

- Tulving E (1983) *Elements of Episodic Memory*. Oxford: Clarendon Press.
- Tulving E (1985) Memory and consciousness. *Canadian Psychologist* **25**: 1–12.
- Tulving E and Schacter DL (1990) Priming and human memory systems. *Science* **247**: 301–306.
- Tulving E and Craik FIM (eds) *The Oxford Handbook of Memory*. Oxford: Oxford University Press.
- Vargha-Khadem F, Gadian DG, Watkins KE *et al.* (1997) Differential effects of early hippocampal pathology on episodic and semantic memory. *Science* **277**: 376–380.
- Viskontas IV, McAndrews MP and Moscovitch M (2000) Remote episodic memory deficits in patients with unilateral temporal lobe epilepsy and excisions. *Journal of Neuroscience* **20**: 5853–5857.
- Warrington EK and Weiskrantz L (1970) Amnesic syndrome: consolidation or retrieval? *Nature* **228**: 628–630.
- Warrington EK and Sanders HI (1971) The fate of old memories. *Quarterly Journal of Experimental Psychology* **23**: 432–442.
- Warrington EK and McCarthy RA (1988) The fractionation of retrograde amnesia. *Brain and Cognition* **7**: 184–200.
- Westmacott R, Leach L, Freedman M and Moscovitch M (2001) Different patterns of autobiographical memory loss in semantic dementia and medial temporal lobe amnesia: a challenge to consolidation theory. *Neurocase* **7**: 37–55.
- Wiggs CL and Martin A (1998) Properties and mechanisms of perceptual priming. *Current Opinion in Neurobiology* **8**: 227–233.
- Winocur G (1990) Anterograde and retrograde amnesia in rats with dorsal hippocampal or dorsomedial thalamic lesions. *Behavioural Brain Research* **38**: 145–154.
- Zola-Morgan S and Squire LR (1990) The primate hippocampal formation: evidence for a time-limited role in memory storage. *Science* **250**: 288–290.

# Memory Distortions and Forgetting

Intermediate article

*Asher Koriat*, University of Haifa, Haifa, Israel  
*Morris Goldsmith*, University of Haifa, Haifa, Israel  
*Ainat Pansky*, University of Haifa, Haifa, Israel

## CONTENTS

*Introduction*

*Forgetting*

*Memory distortion*

*Metacognitive processes and the prevention of memory errors*

*Concluding remarks: how faulty is memory?*

*Forgetting refers to the failure to remember specific facts or events that took place in the past. In contrast, memory distortion includes many ways in which what a person does remember can deviate from what actually happened.*

## INTRODUCTION

Forgetting is perhaps the single most intrinsic aspect of the concept of memory; were there no forgetting, there would be little need for the concept of memory at all. For better or worse, however, forgetting is a ubiquitous phenomenon for all of us.

An influential memory metaphor that was proposed by the philosopher John Locke conceives

memory as a storehouse: a place in which thoughts and experiences are initially stored and later retrieved. Such a conception implies a *quantity-oriented* approach to memory, in which the focus is on how much information is retained (remembered) and how much is lost (forgotten). This approach underlies much of the traditional experimental research on memory. More recently, however, a different conception has been gaining prominence, motivated primarily by real-life memory phenomena. In this *correspondence* conception, memory is treated as a representation or description of past events, and interest focuses on the extent to which that description faithfully portrays those events (see Koriat and Goldsmith, 1996a).

The contrast between the storehouse and correspondence conceptions of memory is useful for distinguishing two different notions of forgetting. The quantity-oriented storehouse view leads to a definition of forgetting in terms of omission, that is, the failure to remember specific facts or events. In contrast, the accuracy-oriented, correspondence conception leads to a focus on the many ways in which what a person does remember can deviate from what actually happened. For instance, we might 'remember' events that never occurred or distort those that did occur. In real-life situations, memory distortions are often more serious than omissions. For example, we would not expect an eyewitness to a crime to remember everything that happened at the time. We do, however, want to be able to depend on what he or she *does* report to be correct.

This article outlines and reviews some of what is known about the causes of omission errors, and about several different types of memory distortions.

## FORGETTING

The first experimental investigation of forgetting was performed by Hermann Ebbinghaus in the late nineteenth century. Ebbinghaus studied lists of nonsense syllables until he achieved perfect recall, and then tested himself after different retention intervals. The resulting forgetting curves showed a great deal of forgetting within the first few hours after learning, quickly levelling off such that relatively little forgetting occurred thereafter. This basic pattern of decelerated forgetting over time has since been replicated repeatedly for various types of memory materials.

Ebbinghaus's approach implies a storehouse conception in which forgetting is defined as the loss of information over time. Such forgetting can derive from the spontaneous decay or weakening of memory traces, but it can also reflect the temporary inaccessibility of information that is otherwise available in memory. For example, experiments show that items that cannot be recalled at one point in time may be recalled (or recognized) on subsequent memory tests, indicating that the memory traces of these items were not lost (this is often experienced by students who recall the 'forgotten' answers to exam questions just after leaving the exam room). Similarly, the 'tip-of-the-tongue' phenomenon, in which one feels that one knows the answer to a question (and really does) but is unable to retrieve it, is familiar to all of us. In fact, it is commonly held that the primary cause of

forgetting is loss of access to stored information rather than loss of the information itself.

A major factor that can impair memory retrieval is interference. *Retroactive interference* occurs when newly acquired information interferes with the retrieval of previously learned information, whereas *proactive interference* occurs when previously learned information interferes with the acquisition and retrieval of new information. For example, remembering where I parked my car yesterday may impair my memory for where I parked it today (proactive interference) and vice versa (retroactive interference). Interference is especially likely to occur when the new and old pieces of information are similar.

People may also fail to retrieve a piece of information simply because the available retrieval cues are insufficient or ineffective. For example, we might fail to recollect the name of an acquaintance we are about to meet, but then her name may suddenly pop to mind when we see her face. Retrieval is especially likely to fail when retrieval cues do not match the way in which the information was initially encoded into memory, a principle known as 'encoding specificity' (Tulving and Thomson, 1973). For example, we may not recall who 'Debra Johnson' is, but then immediately remember her when a friend prompts us with: 'You know – Debbie!' Similarly, retrieval may also be impaired when the retrieval context differs from the encoding context. Thus, one's memory of an event may be enhanced by returning to the same place (external context) in which it occurred, or by re-experiencing the same mood or state of mind (internal context) that one was in at the time. State-dependent learning implies, for example, that if one were to study for an exam while drunk, it might actually be best to show up drunk to the exam as well!

In addition to the cognitive factors mentioned above, Sigmund Freud emphasized the importance of motivational factors that cause people to actively repress the memory of painful or traumatic personal events. Such repressed memories are held to remain active in the unconscious while being sealed off from consciousness. According to psychoanalytic theory, repressed memories cannot be wilfully retrieved, but they may emerge in the course of psychotherapeutic treatment (see below).

Finally, pathological memory disorders involving brain damage caused by injury or disease can obliterate the ability to recall portions of the person's autobiographical experience or to acquire new information. In *retrograde amnesia* a patient fails to recall past events, whereas in *anterograde*

*amnesia* the patient has difficulty forming new memories.

## MEMORY DISTORTION

Although a great deal of what we learn or experience is forgotten, it is perhaps more intriguing that what we do remember is not always veridical. Research on memory distortion and 'false memory' has important implications for real-life issues: for example, to what extent can we trust the memory of a courtroom witness? How reliable is the memory of a childhood traumatic event that is recovered years later in the course of psychotherapy? These questions concern the *accuracy* of what one remembers, rather than the amount.

Two basic principles can be used to explain many memory distortions and false memory phenomena:

1. What people remember depends not only on what actually happened, but also on constructive and reconstructive memory processes that people use to infer what might or should have happened.
2. What people remember depends on their ability to attribute remembered pieces of information to their proper source.

We now present phenomena and findings that illustrate these principles.

### Memory Construction/Reconstruction Errors

Bartlett (1932) promoted the view of remembering as a dynamic, goal-directed 'effort after meaning'. Following his lead, a vast amount of research has shown that what is remembered is not simply a reproduction of the original input, but is an active construction or reconstruction based on inference and interpretation processes that are applied to that input – first when the information is initially encoded, and then again when the stored information is later retrieved.

These inference and interpretation processes are guided by one's general knowledge and expectations about the world. For example, one's cognitive *schema* or *script* about what typically occurs in a restaurant may lead one to fill in and remember details that did not actually occur: that the host paid the bill, for instance, when in fact he walked out without paying. Such schema-based intrusions reflect a confusion between what one expects and what actually happened.

Reconstructive memory processes can also distort remembered details. Such distortions have

been examined extensively in eyewitness research focusing on the effects of *leading questions* (Loftus, 1979). For example, the question 'how fast were the cars going when they *smashed into* each other?' was found to yield significantly higher speed estimates than more neutrally phrased questions, such as 'how fast were the cars going when they *hit* each other?' Apparently, people's memories can be contaminated by implications conveyed in a question's wording. Moreover, when questioned again a week later, witnesses who had previously been asked the leading question were more likely to falsely remember the presence of broken glass than witnesses who had received the more neutral question. In fact, simply using a definite article (e.g. 'Did you see *the* broken headlight?') rather than an indefinite article ('Did you see *a* broken headlight?') can bias witnesses into falsely remembering the specified object or event.

Reconstructive bias need not be externally induced, however. For example, one's current knowledge and beliefs about oneself (self-schemas) can distort one's memory for past beliefs, attitudes, and behaviors, often causing one to remember them as being more compatible with one's current self than they really are.

Finally, another type of reconstructive error derives from people's tendency to remember the general meaning or gist of experienced events rather than their exact details. Consequently, people often report information that is consistent with the gist of an event, though it may be inconsistent with its details. Even when relatively sterile word-list study materials are used, gist-based errors can appear, such as remembering 'canary' or 'bird' when 'sparrow' was actually studied.

### Source/Reality Monitoring Errors

Many memory errors stem from a failure to identify correctly the source of retrieved information. For example, we may remember having called the doctor to cancel an appointment, but in fact we only thought about doing so. *Reality monitoring* – the ability to distinguish actual events from fantasy – is a special case of *source monitoring*: the ability to attribute experiences to their proper source (Johnson *et al.*, 1993). Source-monitoring errors can result in confusions between details of events that were experienced in one situation and those that took place in another. A dramatic example is an incident that ironically involved a well-known memory researcher, Donald Thomson, who was wrongly identified by a rape victim as the rapist. Thomson's alibi both exonerated him immediately

and helped explain the false accusation. He was giving a live television interview at the time of the rape: apparently, the victim had been watching the interview just before she was raped, and confused the memory of his image with that of the rapist. Thus, source-monitoring failures can often be more harmful than retrieval failures: fragments of real experience are accurately and vividly recalled, but are attributed to the wrong person, location, or time, resulting in false memory.

Source-monitoring errors may explain many false-memory phenomena. A prominent example again comes from eyewitness research. Studies indicate that wrong information presented to witnesses after the witnessed event (e.g. a statement or question that erroneously refers to an actual stop sign as a yield sign) can distort their subsequent memory for that event (e.g. remembering having *seen* a yield sign). This phenomenon may derive from deficient source monitoring: the post-event misinformation is more accessible than the original information and is wrongly attributed to the original event.

A second example comes from an experimental paradigm that has attracted much interest recently (Roediger and McDermott, 1995). In this paradigm, subjects study a list of related words (e.g. BED, REST, TIRED, DREAM), all converging on a particular 'lure' word (e.g. SLEEP) that is *not* presented for study. When tested later, the subjects tend to falsely recall or recognize the lure word. Interestingly, subjects are generally quite confident about these false memories, sometimes even claiming to remember the tone of voice in which the (non-presented) word was spoken! Such errors may result from an incorrect inference regarding why the critical lure feels 'activated' or familiar – with the person misattributing the feeling to memory.

There has been a heated debate over the authenticity of memories of childhood sexual abuse that are recovered in adulthood (often through psychotherapy). The question is whether such recovered memories are accurate recollections that were repressed for years due to their traumatic nature, or were false memories induced during the process of therapy (by repeated imagination or compliance with the therapist's suggestions). Can people 'remember' entire events that did not occur? Studies indicate that indeed memory for false events can be implanted: subjects who are urged to repeatedly imagine fictional childhood events subsequently tend to remember those events as real, and even provide additional details about them. Thus, people sometimes attribute to reality an episode that was only suggested to them, or only imagined by

them, demonstrating extreme cases of faulty reality monitoring.

## METACOGNITIVE PROCESSES AND THE PREVENTION OF MEMORY ERRORS

The preceding sections have indicated a variety of ways in which memory can go wrong. When a person has remembered and reported incorrect information, this implies not only a failure of memory, but also of *metamemory* processes; that is, a failure to realize that the remembered information is faulty. Conversely, sometimes information is omitted or 'forgotten' not because the information fails to come to mind, but because the person does not realize that the retrieved information is in fact correct. In this context, metamemory refers to what one knows about one's own memories, and how that knowledge is used to regulate what one reports.

To illustrate, consider a courtroom witness who is sworn to tell 'the whole truth and nothing but the truth'. To fulfill that goal, the witness must try to distinguish between correct and incorrect information that comes to mind, and report only (and all of) the correct information. The attempt to regulate one's memory reporting in order to provide as much information as possible but to avoid reporting wrong information seems to be an intrinsic aspect of remembering in real-life situations. Two types of strategic control over memory reporting have been examined (see Goldsmith *et al.*, 2002; Koriat and Goldsmith, 1996b). The first, *report option*, involves the decision whether to report a remembered piece of information or to withhold it (e.g. to reply 'I don't know'). People tend to avoid reporting information that they feel unsure about, which generally enhances the accuracy of what they report, but may reduce the amount of correct information (i.e. increase omission errors) if people mistakenly screen out correct answers. Importantly, both the accuracy benefits and the quantity costs that ensue from the option of free report depend on two metacognitive factors: (a) monitoring effectiveness – people's ability to monitor the correctness of the information that comes to mind, and (b) control policy – the strictness or liberality of the confidence criterion that is set for volunteering answers.

Many of the cues that people use to monitor their memories have to do with source and reality monitoring (Johnson *et al.*, 1993). Memories of witnessed events tend to be more vivid and include more perceptual detail than imagined events. Thus,

people may utilize a *distinctiveness heuristic* to screen out false memories (Schacter *et al.*, 1999), based on the awareness that the memory of true events should include recollection of distinctive details. Also, when the demands for accuracy are strong, the person may deliberately recruit additional corroborative information that helps verify the source of the retrieved events, or adopt a relatively strict criterion for reporting the information.

A second way in which rememberers regulate the amount and accuracy of the information that they report is by controlling the *grain size* of their answers, choosing a level of precision or coarseness at which they are unlikely to be wrong. Instead of reporting that the accident occurred precisely at 5:21 p.m. (which is likely to be wrong), one may choose to report that it occurred between 5:00 and 5:30, or even 'sometime in the late afternoon' (both of which are more likely to be correct). Of course, coarsely grained answers, though more likely to be correct, generally provide less information than more precise answers. Here too, rememberers tend to utilize their monitoring and control processes in a strategic manner, choosing a grain size that represents an expedient compromise between accuracy and informativeness (Goldsmith *et al.*, 2002).

## CONCLUDING REMARKS: HOW FAULTY IS MEMORY?

The focus on forgetting and memory distortion in this article could leave a pessimistic impression about the general faithfulness of human memory. But is human memory really as flawed as it seems? We think not. First, although some types of memory errors may appear to reflect flaws in the 'system design', they are in fact by-products of otherwise adaptive features of memory. Thus, for example, remembering the gist but forgetting the details of stories and events, or inferring information not actually present in the input, is often what is required in real-life situations. Second, when detrimental memory errors do occur, they appear to derive from the same memory processes that normally lead to accurate remembering. Thus, although schema-based inferences are sometimes wrong, they are probably more often right – assuming that events that take place in the world ordinarily do agree with our general knowledge and expectations. Although perhaps it is natural for memory researchers to focus on the 'dark' side of memory in attempting to understand the causes of forgetting and distortion, it is amazing how much information people actually do remember, the vast

majority of which is correct – or at least useful. Which brings us to one final point. Some of the functions of memory are expressed neither in its quantity nor in its accuracy, but rather, in its personal and social *utility* (Neisser and Winograd, 1988). Thus, for instance, our memories are important vehicles for preserving a sense of self, and in facilitating our interactions with others (e.g. storytelling and reminiscing). Such goals may be achieved despite (and perhaps because of) a certain amount of forgetting and distortion. Current work has begun to address these broader functions of memory, and how they are realized.

## References

- Bartlett FC (1932) *Remembering: A Study in Experimental and Social Psychology*. New York, NY: Cambridge University Press.
- Goldsmith M, Koriat A and Weinberg-Eliezer A (2002) Strategic regulation of grain size memory reporting. *Journal of Experimental Psychology: General* **131**(1): 73–95.
- Johnson MK, Hashtroudi S and Lindsay DS (1993) Source monitoring. *Psychological Bulletin* **114**: 3–28.
- Koriat A and Goldsmith M (1996a) Memory metaphors and the real-life/laboratory controversy: correspondence versus storehouse conceptions of memory. *Behavioral and Brain Sciences* **19**: 167–228.
- Koriat A and Goldsmith M (1996b) Monitoring and control processes in the strategic regulation of memory accuracy. *Psychological Review* **103**: 490–517.
- Loftus EF (1979) *Eyewitness Testimony*. Cambridge, MA: Harvard University Press.
- Neisser U and Winograd E (1988) *Remembering Reconsidered: Ecological and Traditional Approaches to the Study of Memory*. New York, NY: Cambridge University Press.
- Roediger HL and McDermott KB (1995) Creating false memories: remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition* **21**: 803–814.
- Schacter DL, Israel L and Racine C (1999) Suppressing false recognition in younger and older adults: the distinctiveness heuristic. *Journal of Memory and Language* **40**: 1–24.
- Tulving E and Thomson DM (1973) Encoding specificity and retrieval processes in episodic memory. *Psychological Review* **80**: 359–380.

## Further Reading

- Baddeley AD (1990) *Human Memory: Theory and Practice*. Needham Heights, MA: Allyn & Bacon.
- Goldsmith M and Koriat A (1999) The strategic regulation of memory reporting: mechanisms and performance consequences. In: Gopher D and Koriat A (eds) *Cognitive Regulation of Performance: Interaction of Theory and Application. Attention and Performance XVII*, pp. 373–400. Cambridge, MA: MIT Press.

- Koriat A, Goldsmith M and Pansky A (2000) Toward a psychology of memory accuracy. *Annual Review of Psychology* **51**: 481–537.
- Loftus EF (1992) When a lie becomes memory's truth: memory distortion after exposure to misinformation. *Current Directions in Psychological Science* **1**: 121–123.
- Loftus EF (1997) Creating false memories. *Scientific American* **277**: 50–55.
- Mitchell KJ and Johnson MK (2000) Source monitoring: attributing mental experiences. In: Tulving E and Craik FIM (eds) *The Oxford Handbook of Memory*, pp. 179–195. New York, NY: Oxford University Press.
- Roediger HL III (1996) Memory illusions. *Journal of Memory and Language* **35**: 76–100.
- Schacter DL (1999) The seven sins of memory. *American Psychologist* **54**: 182–203.
- Schacter DL, Norman KA and Koutstaal W (1998) The cognitive neuroscience of constructive memory. *Annual Review of Psychology* **49**: 289–318.
- Tulving E and Craik FIM (eds) (2000) *The Oxford Handbook of Memory*. New York, NY: Oxford University Press.

# Memory Mnemonics

Intermediate article

John Best, Eastern Illinois University, Charleston, Illinois, USA

## CONTENTS

*Introduction*

*Common mnemonic methods*

*Situations where mnemonic methods are appropriate*

*Theoretical import of mnemonics*

*Mnemonics are techniques that are used to improve both the amount of information that a person might retrieve from memory, and its accuracy. These techniques typically use highly overlearned organizational schemes and visual imagery.*

## INTRODUCTION

The term 'mnemonics' refers to a class of strategies for organizing material that a person believes he or she will want to retrieve. Thus, they have features in common with strategies used in other domains: their use is always conscious, deliberate, and effortful. The proponents of mnemonics believe, however, that the effort involved in using a mnemonic technique is amply rewarded by ease and accuracy at retrieval time.

Generally speaking, the effectiveness of most mnemonic techniques results from their exploitation of some other characteristic of the human cognitive system. For example, humans have long known they might improve their retrieval by incorporating some type of sensory information into the memory they wish to retrieve. Thus, when we use jingles and nursery rhymes to help us retrieve otherwise abstract things, we are exploiting the fact that the acoustic or phonetic properties of a stimulus can be used to help organize it. Similarly, the

power of human imagination, with its ability to create unusual and hard-to-forget visual images, is even more likely to play a role in many formal mnemonic techniques.

Despite some impressive findings, the overall utility of mnemonic techniques has not yet been conclusively demonstrated. Similarly, it is not currently clear whether or not the astonishing feats of memory produced by modern mnemonists have any real implications for existing theories of 'normal' memory.

## COMMON MNEMONIC METHODS

### Loci

*Loci* is a Latin term pronounced 'low-sigh' and meaning 'locations' (singular: locus). The 'method of loci' thus refers to the notion of using a sequence of highly overlearned and easily visualized locations as a system for organizing memory stimuli. It is a technique whose origins lie in antiquity: the Greek bards of the fifth century BC used it to organize recitations of many hours' length.

To use this technique, you must know, and be able to visualize, a set of places in the exact order in which you might encounter them. For example, you might visualize the buildings you would