Did this Really Happen? The Monitoring and Control of Human Memory

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"Unless we remember we cannot understand."
E. M. Forster

1. Introduction

The importance of memory to human existence can hardly be overestimated. Without the mental faculty of memory there would be no understanding, no knowledge. Reality would be a continuous stream of transient and chaotic perceptions. Of course, since humans first began using external media to record their experiences and knowledge, various technological tools have been developed to aid in the problem of memory storage and retrieval. Nevertheless, as long as people constitute a primary source of information and continue to be responsible for transforming stored information into knowledge, the quality of human knowledge will continue to depend, to a great extent, on the quality of human memory.

Experimental psychologists have conducted a vast amount of research over the past century directed toward understanding the workings of human memory. Is this work relevant to the topic of monitoring for safety and security? I argue that it is.

I begin with a premise that seems fairly self-evident: A substantial amount of information related to safety and security has its source in the memories of human beings. Therefore, the reliability of that information depends on the reliability of those memories. Yet, a great deal of memory research has shown that human memory is quite fallible: Not only is information forgotten, but also, and more interesting, are the many demonstrations of distorted and false memories—sincerely held memories of facts and events that are partly or entirely wrong[1]. False-memory phenomena have gained a particularly large amount of attention in the context of eyewitness memory research, where the implications for law enforcement and the legal system have generated great

[1] Koriat, Goldsmith & Pansky 2000; Roediger 1995; Schacter 1999.

interest[2]. One of the major contributions of this literature has been to impart a healthy scepticism regarding the reliability of eyewitness accounts, and to suggest some ways of improving the situation. This message, however, may not have impacted equally in the many safety and security related domains[3].

Of course, the fact that memory is fallible does not mean that it should never be trusted, or that it is usually wrong. On the contrary, as will be discussed later, under typical conditions in which people are allowed to freely report what they remember, most of the reported information is correct. However, the fact that memory can sometimes go wrong leaves both the recipients of information and the rememberers themselves with the problem of distinguishing between remembered information that should be trusted, and remembered information that should not.

This is where monitoring is needed. As described below, a major line of defense against false memories is provided by an array of subjective monitoring and control operations invoked during the process of remembering[4]. Monitoring refers to the use of various cues and heuristics to evaluate the source and likely accuracy of the information that comes to mind. Control refers to decisions that are based on the subjective monitoring, such as whether or not to report the remembered information, and if so, at what level of precision or coarseness. It turns out that when people are allowed to monitor and control their own memory reporting, they can enhance the accuracy of what they report substantially compared to situations in which they are forced to report all of the information that they remember.

However, these subjective monitoring and control processes are far from perfect. Therefore, a second line of defense is needed—one that can be invoked by external agents within the relevant system, such as law-enforcement agents, accident investigators, or courtroom judges. In principle, there are two complementary approaches: The first, which has been widely researched and implemented[5], involves the development and use of special memory elicitation techniques that minimize the potential contamination of memory, while eliciting a maximum amount of accurate information. The second approach, which is still in an early stage of research, and presents some very formidable theoretical and practical challenges, involves the development of system-based memory monitoring techniques, which would attempt to identify when a person's memory is accurate and when it is not. This idea is similar to the well-known lie detector or polygraph, but here the goal would be to distinguish between

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2 Loftus 1996; Pansy, Koriat & Goldsmith 2005; Wells, Malpass, Lindsay, Fisher, Turtle & Fulero 2000.
3 Kelloway, Stinson & MacLean 2004.
4 Goldsmith & Koriat 2008; Koriat, Goldsmith & Halamish 2008.
5 Fisher & Schreiber 2006; Wells et al. 2000.

accurate and inaccurate memories of witnesses who are presumably trying to be truthful.

Beyond its theoretical and practical relevance, however, our current understanding of the processes that lead to memory errors and distortions, and of the metacognitive monitoring and control processes used in combating those errors, raises some deeper meta-theoretical issues concerning the rational model of human behavior, and the functional utility of a memory system that exhibits "bounded" rationality. These points will be touched upon in concluding the chapter.

2. The Fallibility of Memory: Forgetting and False Memory

One of the most salient properties of memory is its fallibility, generally characterized as "forgetting." Yet, there are two very different notions of forgetting that must be distinguished. Each is tied to a different underlying conception of memory and memory fallibility[6].

2.1. Forgetting and the Storehouse Metaphor

Attempts to understand memory and forgetting have made use of various metaphors. One of the most influential memory metaphors was proposed by the empiricist philosopher, John Locke, who conceived of memory as the "storehouse of our ideas." The storehouse metaphor treats memory as a place in which items of information are initially stored and then later retrieved. Memory performance is then evaluated in terms of how much information is retained (remembered) and how much is lost (forgotten). Not only is this conception intuitively appealing, it also has guided much of the traditional experimental research on memory[7], beginning with Hermann Ebbinghaus'[8] seminal work in the late 19th century. Ebbinghaus studied lists of nonsense syllables until he could recall them without error, 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, and under many different study and test conditions.

The Ebbinghaus tradition of memory research has examined various factors which might be responsible for the loss of information from memory. One such factor is spontaneous decay or weakening of memory traces over time. Although such decay might occur, accumulating evidence suggests that it alone cannot account for all, or even most, cases of forgetting. For example, experiments

6 Koriat & Goldsmith 1994, 1996a, 1996b; Koriat et al. 2000.
7 Roediger 1980.
8 Hermann Ebbinghaus 1895.

show that items that cannot be recalled at one point in time may be recalled or recognized successfully on subsequent memory tests, indicating that the memory traces of these items were not lost but merely temporarily inaccessible. This state of affairs is also reflected in the familiar "tip-of-the-tongue" phenomenon, in which one has the feeling that one knows the answer to a question but is currently unable to retrieve it. Based on these and other types of evidence, it is commonly held that the primary cause of forgetting is loss of access to stored information rather than loss of the information itself. This loss of access, due to interference from other pieces of stored information, may be only temporary, and may depend heavily on the way in which memory is queried[9].

In fact, people may fail to retrieve a solicited piece of information simply because the available retrieval cues are insufficient or ineffective. Such failure is especially likely when the cues available during retrieval do not match the way in which the information was initially encoded into memory, a principle known as "encoding specificity"[10]. Thus, for example, we may not recall who "Samuel Johnson" is when a friend mentions his name to us, but then immediately remember him when the friend repeats: "Don't you remember Sammy?" Similarly, incongruity between the general context in which the information was originally encoded and the context in which we attempt to remember it may also impair retrieval. Thus, one's memory of the details 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. In a dramatic demonstration of state-dependent learning, scuba divers who studied a list of words underwater were subsequently able to remember more of those words when the testing was also conducted underwater than when it was conducted on dry land[11].

2.2. False Memory and the Reconstruction Metaphor

Although the storehouse conception and its variants (e.g., the "computer" metaphor) are useful in capturing certain aspects of memory, they are less able to accommodate other aspects of memory that reveal themselves in more complex, real-life situations[12]. Consider, for example, the Rashomon story, made popular in Akira Kurosawa's (1951) classic film. In this story, four different characters witnessed the same crime, yet their accounts are so different that one might think that they had each witnessed a different set of events! This is so, even though all of them are sincerely telling the "truth," from their perspective. The point that Rashomon makes very strongly, is that memory—and even perception—does not operate like a computer or video camera. Not only is information forgotten, but much of the information that is "supposedly

[9] Pansky et al. 2005.
[10] Tulving & Thomson 1973.
[11] Godden & Baddeley 1975.
[12] Koriat & Goldsmith 1996b.

remembered" may be distorted or confabulated, and is at the very least, inherently subjective. This subjectivity occurs in the initial perception of events, as well as in their later recollection.

Although difficult to reconcile with the storehouse metaphor, the Rashomon message fits quite well with an alternative view of memory, proposed by Sir Frederick Bartlett[13], in which memory is viewed as a much more active process, that initially constructs—and then later reconstructs—reality. Bartlett viewed memory as an active "effort after meaning," whose goal is to arrive at a coherent and organized representation of past events that are themselves inherently unorganized. In this view, reality is a complicated web of events and stimuli that must be understood and interpreted even as it is being perceived. The information that enters our minds is subjectively selected, adapted, and structured by our preexisting knowledge and expectations about the world—cognitive "schemas". Later, in remembering a particular event or episode, relevant schemas and related inference processes are again invoked to reconstruct a coherent description of the event. These constructive and reconstructive processes may be quite automatic, so that we are typically unaware of the role that such processes play in shaping our memories.

Under the reconstructive view, then, we do not need to be concerned only about information loss, but also, and perhaps primarily, about extraneous information and distortions that may be introduced in the process of constructing and reconstructing a representation of past events. For example, when told that "John entered a restaurant and ordered a hamburger," one might mistakenly remember being told that John *ate* the hamburger, though this was not explicitly stated. In this case, one's knowledge about what typically occurs when someone eats at a restaurant has activated a mental "restaurant script"[14], allowing one to fill in details that were not actually heard. Although this is arguably a generally adaptive function of cognitive scripts and schemas, in some cases the actual details will deviate from those that were inferred (e.g., after receiving an urgent phone call, John might have left the restaurant without eating his hamburger). Similarly, when research participants were asked to wait briefly in a university office, and later asked to remember what objects were present in that office[15], they tended to falsely recall the presence of "books," which would normally be found in such an office, though there were no books on the shelves in that particular office. Such errors may be seen to involve a confusion at the time of remembering between what one would expect to have occurred/been present, and what actually occurred/was present.

In addition to such schema-based intrusions, in which false details are added to the actual input, reconstructive memory processes may also yield memory

[13] Bartlett 1932.
[14] Schank & Abelson 1977.
[15] Brewer & Treyens 1981.

distortions in which the details of a remembered event are changed. Racial stereotypes, for example, are a particular—and unfortunate—type of cognitive schema. Thus, in one study, Boon and Davies[16] showed participants a slide show involving an argument between a black man and a white man on the London underground. In one version, the critical slide presented the white man holding a knife threateningly towards the black man. Yet, a significant number of participants falsely remembered the black man as the one holding the knife. In another version, in which the black man was in fact the one holding the knife, almost no one made the counter-stereotypical error, mistakenly remembering the white man as holding the knife.

The examples so far illustrate the influence on memory of specific, preexisting schemas or stereotypes. However, the information used in memory reconstruction can also be acquired or created dynamically, on the fly. One very prominent and influential body of work demonstrating various types of reconstructive influences on memory was pioneered by Elizabeth Loftus in her work on eyewitness memory[17]. This work has been particularly important in bringing to the fore the potential contaminating effects of information to which witnesses are exposed after the witnessed events, and in particular, information that might be transmitted—intentionally or unintentionally—in the questions themselves. Thus, for example, *leading questions* using a definite article (e.g., "Did you see *the* broken headlight?") or otherwise implying the existence of an object or detail that was not part of the original event, have been found to bias subjects toward falsely remembering these objects compared to a more neutral phrasing (e.g., Did you see *a* broken headlight?)[18]. In a classic study[19], participants viewed a film clip depicting an automobile accident and later answered a question that was phrased either "About how fast were the cars going when they *hit* each other?" or "About how fast were the cars going when they *smashed into* each other?" Participants receiving the latter wording of the question provided estimates that were, on average, about 20% faster than those provided by participants receiving the former wording. Apparently, the participants' memories of the witnessed event were influenced by inferences implied by the question's wording (hit or smashed). Moreover, when questioned again a week later, participants who had previously received the "smashed" question were twice as likely to falsely remember the presence of broken glass as were participants who had been given the "hit" wording.

These examples and many other studies like them, illustrate one prominent source of memory errors, which are the inferences that people make regarding what probably happened, which then become confused or integrated with remembered information about what actually happened. In fact, many memory

[16] Boon & Davies 1988.
[17] Loftus 1996.
[18] Loftus & Zanni 1975.
[19] Loftus & Palmer 1974.

errors involve misattributions regarding whether an event has actually taken place or was merely imagined or thought about[20]. For example, we may mistakenly remember having called the doctor to cancel an appointment, even though we only thought about doing so. Memory errors can also result from *source confusions* in which details of actual events that were experienced in one situation are wrongly attributed to another[21]. A dramatic example is an incident that ironically involved a well-known memory researcher, Donald Thompson, who was wrongly identified by a rape victim as the rapist[22]. Thompson'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 somehow confused his image with that of the rapist. Thus, failing to correctly attribute the source of a piece of information about an event can be just as harmful (or more so) as failing to recall the information itself. Often, fragments of real experience are accurately and vividly recalled, but are attributed to the wrong person, location or time, resulting in false memory.

Source confusions have been used to explain a wide variety of false-memory phenomena, including the effects of post-event information on eyewitness testimony, mentioned earlier. Studies indicate that misleading information that is presented to the person after the event has occurred (e.g., by deliberately referring to the actual "stop" sign as a "yield" sign) can distort the person's subsequent memory for details of the event (e.g., creating a tendency to remember having in fact seen a yield sign). One explanation of this phenomenon is that it involves source confusion: The post-event misinformation is reported instead of the original information because it is wrongly attributed to the original event. Similar confusions may underlie false memories of entire events that did not actually occur[23]. For example, people who are urged to repeatedly imagine fictional childhood events (e.g., getting lost in a shopping mall, riding in a hot-air balloon) subsequently tend to remember those events as real, and even provide additional details about them. Thus, under the right conditions, people may wrongly attribute an entire event that was only suggested to them, or only imagined by them, to reality, demonstrating extreme cases of faulty reality monitoring.

3. Metacognitive Monitoring and Control Processes

The preceding sections have indicated a variety of ways in which memory can go wrong. Not only is memory generally incomplete, more alarming is the fact that it can also be quite wrong. Indeed, the realization that people can "remember" and report false information defines a serious problem at a system

[20] Johnson & Raye 1981.
[21] Johnson, Hashtroudi & Lindsay 1993.
[22] Cited in Schacter 1996 p.114.
[23] Loftus 1997.

level, regarding how to treat the reported information. But first and foremost, it defines a problem at a personal level for individual rememberers: To what extent can people distinguish between what they know and what they don't know, and act accordingly? This question has received increasing attention in recent years, particularly in the study of *metacognition*[24]. In this context, metacognition—and more specifically, metamemory—refers to what individuals know about their own memory processes (referred to as *monitoring*), and how they put that knowledge to use in regulating their memory performance (referred to as *control*).

To illustrate the metacognitive monitoring and control processes used in regulating memory reporting, consider a courtroom witness who has sworn to tell "the whole truth and nothing but the truth." To fulfill that goal, the witness must monitor the information that comes to mind to distinguish between the information that he/she actually experienced and that which he/she might have inferred, imagined, or only heard about[25]. This monitoring is based on a variety of subjective cues. For example, actual memories of witnessed events tend to be more fluent, vivid and perceptually detailed than imagined events, and rememberers' source attributions and confidence levels are sensitive to these phenomenological qualities. In addition, when the demands for accuracy are strong, the person may recruit additional corroborative information that helps verify the source of the retrieved events in a more analytic manner. Studies show that false memories due to post-event misinformation, for example, can be reduced by inducing people to consider more stringently the source of the information that comes to mind. Such instructions are especially effective when distinctive contextual details are available that can help differentiate between different sources of remembered information. In general, a variety of metacognitive strategies and heuristics are used by rememberers in the attempt to screen out false memories[26].

Turning now to the "control" aspect, the ability to regulate one's memory reporting in order to avoid reporting wrong information that comes to mind seems to be an intrinsic aspect of memory in real-life situations. Two types of strategic control over memory reporting have been examined[27]. The first, *report option*, involves the decision of whether to report a remembered piece of information or to withhold it (e.g., 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 quantity of correct information (if people mistakenly screen out correct answers), yielding a *quantity-accuracy trade-off*. From this perspective, the oath to "tell the whole truth and nothing but

[24] Koriat 2007.
[25] Johnson et al. 1993.
[26] See Odegard & Lampien 2006; Pansky et al. 2005.
[27] Goldsmith & Koriat 2008.

the truth" sets an unrealistic goal for the witness: Generally, if one strives to tell the whole truth, one will not be able to tell nothing but the truth, and vice versa.

Importantly, however, both the accuracy benefits and the quantity costs that ensue from the option of free report depend on two factors[28]: (a) *monitoring effectiveness*—people's ability to identify the wrong information that comes to mind, and (b) *control policy*—the strictness or liberality of the confidence criterion that is set for volunteering answers. With regard to monitoring effectiveness, the more effective one is in differentiating correct from incorrect information, the higher the level of accuracy that can be achieved by selective reporting and the lower will be the quantity cost in terms of mistakenly withholding correct information. With regard to the control policy, remembers will generally set a confidence criterion that is sensitive to the competing demands for memory accuracy and memory quantity in a given situation. For example, a courtroom witness would probably set a relatively high criterion, giving priority to memory accuracy, whereas the same person at a social gathering might set a much lower criterion, giving priority to memory quantity (or other personal goals). Differences in monitoring effectiveness and in control policy have been shown to contribute to both situational and developmental differences in memory accuracy[29].

A second way in which rememberers enhance the 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[30]. For example, when asked to specify what time an event occurred, a rememberer who is unsure might provide a relatively coarse response such as "between 5:00 and 6:00 p.m." or "in the late afternoon," rather than venture a more precise response. In this regard, it has been observed that when people are asked open-ended questions and are not pressured to provide a detailed response, they tend to answer at a level of generality at which they are not likely to be wrong[31]. Of course, more coarsely grained answers, while more likely to be correct, are also less informative. Thus, the control of grain size in memory reporting is guided by an accuracy-informativeness trade-off similar to the accuracy-quantity trade-off that guides the exercise of report option[32]. People choose the grain size of their answers in a strategic manner, sacrificing informativeness (precision) for the sake of accuracy when confidence in the more precise-informative answer is low. They also take into account the relative payoffs for accuracy and informativeness in choosing the grain size of their answers, tending to provide more precise answers (thus taking a greater risk of being wrong) when the relative payoff for informativeness is high than when it is low.

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28 Koriat & Goldsmith 1996c.
29 Goldsmith & Koriat 2008.
30 Goldsmith, Koriat & Weinberg-Eliezer 2002.
31 Neisser 1988.
32 Goldsmith et al. 2002; see also Yaniv & Foster 1997.

Goldsmith, Koriat, & Pansky[33] examined the potential role of control over grain size in modulating the changes that occur in memory over time. Starting with the well-known finding that people often remember the gist of an event though they have forgotten its details, they asked whether rememberers might exploit the differential forgetting rates of coarse and precise information in regulating the accuracy of the information that they report over time. The results suggested that when given control over the grain size of their answers, people attempt to maintain a stable level of report accuracy by providing coarser answers at longer retention intervals.

The monitoring and control processes involved in the regulation of memory grain size appear to be similar to those underlying the decision to volunteer or withhold specific items of information[34]. In both cases, the likely accuracy of candidate answers is subjectively assessed and is expressed in terms of subjective confidence. Rememberers strive to provide the most precise answer whose assessed likelihood of being correct is sufficiently high (i.e., which satisfies a subjective confidence criterion). A minimum level of informativeness is also required, however. If no candidate answer is available that can simultaneously satisfy both the confidence and informativeness criteria, the answer will tend to be withheld entirely[35].

4. System-Level Memory Monitoring and Control Mechanisms

From a practical standpoint, the research referred to in the preceding section indicates that rememberers are not entirely defenseless against false memories, and that the first line of defense against the reporting of wrong information is the metacognitive monitoring and control exercised by individuals in regulating their own memory reporting. An additional implication which should be noted, is that typically, the information that people report from memory is that which has managed to pass a variety of self-invoked memory screening processes, and is therefore an "edited" version of a much larger set of information that was generated internally during the process of remembering. In some cases one may want to circumvent such editing, for example, when one is more concerned about maximizing the quantity of the information that is elicited than about its quality (e.g., when striving to generate "leads" in the initial stages of an investigation).

Another point that must be reemphasized is that the individual's monitoring and control processes are far from fool-proof. Indeed, it is rather ironic that the processes that people use to monitor the accuracy of their memories are heuristic and inferential, similar to the type of reconstructive inference and

[33] Goldsmith, Koriat & Pansky 2005.
[34] Goldsmith & Koriat 2008.
[35] Ackerman & Goldsmith 2008.

(mis-)attribution processes that create false memories in the first place. Thus, one of the most striking aspects of many false-memory phenomena is that they are subjectively compelling: Such memories are often very fluent, vivid, and consistent with associated context, such that they are held with high confidence, passing through the metacognitive editing mechanisms.

For this reason, a second line of defense is needed, at the system level. As mentioned earlier, the issue of false memory has received a great deal of attention in connection with the potential unreliability of eyewitness testimony, and the problem this poses for the legal system. Indeed, eyewitness testimony is a staple ingredient of virtually all criminal legal proceedings[36]. Yet, reliance on erroneous eyewitness testimony has been shown to be the most common cause of the false conviction of innocent people[37]. In fact, in a study initiated by the U.S. Department of Justice, DNA evidence was reexamined for cases in which defendants were convicted prior to the forensic use of DNA technology[38]. This DNA typing led to the exoneration of 172 people who were mistakenly convicted, 14 of whom were sentenced to death. Analyses of exoneration cases revealed that the majority of these innocent people were convicted on the basis of eyewitness testimony. However, because most crimes do not include DNA-rich biological traces, reliance on eyewitnesses for solving crimes has not been significantly diminished by the development of forensic DNA tests[39]. The issue of how to treat the problem of eyewitness memory at a system level remains.

One general approach has been to attempt to prevent false memory by manipulating key variables over which the legal system has control, sometimes called "system variables"[40]. The most important of these concern the methods used to elicit information from witnesses, in particular, witness questioning and suspect identification (lineup or parade) procedures. A great deal of progress has been made in this direction[41], with research findings making a substantial contribution to legal guidelines and practices in various countries across the world[42]. Thus, for example, significant benefits have been gained by structuring questioning interviews to avoid memory contamination stemming from leading questions and directed questioning of the type brought out in the research by Loftus and others, mentioned earlier. The "cognitive interview" (CI) developed by Fisher and Geiselman[43] is a particularly prominent method that incorporates such interview structuring and communication techniques, as well as additional memory enhancing mnemonics designed to increase the amount of accurate information obtained from witnesses.

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[36] Overbeck 2005.
[37] Huff, Rattner, & Sagarin 1996.
[38] Connors, Lundregan, Miller & McEwan 1996; Wells et al. 2000.
[39] Wells & Olson 2003.
[40] Deffenbacher 1991; Wells & Olson 2003.
[41] See, e.g., Fisher & Schreiber 2006; Memon, Vrij, & Bull 2003.
[42] See Wells et al., 2000.
[43] Fisher & Geiselman, 1992.

Notwithstanding such progress, there are a myriad of factors affecting the accuracy of eyewitness reports that are not under the control of the legal system. These include situational factors such as viewing conditions, the speed at which the events took place, the amount of time that has passed since the event, and attributes of the witness, such as age, gender, intelligence and emotional state at the time of the event[44]. Such variables are sometimes called "estimator variables," because although the system cannot control them, it can perhaps take them into account in deciding how much weight to give to the testimony of an eyewitness in a particular case[45].

Thus, in principle, a second approach to dealing with the problem of false memory is to develop system-based monitoring techniques that might identify, rather than prevent, false memories. Such techniques would be analogous to the well-known "lie detector" or polygraph methods, which have achieved a certain amount of success[46]. However, the goal here would be far more challenging—to assess the overall reliability (likely accuracy) of the memory of a witness who is attempting to testify truthfully, and to distinguish between reported statements that are more likely versus less likely to be correct[47]. In this regard, in addition to the types of estimator variables just mentioned, there has been some work based on *interpersonal reality monitoring*[48], in which phenomenal characteristics revealed by the content of the witness' memory report are extracted and coded by trained evaluators[49]. Several criteria have been found to be diagnostic of reporting real versus imagined events, particularly the presence of visual and auditory details, contextual information, time information and realism[50]. Nevertheless, the degree of success and the range of application (e.g., to individual statements rather than to an entire free-narrative report[51]) are still very limited. Given the tremendous potential benefits of progress in this direction, more innovative research is certainly called for. Recent advances in brain measurement and imaging technology may also open up new possibilities of distinguishing true and false memories based on neurophsyiological markers[52]. For an ongoing E.U. funded project attempting to develop and integrate several different methods, see EYEWITMEM FP6-043460 (http://nest.haifa.ac.il).

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44 Soraci et al. 2006.
45 Kassin, Tubb, Hosch & Memon 2001.
46 Granhag & Vrij 2005.
47 Davies 2001.
48 Johnson, Foley, Suengas, & Raye, 1998.
49 E.g., Barnier, Sharman, McKay & Sporer 2005; Strömwall, Bengtsson, Leander, & Granhag, 2004.
50 Masip, Sporer, Garrido & Herrero 2005.
51 Cf. Roberts & Higham 2002.
52 E.g., Abe et al. 2008; Chua et al. 2004; Gallo et al. 2006; Garroff-Eaton et al. 2007; Kim & Cabeza 2007.

Concluding Remarks: A Rational Look at Memory Accuracy and Error

The work on memory accuracy and error discussed in this chapter could leave a pessimistic impression about the general unfaithfulness of human memory, leading one to "question the wisdom of Mother Nature in building such a seemingly flawed system"[53]. But is human memory really as flawed as it seems? First, although some of the memory deficiencies may appear to reflect flaws in the system design, these may be by products of generally adaptive features of memory. For example, there are many situations in which gist memory provides a sufficient basis for one's current decisions and actions. There is often no need to get bogged down with memory of the precise details, and indeed, it would probably be counterproductive to do so[54]. Similarly, constructing the memory that "John ate a hamburger" after being told only that "John ordered a hamburger" would arguably be adaptive in most real-life situations, yet this would be considered an "intrusion error" in most memory experiments. Second, it should be noted that a great deal of the work on false memory appears to defy the principle of representative design advocated by Brunswik[55][56]. In order to shed light on the mechanisms that create false memories, researchers will often "stack the deck" by creating special situations in which memory and metamemory processes are most likely to be fooled[57]. From a "basic science" standpoint, this is a legitimate research strategy which is commonly used in studying perceptual as well as memory processes. However, it may lead to an overly dark impression of the general fallibility of human memory. The accuracy of free recall, for example, has been found to be quite high across many experiments, with typically 85% to 95% of the reported information being correct[58]. In fact, Fisher[59] reached the conclusion that "when uninfluenced by external pressure, most of the recollections that we bring to conscious awareness are accurate"[60].

Such considerations imply that the reliability or unreliability of human memory must be analyzed from a functional-ecological perspective. Clearly, human memory does not operate in a vacuum, and hence memory accuracy and error should be examined in light of the personal and social goals of particular rememberers in particular real-world contexts. Some authors have gone so far as to propose that memory be evaluated in terms of its personal subjective utility rather than simply in terms of its quantity and accuracy[61]. This should not be

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53 Schacter 1999 p. 196.
54 Cf. Grice's 1975, 'pragmatic principles of social communication'.
55 Brunswik 1955.
56 See also Gigerenzer, Hoffrage, & Kleinbolting 1991.
57 Koriat et al. 2000; Roediger 1995.
58 Fisher 1995; Koriat 1993; Koriat & Goldsmith 1994; 1996c.
59 Fisher 1995.
60 Fisher 1995 p. 741.
61 E.g., Neisser 1996; Winograd 1994.

taken to imply, however, that memory performance at the individual level can or should be described in terms of a rational economic model.

On the contrary—over the past several decades, the classical view of human behavior as adhering to the laws of probability theory and logic has been supplanted in experimental psychology by the notion of *bounded rationality,* broadly defined as a view of rationality that takes into account the organisms' adaptive goals, natural environments, and cognitive constraints[62]. Memory and metamemory processes, like other types of inference and decision processes, make use of "fast and frugal" heuristics that allow humans to achieve their goals under conditions of limited time, information, and computational capacity. Thus, with regard to forgetting, it may in fact be generally adaptive that the accessibility of old, seldom used information declines over time, thereby reducing interference to currently relevant information, even though the consequence of this is that some needed items of information will occasionally be unavailable[63]. With regard to false memory, the potential adaptive advantage of reconstructive inference and attribution processes responsible for some of the documented memory errors has already been mentioned. Moreover, some studies suggest that use of reconstructive processing may at least partly be under the control of the rememberer[64]. Hirt et al.[65], for example, found that people who were instructed to focus on comprehension while reading a textual passage later exhibited a substantial expectancy-driven bias in recall, whereas those who read the same passage under verbatim recall instructions did not. Furthermore, the degree of this difference increased with retention interval, supporting the view that reconstructive inference is particularly likely when the memory representation is weak[66]. Ross[67] concluded that "people can choose to engage in relatively effortless, theory-guided recall or a more effortful and extensive memory search"[68], and that this choice will depend, among other things, on how motivated people are to accurately reproduce the details. In line with this idea, a wide range of results in social cognition lead to a view of the perceiver/rememberer as "a motivational tactician, choosing among a number of possible strategies, depending on current goals"[69].

Metacognitive control processes also seem to involve bounded rationality. For example, in their study of the control of grain size in memory reporting mentioned earlier, Goldsmith et al.[70] found that people use a simple "satisficing"

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62 E.g., Chase, Hertwig and Gigerenzer 1998; Chater, & Oaksford 1999; Kahneman 2003; Simon 1956, 1990.
63 Anderson & Schooler 1991.
64 E.g., Reder 1987; Ross 1989; Winograd 1994.
65 Hirt et al.1995.
66 Brewer & Nakamura 1984.
67 Ross 1989.
68 Ross 1989 p. 355.
69 Fiske 1993 p. 172.
70 Goldsmith et al. 2002, 2005.

strategy[71] to choose the grain size (precision) of their answers, providing the most precise-informative answer that has a reasonably high likelihood of being correct, rather than undertaking a more optimal but cognitively demanding strategy that strives to maximize the expected subjective utility of each provided answer. Such heuristic shortcuts notwithstanding, adults and even 6-year old children have been shown to control their memory reporting in an effective manner, adjusting their report criterion and joint levels of memory accuracy and quantity performance in accordance with the relative incentives for accuracy versus informativeness[72]. Indeed, when allowed to do so, remembers can generally be counted on to utilize their metacognitive monitoring and control processes in a strategic, though not always completely optimal manner[73].

In sum, although individuals' memory and metamemory processes are certainly far from perfect, they may be quite appropriate for most of their daily needs. Nevertheless, from the perspective of systems and agencies who depend on human memory for critical information, it would be "rational" (prudent) to treat the veracity of such information with due caution, and to attempt to devise ways in which the rememberer's own monitoring and control processes can be improved and supplemented, to the extent that this is possible.

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[71] Simon 1956.

[72] Goldsmith et al. 2002, 2005; Koriat & Goldsmith 1996c; Koriat, Goldsmith, Schneider, & Nakash-Dura 2001.

[73] See also Higham 2007.

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Acknowledgment

The preparation of this chapter was supported by grant FP6-043460 from the European Commission within the 6th Framework Programme, New And Emerging Science And Technology (NEST).

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2008

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ISBN 978-90-5677-068-6