BJA

British Journal of Anaesthesia, 121 (1): 210–218 (2018)

doi: 10.1016/j.bja.2018.03.008

Review Article

Complexities of human memory: relevance to anaesthetic practice

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Abstract

Mechanisms of anaesthetic actions on memory have largely focused on easily definable aspects of episodic memory, with emphasis on particular drug interactions on specific memory processes. However, the memory landscape of the perioperative experience includes many facets that lie outside these conceptualisations. These include patient recall of preoperative conversations, patient beliefs regarding allergies and unusual/uncommon anaesthetic events, memories of awareness, and particularly vivid dreams during anaesthesia. In no small part, memories are influenced by a patient's interpretations of events in light of their own belief systems. From the practitioner's point of view, relating fully to the patient's experience requires some framework of understanding. The purpose of this review is to highlight research over the previous decades on belief systems and their interactions with autobiographical memory, which organises episodic memories into a personally relevant narrative. As a result, memory is a set of continuously malleable processes, and is best described as a (re)constructive rather than photographic instantiation. Belief systems are separate but closely interacting processes with autobiographical memory. The interaction of a constantly evolving set of memories with belief systems can explain phenomena such as illusions, distortions, and (re)constructions of factitious events. How anaesthetics and our patient interactions influence these behaviours, and *vice versa*, will be important questions to explore and define with future research.

Keywords: anaesthesia; episodic; memory; mental recall

The classic construct of memory systems arose from the iconic case series reported by Scoville and Milner in 1957,[1] which included the patient HM and revealed the importance of the medial temporal lobes for formation of conscious memory.[2] Approximately 30 years after the Scoville and Milner[1] report, Squire and Zola-Morgan[3] proposed classification of memory into conscious and unconscious categories, which has served well as the basis for understanding human memory systems. Conscious memories comprise both semantic memories, i.e. factual knowledge of the world, and episodic memories, i.e. memory for specific events recalled in a particular time and place. This conceptualisation is aided by considering memory formation as a temporal process of information transfer and modification from the outside world. Information from sensory inputs is processed in transient buffers of working memory and collated with previous knowledge (semantic memories) to form episodic memories during encoding. During and after encoding a series of time dependent processes of consolidation transform labile new memories into more permanent stabilised memories. Newly

Editorial decision: March 16, 2018; **Accepted:** March 16, 2018

formed labile memories can be modified not only by other external events but also by internal cognitive processes, such as beliefs. Recently it has been demonstrated that, under certain circumstances, stabilised memories can become labile again during retrieval. Retrieved memories can be newly modified and then stabilised again during re-consolidation.[4,5] In this review, the focus will be on autobiographical episodic memories and their interactions with current knowledge residing in an individual's semantic memory (semantic memory may contain knowledge important to the individual that is not entirely representative of external reality). Autobiographical memories (ABMs) comprise a set of personally relevant episodic memories, relating to each other in such a way as to create an internal sense of self (conceptual self) that is personally beneficial, explained more fully below (but that is not to say that ABMs comprise only favourable memories).

Actions of anaesthetics on episodic memory have been conceptualised in terms of information flow.[6] Anaesthetics strongly impair episodic memories in a dose related fashion causing anterograde amnesia, lack of memory for events after the administration of drug. Lack of memory can arise on the basis of sedation where inattention to the outside world interferes with encoding of memory, from a sedation independent amnestic action, or both. The latter occurs at lower than sedative doses and allows encoding to occur, which is then followed by rapid forgetting.[7] Thus, memories of perioperative experiences occur in a setting where drugs that impair or ablate memory are used. A somewhat novel consideration detailed in this paper, is that individual beliefs can greatly affect memory, and these are important in fully understanding memory in the perioperative period. The ability of beliefs to modulate memories arises from the underlying neurobiology of information processing as briefly described above. Some considerations relevant to anaesthesia practice are presented and then followed by a presentation of concepts underlying ABM and belief systems.

The standard methodology for determining if a patient has conscious recollection of intraoperative events (awareness with recall, AWR) is the Brice questionnaire, frequently modified to incorporate additional items of interest, such as dreaming and emotional qualities.[8] The incidence of positive responses when using the Brice questionnaire is substantially higher, on the order of a magnitude, than more routine postoperative surveys.[9–12] The reason for this is unclear, but it has been well-demonstrated that repeated questioning results in higher detection rates than a single enquiry, most commonly in a cumulative fashion over the interviews. Some patients do report vacillations between remembering and forgetting.[13,14] Why this occurs is unknown, and it may be difficult to tease out as the gold standard of AWR occurrence is an independent confirmation of events. Unfortunately, this information is available only in a minority of cases. Patients themselves may have differing levels of belief in an event such as awareness. As will be described later, one may believe in the occurrence of an event and at the same time believe recall is inaccurate (and *vice versa*). Thus, responses given to enquiries regarding recall may be variable at different time points just on the basis of beliefs. AWR is frequently classified along the lines of a definite/probable/possible categorisation, often without explicit details as to how categorisation occurred (beyond adjudication by experts). A question not examined to date is what effect a patient's belief in AWR, regardless of veracity, affects them over time. This patient population has not been captured, as these cases are not considered as AWR in the usual classification systems. This group of patients might provide important insight into how beliefs regarding perioperative events impact psychological symptoms over time.

Many factors will affect memory in the perioperative period in addition to anaesthetic medications. As will be discussed below, it is unlikely that anaesthetic drugs cause retrograde amnesia (loss of memory for events before drug administration). The reported patient experience of memory impairment for perioperative events is probably a result of other factors, and is estimated to be from 15% to 25% in un-premedicated patients.[15,16] A significant factor may be whether recall (internally generated memories) or recognition (choosing which item/event occurred) is ascertained. Regarding perioperative events (e.g. conversations in pre-holding), recall is usually elicited. It is well known that recognition rates are higher than recall, and this seems to hold in the perioperative period.[17] To delineate these effects further, an understanding of how memory can change over time or be influenced by current beliefs will be necessary.

The concepts discussed in this review will help contextualise the above and other considerations into a framework that has experimental validity. To this end, the major focus of this review is to acquaint the reader with a large body of literature that has developed over the previous decades regarding remembrance of events, often of a traumatic nature, that may or may not be verifiably true. The unfortunate shorthand description of this body of literature as 'false memory' studies may have hindered consideration of this literature in the anaesthesia field, as the implication is that unverifiable AWR is a 'false memory'. Although false memories can indeed be created and studied in an experimental sense, the thrust of this review is to focus on presenting well developed concepts that go beyond the basic conscious/unconscious memory classifications. These conceptualisations are useful to understand how memories can change over time, are modulated by experimental intervention, and, most importantly, how ABMs interact with belief systems. Such knowledge will not only be helpful in further elucidation of perioperative memory phenomena, but also for the clinician to relate more fully with their patients when belief systems come into play.

Impetus to develop more complex models of human memory

The body of literature referred to in this review arose in response to issues surrounding the veracity of eye witness testimony or of retrieved distant or traumatic memories (often with the help of a professional).[18] As a result, more elaborate conceptualisations of human memory have been developed.[19] In these, episodic memories support personally relevant ABMs that interact with belief systems, which in turn have been generated from previous events and beliefs. The result is an iterative system of malleable memories.[20] ABMs act as the foundation for a feeling of internal coherence and of contextualisation in a social system, which can broadly be defined as the 'conceptual self'.[21] To this end, memories are shaped in a personal way to form a coherent narrative of the conceptual self.[22] A great deal of behavioural evidence confirms that memories are not static records of previous events, but rather continuously malleable (re)constructions of previous memories.[23,24] In line with neurobiological constructs, memories can be recalled, influenced, and reconsolidated into a different version of events that may differ slightly or greatly from the