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## Misfortunes of memory

BY ELIZABETH F. LOFTUS

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Information presented after a witnessed event may become incorporated into a person's memory, and either supplement or alter the original memory. One consequence is a distorted recollection of the event. Many variables influence the likelihood that memory is distorted by post-event suggestion, including (1) the violence of the event itself, (2) the time intervals between the event, post-event information, and final test, (3) the syntactic form of the post-event information, and (4) the presence of warnings cautioning about the possibility of post-event suggestion, and the timing of those warnings. A common principle tying these findings together is the notion of 'detection of discrepancies'. Recollection change is enhanced to the extent that a person does not detect discrepancies between the original memories and the post-event information at the time that the latter is being processed.

Yea, from the table of my memory  
I'll wipe away all trivial fond records,  
All saws of books, all forms, all pressures past  
That youth and observation copied there,  
And thy commandment all alone shall live  
Within the book and volume of my brain  
Unmixed with baser matter...

W. Shakespeare, *Hamlet*, I, v.

Aside from their religious quality, these lines convey some rather interesting ideas about the operation of human memory. At one level they suggest the notion that the memories laid down by past observations can be eliminated from the mind, replaced by newer memories that will remain in their stead. There is the further suggestion in these lines that the process of substituting new memories for old can be under a person's own control. This is an intriguing idea, but is there any evidence for it?

Over the past decade I have been studying a phenomenon that resembles the 'wiping away' of the records of a person's memory. In this research, subjects witness a complex event, like a film of a crime or accident, and subsequently receive some new information about the event. When exposed to misleading post-event information, subjects have misrecalled the colour of a car that was green as being blue, a yield sign as a stop sign, broken glass or tape recorders that never existed, and even recalled something as large and conspicuous as a barn when no barn was ever seen. Since many published accounts of these findings exist (and the studies are reviewed again by Loftus (1979), only a brief description is provided here.

In a typical experiment, subjects see a complex event and are then asked a series of questions that expose them to post-event information. Typically some of the questions are designed to present misleading information, i.e. to suggest the existence of an object or detail that did not in fact exist. Thus, in one study, subjects who had just watched a film of a car accident were

asked, 'How fast was the white sports car going when it passed the barn while travelling along the country road?' whereas no barn existed. Those subjects were substantially more likely to later 'recall' having seen the non-existent barn than were subjects who had not been asked the misleading questions. Why does this occur? One hypothesis is that the questions are effective because they contain information – in this case false information – that becomes integrated into the person's recollection of the event, thereby supplementing that memory.

In other studies, it has been shown that new information can do more than simply supplement a recollection: it can occasionally alter, or transform, a recollection. Thus, in one study, subjects saw a series of slides depicting successive stages in an accident involving a car and a pedestrian. During the series, the car, a red Datsun, was seen travelling along a side street towards an intersection at which there was a stop sign for half of the subjects and a yield sign for the remaining subjects. Some subjects then received a question containing a piece of misinformation: for example, the question 'Did another car pass the red Datsun while it was stopped at the stop sign?' contains a piece of misinformation when it is asked of subjects who actually saw the yield sign. And, finally, subjects were tested for their recollection of the sign. Depending upon the time intervals that occurred between the slides, the intervening questions, and the final recollection, as many as 80% of subjects indicated that their recollections were influenced by the misinformation.

In other experiments, new information presented as another witness's description, or by allowing the subject-witness to overhear a conversation, similarly caused changes in the recollection of details. For example, Loftus & Green (1980) showed subjects photographs of individuals. Afterwards some subjects read a description attributed to another person that either did or did not contain an erroneous detail. For example, in one case a person with straight hair was described as having curly hair. When later tested, 22% of subjects who heard misinformation included the misinformation in their own verbal description of a target face, and 33% included the detail in their reconstructions of the face. The erroneous details rarely occurred when they had not been mentioned by the other witness.

These experiments, and others that used variations of this procedure (see, for example, Dodd & Bradshaw 1980; Johnson 1979; Lesgold & Petrush 1977; Read & Bruce 1983) show that people will pick up information, whether it is true or false, and integrate it into their memory, thereby supplementing or even altering their recollection. Children, too, are susceptible to post-event suggestions, although perhaps no more so than adults (Duncan *et al.* 1982). Many interesting questions about the alteration of memory have been investigated. For example, Lehnert *et al.* (1983) have asked about the 'scope' of memory modification. If an event is directly altered by post-event inputs, are the resulting states from that event also altered? If a post-event suggestion causes a person to 'remember' that a man closed a window rather than opened it, will the person also come to 'remember' that the window was closed because the visitor was cold rather than warm? Any indirect memory modifications resulting from a misleading post-event input would indicate that direct memory modifications force a 'ripple effect' throughout the memory representation. The data on this point are clear. Not only did Lehnert *et al.* find that modifying a state (whether the visitor was cold or warm) is easier than modifying an action (whether the man opened or closed the window), but they found that propagation of modifications through memory occurs, especially from states to related actions and less reliably from actions to related states.

The alteration of recollection appears to be a fact of life. Once an alteration has occurred, it is very difficult to induce a witness to retrieve the original memory. Although an occasional

attempt to recover the original memory proves successful (Bekerian & Bowers 1983), most attempts have met with failure (see, for example, Hertel 1982).

Up to this point, I may have painted an excessively depressing picture of people's ability to retain accurate information in memory and to resist suggestive information. In fact, there are numerous times when people are quite able to resist suggestive influences. For example, in a study by Dodd & Bradshaw (1980) some subjects were able to resist misleading suggestions. In this research, subjects viewed an accident depicted in a series of slides. Misleading information that ostensibly came from a neutral source (e.g. a bystander) was incorporated into memory, but that same information, when attributed to a biased source (the driver who caused the accident) was not. In the work of Read & Bruce (1983) the impact of misinformation was reduced substantially when subjects were more rather than less familiar with the environmental context in which the incident had occurred, when they paid more attention to the thematic content than to the surface features of the event, and when they had been informed a month earlier, rather than being uninformed, about findings in eyewitness research. In another set of studies, subjects who were warned about the possibility of misinformation just before receiving some information were less influenced by it. They appeared to scrutinize the post-event information more carefully and this resulted in a greater resistance to its suggestive effect (Greene *et al.* 1982). Unfortunately, warnings given after the suggestive information had already been incorporated into memory had no effect whatsoever.

#### THE FATE OF MEMORY

There now seems to be little doubt that a person's recollection can be easily altered by exposure to new information. However, there is still a question of why. Why is the post-event information remembered instead of what was originally experienced? A further question concerns the fate of the underlying memory traces. Have they truly been updated or altered by the post-event information so that the original traces could not be recovered in the future? I have referred to this as the 'alteration' hypothesis, and it suggests that the original memory representations are altered when post-event information is encoded that differs from what was originally experienced. The alternative position is the 'coexistence' hypothesis, which assumes that the original and post-event information coexist in memory. The introduction of post-event information, under this position, is thought to make the original memories simply less accessible, but still potentially recoverable at some future time.

The coexistence–alteration issue is important from both a theoretical and a practical standpoint. Speaking practically, the dichotomy bears on attempts that one might make to correct a memory after it has been biased by post-event suggestion. Under the coexistence view, but perhaps not the alteration view, it makes sense to vigorously pursue retrieval techniques (e.g. hypnosis, reinstatement of context) that might access the original information. Under the alteration view, one's efforts would be placed elsewhere because it is likely that the only way to return to the original information is by a 're-alteration' of memory.

Theoretically speaking, the dichotomy bears on one of the most fundamental questions about memory: the permanence of memory traces. The coexistence view is consistent with the idea that all information, once stored in memory, remains there more or less permanently. The alteration view implies a true loss of information from memory due to the updating, substitution or blending in of new inputs.

Many people hold the view that memories, once stored in the human mind, last forever.

Wilder Penfield, a noted Canadian neurosurgeon, explicitly concluded that the brain contains a complete record of past experience that preserves an individual's past perceptions in astonishing detail. In this conclusion he has provided the strongest version of a memory-permanence hypothesis: a view that might be called the 'video-recorder model'. Penfield arrived at his belief on the basis of descriptions given by his patients while their brains were being electrically stimulated during surgery. Their reports were vivid: 'I hear voices. It is late at night, around the carnival somewhere – some sort of traveling circus. I just saw lots of big wagons that they use to haul animals in.' Yet Penfield never verified these so-called 'memories', and never seemed to consider the possibility that they might have been pure fantasy. To base such strong conclusions on the dubious protocols of a handful of patients was clearly unwarranted. And yet Penfield was sure he had found evidence for a permanent record in the brain (Penfield & Roberts 1959; Penfield & Perot 1963).

Penfield is far from alone among those who have accepted this conclusion. In a survey of psychologists and lay people conducted not long ago, over two-thirds of respondents indicated a belief that nothing is really ever lost from memory (Loftus & Loftus 1980). Neisser (1982), in an article entitled 'On the trail of the tape-recorder fallacy', has offered an intriguing explanation for why people have clung so uncritically to this view. He claims that wide acceptance of any interpretation of human nature depends on the cultural availability of the concepts involved. People easily believe in mental tape recorders because they are very familiar with physical tape recorders. Models of the mind in general, and theories of memory specifically, seem to follow the latest advances in gadgetry. At one time, scientists based their theories on hydraulics because this technology was available. Later they based their theories on telephone switchboards, when this technology came into vogue. More recently models of the mind have been based on computers. In short, claims Neisser, commonplace notions of memory are heavily influenced by technology. Understanding this influence may help us to become free of it.

Within this intellectual battleground, some researchers have formalized the view that as a general rule all memories are potentially recoverable and that faulty recall is a problem of accessibility (Morton *et al.* 1981; Shaughnessy & Mand 1981). Morton *et al.* have proposed a 'headed-records framework', which assumes that when an event is witnessed, a record is laid down in memory. Each time the event is subsequently brought to mind, a new record is established, each with its own individualized heading. Later headed-records can interfere with the retrieval of earlier ones, but if the proper cue is provided, the original headed-record will be accessed. A major assumption of the Morton *et al.* framework is that once a headed-record has been formed, it cannot be deleted, changed or updated. The only changes permitted to the memory structures are the addition of new headed-records. An account of experiments involving the introduction of misinformation assumes that the 'true' information is in the first record while misinformation is in a different record. Under various conditions one rather than the other record will be accessed.

Shaughnessy & Mand have applied a 'frequency theory' of memory to the task of a subject remembering a complex event. An account of experiments involving the introduction of misinformation assumes that subjects who receive misleading information have in memory one accurate and one inaccurate memory (1–1), whereas control subjects have only the single accurate memory (1–0). If subjects base their responses purely on the frequency information the (1–1) subjects would be expected to exhibit substantially fewer correct responses than the



(1–0) subjects. This formulation, like that of Morton *et al.*, assumes that both the original and subsequent memories coexist in memory.

Coexistence frameworks derive their support from studies that show successful recovery of original memories. Although some instances have been reported in which allegedly altered memories reappear (Bekerian & Bowers 1983; Christiaansen & Ochalek 1982), this still does not mean that all memories are similarly recoverable.

A contrasting position is that some memories may undergo destructive transformation due to post-event inputs, and the original memories may no longer be retrievable (Loftus & Loftus 1980). This position has been strengthened (although by no means proved) by numerous empirical attempts to recover original memories that have failed. Even the ‘mysterious’ technique of hypnosis has failed to lead to the original memories once they have been altered (Putman 1979; Sheehan & Tilden 1983; Zelig & Beidleman 1981). Of course such failures do not prove that the original memories do not exist, because it can always be argued that the original memory does exist but that the appropriate retrieval method was not used, or that the method used was not sufficiently powerful. The following anecdote, used to discuss the concept of statistical power in a recently published statistics textbook, illustrates this point rather graphically (Loftus & Loftus 1982; pp. 242–243):

In March of 1977 ski season finally arrived in the Pacific Northwest. Shortly after the slopes opened, one of the authors of this book (G.L.) decided to take his first skiing trip of the year. In preparation for this adventure G.L. rummaged around his house, gathering together ski gear that had been lying dormant since the previous season. This search turned up all crucial items except for G.L.’s ski goggles, which were nowhere to be found. G.L. concluded that his goggles had probably been lost during a previous ski trip, or perhaps over the summer and announced in some exasperation that he was planning to go out and spend \$20 for a new pair. The other author (E.L.), horrified at such an idea, demanded that G.L. undertake a power thorough (powerful) search.

Had G.L. found his goggles, this would be proof enough that they existed. However, suppose that G.L.’s more thorough search for his wayward goggles had failed. Suppose he had completely ransacked the house and still failed to find them. The goggles might still have been hidden in some remote nook or cranny (the position E.L. would take), but for all practical purposes it might make sense to conclude that the goggles were simply not there (the position G.L. would be likely to take). The story, which happily ended with G.L.’s finding his ski goggles in a remote corner of his cupboard, illustrates this point: proving that an original memory does exist is relatively easy; one simply locates it and this is proof enough. However, proving that an original memory does not exist is likely to be virtually impossible.

Whatever the ultimate answer to the permanence question, it is still fruitful to ask about the various conditions that encourage distortion in recollection and those that seem to minimize it. As it happens, there is a growing literature on just this point. I shall discuss four separate lines of research, each of which helps to delimit the boundary conditions for the recollection change phenomenon. I shall then show how these superficially unrelated lines of research can be tied together within the umbrella of a single common principle.

## CRITICAL FACTORS IN RECOLLECTION CHANGE

*Time intervals*

The intervals of delay between viewing an initial event, encountering a subsequent misleading message, and engaging in a final test of recollection have been found to be major determinants of changes in memory for an event (Loftus *et al.* 1978). The number of subjects whose recollection is distorted increases with longer as opposed to shorter intervals between an event and subsequent misinformation. Put another way, recollection change appears to be enhanced by the fading of original memory with the passage of time.

*Form of the post-event information*

The syntax of a post-event message influences the likelihood of its acceptance. In one study, students attending a university lecture were surprised by intruders who suddenly entered the lecture hall, loudly insulted the professor, and then just as suddenly departed (Loftus 1981). After the intrusion, subjects answered a questionnaire about the incident. For some subjects, the questionnaire included one item that referred misleadingly to a non-existent moustache. In fact, two versions of the misleading question were presented to different groups of subjects. In one version, the moustache was the subject of a simple interrogative question: 'Was the moustache worn by the tall intruder light or dark brown?' In the second version, the moustache was the object of an auxiliary clause: 'Did the intruder who was tall and had a moustache say anything to the professor?' Two days later, subjects were tested for their recollection of the details of the incident, and specifically asked if they had seen a moustache on the tall intruder. The results indicated that recollection was more often affected by the misleading object of an auxiliary clause than by the same misinformation presented in the focus of the question.

One explanation for this result is that less attention was given to the misinformation when it was embedded in a minor clause. In this case, the misinformation is casually or unintentionally assimilated. When placed at the focus of the question, the misinformation seems to be given more direct and critical attention and the likelihood of its rejection is enhanced.

*Violence of the event*

Loftus & Burns (1982) showed subjects a short film of a mentally shocking event in which a young boy is violently shot in the face. Compared with other subjects who saw a non-violent version of the same film, those who saw the mentally shocking version showed poorer retention of the details of the film. For example, in the non-violent version of the film, almost 28% of the subjects recalled the number on the boy's jersey, whereas less than 5% could recall it from the violent film. One explanation for this result is that mentally shocking episodes disrupt the lingering processing necessary for full storage of information in memory. In more recent studies it has been observed that the details of violent events (as compared with non-violent) are more vulnerable to post-event misinformation. One explanation for this greater vulnerability is that a poorer memory is formed, which is less likely to conflict with subsequent misinformation when it is encountered.

*Warnings*

A series of experiments reported by Greene *et al.* (1982) indicates that alteration of recollection can often be minimized if subjects are warned that a post-event message that they are about to receive might contain misinformation. However, the immediacy of the warning

appears to be critical. To be effective, the warning must be given just before the presentation of the misleading message. In this research, the amount of time taken by subjects to read the post-event message was recorded. Subjects who were warned just before encountering the post-event information read that information more slowly, and apparently more carefully, than subjects who were not warned at all.

In summary, I have reviewed four lines of research on alteration of recollection. In all of these cases the subject's detection of discrepancies between the original memory and the post-event message (or failure to detect discrepancies) appears to have been a crucial factor. With a long interval between the event and misinformation, with misinformation that is subtly embedded, with information acquired in the course of viewing a violent event, it appears that the ability of subjects to detect a discrepancy between the event information and the post-event information is minimized. Conversely, when subjects are warned about the likelihood of incorrect information, they scrutinize the post-event information, and the likelihood of detection of a discrepancy is enhanced. Thus the detection of discrepancies appears to be an important mediating variable, i.e. a common underlying factor in the operation of a number of other variables. This analysis leads naturally to the proposal of a basic principle of recollection change: change in memory for an event is more likely to occur if discrepancies between the original event and post-event information are not initially detected.

#### REAL AND 'UNREAL' MEMORIES

Is there any way to distinguish a memory that results from a true perceptual experience and one that results from post-event suggestions? In an article entitled 'Reality monitoring', Johnson & Raye (1981) suggest that the representations may be different. The representation of an externally generated event is thought to contain more spatial and temporal attributes, more sensory attributes and more semantic detail. The representations of an internally generated event may include more information about the cognitive operations that produced these details. Although this distinction may be promising, it must be kept in mind that these speculations were derived on the basis of experiments that used relatively impoverished, pallid stimuli. There is no guarantee that the distinction would hold with memories for more complex, naturalistic events. One recent doctoral dissertation examined this issue with more realistic materials, specifically a videotape depicting an assault (Buck 1979). A specific objective of that work was to learn if the physiological response that occurs to items of information acquired after an event is equivalent to the response produced by items associated with the event itself. Two cardiovascular measures and measures of electrodermal response and respiration were used, but no differences were found between responses to actual events and responses to suggested events.

Using a series of slides depicting a car accident, we have recently attempted to find differences between memories that are the result of actually perceiving an object and memories that are the result of having the object suggested. Specifically we asked subjects who had either seen a car go through an intersection with a yield sign, or who had merely had the yield sign suggested to them, to give a detailed description of the object. When examined one at a time, the real and 'fake' descriptions are virtually indistinguishable from one another. One can achieve a flavour for the similarity by examining these five descriptions.

1. As the car was approaching the intersection, I saw the yield sign at the corner.
2. I saw the sign as the Datsun pulled up towards it.



3. When the Datsun pulled up the yield sign, it was there on the right corner. It was a red and white triangle not yellow.

4. The yield sign was on the right of the road before the Datsun turned the corner. It had nothing to do with the accident but was there so the Datsun wouldn't go into the traffic and possibly get hit by the bus that came by.

5. It was on the corner on the right of the street.

Which are the 'real' descriptions and which are the 'fake' ones? When asked to classify each description according to whether it was produced by a person who actually saw the sign versus a person who simply had it suggested, judges (even seasoned cognitive psychologists) generally cannot tell. In reality, the first three descriptions came from people who saw the sign, while the last two came from people who had it created in their minds.

Although it is difficult to classify correctly an individual description as to its authenticity, when a large set of descriptions from people who actually saw the sign was compared with a set of descriptions from people who did not, some interesting differences emerged. People who did not actually see the sign used more words, on average, to describe what they had 'seen'. This observation prompted a colleague to remark, 'They're simply whistling in the wind.' A second difference concerns the substance of the descriptions: those who actually saw the sign were more likely to say something about its specific features (e.g. 'It was a red and white triangle not yellow.'), whereas those who did not see it were more likely to describe the surrounding objects (e.g. 'It... was there so the Datsun wouldn't go into the traffic and possibly get hit by the bus that came by.'). Despite the emergence of these group differences, it should be kept in mind that there is a tremendous variability between people both in the length and the content of descriptions. This variability suggests that it will remain very difficult in real-world situations for us to distinguish true recollections from those that have been created.

#### NATURAL SELECTION IN MEMORY

There is little doubt that human recollection can be supplemented, partly restructured, and even completely altered by post-event inputs. It is susceptible to the power of the simple word. What is still in dispute is the mechanism by which these changes occur, and the fate of underlying memory traces. Perhaps some memory traces are modified by subsequent inputs while others are not. If so, then a major question that confronts the memory theorist is this: under what circumstances does one process rather than the other occur? For situations in which original memories remain intact, it makes sense to develop techniques, such as hypnotic intervention, that can be used to facilitate their retrieval. However, we cannot ignore the possibility that some memories may undergo transformation due to post-event suggestion, and no technique would result in successful retrieval.

One might ask why we would have been built with memories that are vulnerable to misleading information. Perhaps we are seeing a by-product of a system that ordinarily serves us quite well. Just as visual illusions occur in a system that is ordinarily quite functional, so might memory distortions occur in a system that ordinarily works rather well. Over 20 years ago, in a book with the now rather dated title of *The psychology of meaningful verbal learning*, Ausubel (1963) wrote about 'the subsumption process' in learning and forgetting. New information that enters the cognitive field naturally interacts with, and is appropriately subsumed within, relevant portions of the cognitive system. The subsumption of traces, according to Ausubel, provides

anchorage for the new material, and thus constitutes the 'most orderly, efficient and stable way of retaining it for future availability' (p. 25). Put another way, the integration mechanism permits memory to behave in an orderly, efficient and stable manner.

In genetics, natural selection is the mechanism by which only useful genetic information is retained (Blackmore 1977). It is tempting to think of an analogous construct in cognition: perhaps we have been blessed with another sort of natural selection mechanism, one by which only the fittest memories survive.

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