an interface with episodic LTM, using conscious awareness as a retrieval process. I was tempted to crash the episodic memory party with a presentation on the buffer, but the programme was full, and at under 1 year old, the episodic buffer is a little young for parties. We have therefore limited the discussion to episodic long-term memory, a concept that was initiated almost 30 years ago by Endel Tulving, who continues to develop and refine our understanding of memory, and who, in a final discussion (Tulving 2001), appropriately has the last word.

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