Chapter 13: Memory awareness in rhesus monkeys (*Macaca mulatta*)

Robert R. Hampton

Two Types of Memory

Human beings have at least two types of memories: explicit or declarative memories that are accompanied by conscious awareness and implicit memories that unconsciously influence behavior (e.g. Squire, Knowlton, & Musen, 1993; Squire & Zola-Morgan, 1991; Tulving & Schacter, 1990). The existence of these two types of memory has been demonstrated by both the independence of the two types of memory, as observed in behavioural studies, and by the dependence of explicit memory on the temporal lobe in humans. In humans, implicit memory is often inferred when subjects state that they do not remember target information, yet perform better than expected by chance when forced to guess. Such a pattern indicates that they do possess a memory of which they are unaware. Unfortunately for students of nonhuman cognition, the same procedures used with humans to discriminate between explicit and implicit memory have proven to be difficult or impossible to apply with non-verbal species.

A classic demonstration of the independence of implicit and explicit memory is that of skill learning by the patient H. M. Across repeated training episodes, H. M. will deny having practised a given skill before (and indeed will fail to recognize the test room, the experimenter and the apparatus). Yet, his performance improves at a rate that approximates that of a mentally intact human (Gabrieli, Corkin, Mickel, & Growdon, 1993). The cognition of H. M. is truly remarkable because, although he verbally denies remembering, his performance reveals that he has nonetheless retained information. Most studies of nonhumans provide no means comparable to human verbal behaviour through which subjects can deny or confirm the presence of knowledge independently from performance (Smith, Shields, & Washburn, 2003; Weiskrantz, 2001). Thus, behaviours ranging from birds finding hidden seeds to monkeys recognizing which of several objects they have recently seen readily
demonstrate that nonhumans do indeed have memories. However, it has proven more difficult to determine what types of memories nonhuman species possess and whether they are capable of being aware of their own memories.

Due to the difficulty in developing procedures to discriminate between implicit and explicit memory in nonhuman animals, tests of the existence or absence of both types of memory in nonhumans have been few in number. Consequently, while some authors have concluded that it is unlikely that nonhumans possess explicit memories (Tulving & Markowitsch, 1994), many others are resigned to an agnostic stance on the issue (e.g. Shettleworth, 1998). This chapter describes two recently developed behavioural techniques that aimed to provide direct tests for explicit memory in nonverbal species. It will be argued that making the distinction between implicit and explicit memory need not depend on language. Whereas verbal reports, such as ‘I remember’, ‘I forgot’ and ‘I am guessing’, provide a convenient window through which human explicit memory can be observed, explicit memory does not merely enable verbal reports of the subjective experiences accompanying memory. It plays a far more central role in behaviour and cognition. The focus on this role may be sharpened if we divert our attention away from the phenomenology or experience of explicit memory. One way to accomplish this is to examine the function of explicit memory and how this function results in the explicit memory phenotype via natural selection.Specifying the function of explicit memory permits the formulation of hypotheses pertaining to behavioural capacities that are uniquely available to animals with explicit memory. In brief, it is necessary to specify those abilities possessed by an animal with explicit memory, which are not possessed by one without it. Procedures can then be developed to detect these target abilities. Once such procedures are developed, they could also be applied to studies on humans, thereby enabling direct comparisons between humans and nonhumans.

The principal hypothesis of this chapter is that explicit memory facilitates the monitoring of the availability of knowledge, thereby permitting adaptive choices between behavioural options. Memory awareness enables discrimination between knowing and not knowing. Consider the simple act of making a phone call. Before calling a friend, humans typically try to consciously recall the phone number. We dial the number immediately after having successfully retrieved it. However, if we fail to recall the number, we would postpone making the phone call for fear of dialing the wrong number. In such a situation, most people would either avoid making the call altogether or would refer to a phonebook to retrieve the number. Without memory awareness, such adaptive decision making would not be possible. If the memory for the phone number were implicit, we would be unable to discriminate between knowing and not knowing the number, similar
to the manner in which H. M. is unable to discriminate between knowing and not knowing a particular skill.

This chapter provides some evidence suggesting that rhesus monkeys make decisions similar to those made in the example of a human making a phone call. In at least two situations, monkeys are able to choose between behavioural options based on the availability of knowledge. In the first situation, monkeys selectively avoid memory tests when they do not remember knowledge required to perform accurately. In the second one, monkeys act immediately when they possess the required information, but pause to seek more information when the required knowledge is lacking. In both these situations, monkeys appear to be capable of using memory awareness to judge their own knowledge states.

To Test or Not to Test: Can a Monkey Answer the Question?

Matching-to-sample procedures are frequently used to measure nonhuman memory. Each test trial begins with the presentation of a sample stimulus, such as a picture or an object, which the animal is required to remember across a delay interval, usually lasting from a few seconds to some minutes. At the end of the delay interval, subjects are presented with a group of stimuli, including the sample stimulus presented at the beginning of the trial. If the subject selects the sample stimulus at a rate that is higher than what would be expected from mere guessing, we infer that the subject has retained some memory of the sample stimulus over the delay period. Under these conditions, although it is clear that the animal has a memory, there are no grounds for inferring that the animal is aware of possessing the memory. It is possible that the performance of animals in matching-to-sample tests is controlled by implicit memory similar to the intact implicit memory in the patient H. M. In order to test for memory awareness, a modification of the matching-to-sample procedure is required. In contrast with the standard matching-to-sample procedure, wherein the animal has no choice but to take the memory test, in this modified procedure, the animal may profit by discriminating between trials on which it remembers the sample and trials on which it has forgotten it.

A schematic of a matching-to-sample procedure with an additional test for memory awareness is shown in Figure 1 (Hampton, 2001). At the beginning of each trial, the monkeys viewed a centrally located image on a touch-sensitive computer monitor (Figure 1, top panel). They touched the image, demonstrating that they had viewed it. The screen was then blank for a delay period. At the end of the delay period during initial training, the monkeys were immediately presented with four images, each occupying one of the four corners of the computer monitor (lower left panel). In order to receive a reward, the monkeys
Figure 1.
Test of memory awareness. Each coloured panel represents what monkeys saw on a touch-sensitive computer monitor at a given stage in a trial. At the start of each trial, subjects studied a randomly selected image. A delay period followed, during which monkeys often forgot the studied image. On two-thirds of the trials, the monkeys chose between taking a memory test (right panel, left hand stimulus) and declining the test (right panel, right hand stimulus). On one-third of the trials, the monkeys were forced to take the test (left panel). Better accuracy on chosen memory tests than on forced tests indicates that monkeys know when they remember and decline tests when they have forgotten, if given the option.

had to touch the image that was identical to the one viewed at the beginning of the trial. Before proceeding to the critical test sessions, the task was made difficult by increasing the delay period to a point at which the monkeys often made mistakes. Thus, on some trials they remembered the sample, while on others, they had forgotten it.
In order to test for memory awareness, the monkeys were given the choice between taking the memory test and receiving a favoured reward for correct responses (but nothing for incorrect responses) or declining the test and receiving a less desirable, but guaranteed reward (middle panels). This choice phase occurred at the end of the delay on each trial, but before the monkey saw the test array. Faced with these contingencies, a monkey could maximize reward by choosing to take the memory tests only when memory for the studied image was good, and avoiding the memory test (settling for the lesser, but guaranteed reward) when memory was relatively poor.

Two monkeys (Shepard and Gagarin) were tested on matching-to-sample with four new images used each day. On each trial, one of the four images was randomly selected to serve as the sample for that trial; the other three images served as distracters, yielding a chance rate of 25%. Initially, the monkeys were given only the primary matching task, without the secondary choice phase in which they could decline memory tests. The delay over which the monkeys were required to remember the sample on each trial was gradually increased until they made errors on approximately 35% of trials. Under these conditions, it was certain that the monkeys would experience a substantial number of trials on which they forgot the identity of the sample. Shepard was tested after a delay of 34 s and Gagarin after a delay of 38 s.

The choice phase stimuli were then incorporated into the testing. At the end of the delay period on each trial, one of two stimulus arrays was presented. On one-third of the trials, the array consisted of the stimulus associated with taking the memory test. On these forced-test trials, monkeys were required to touch this stimulus in order to proceed to the memory test. During the test, correct responses were rewarded with highly desirable peanuts, while a distinctively coloured error screen and no reward followed incorrect choices. These trials were therefore almost identical to the normal matching-to-sample trials, except that the monkeys had to touch the stimulus associated with the tests before proceeding to the test. On the remaining two-thirds of the trials, the monkeys were given a choice between taking the test and declining it. If they selected the stimulus associated with taking the memory test, the trial proceeded as described earlier. If they selected the stimulus associated with avoiding the memory test, a final response screen was displayed. After they touched the image on this screen, which was unrelated to the other test images and was presented in a location not used for other images, the monkeys were rewarded with less desirable primate pellets.

If monkeys can accurately assess whether or not they remember the studied image, they should choose to take the test when they remember and avoid the test on trials in which the studied image is forgotten. Reliable discrimination
between trials on which memory was good and those on which memory was poor should result in more accurate performance on trials the monkeys chose to take as compared to those they were forced to take. Both monkeys were more accurate on chosen rather than forced memory tests (Figure 2; paired t-tests: Shepard, $t = 3.91, p < .01$; Gagarin, $t = 4.51, p < .01$). However, accuracy on these tests does not directly reflect the accuracy expected on trials in which the monkeys declined the memory test. Memory was not tested on trials after the monkeys had chosen to decline the test, although this might provide a direct measure of memory, for the following reasons. First, any reasonably large number of probe tests in which the monkeys were forced to take a memory test although they had declined to do so would undermine the contingencies of the experiment. It is by virtue of these contingencies that the monkeys learnt the significance of taking and declining the memory tests. Second, the monkeys expect a small, reliable reward after declining the test. If they were forced to take the test instead, they would most likely be surprised and possibly frustrated by the unexpected change. Surprise or frustration could disrupt performance and impair accuracy thereby providing a plausible alternative explanation for a decrement in performance on such trials. Therefore, it is preferable to rely on a less direct measure.

Fortunately, the data required to infer the expected accuracy on trials in which the monkey apparently forgot and thus declined the test are available. Accuracy on forced tests is a weighted average of accuracy on tests that the
subjects would have declined when given the choice, and tests that they would have freely chosen to take irrespective of other factors. The expected accuracy on declined trials is substantially lower than this weighted average. Accuracy on freely chosen tests is known, as is the proportion of tests taken and declined on free choice trials; thus, the expected accuracy on trials in which the monkeys declined the memory test can be determined. Using the proportions of tests that the monkeys declined when given the opportunity (Shepard, 0.51; Gagarin, 0.36) and the accuracies shown in Figure 2, the expected accuracies on the trials monkeys declined were determined to be 58.1% and 46.8%, as compared with 85% and 87% on chosen trials, respectively. The accuracy of memory on trials declined by the monkeys is therefore substantially lower than it is on other trials, and monkeys experience a substantial increase in reward rate by avoiding these tests.

**Competing Explanations**

The relevance of these findings to memory awareness depends on the determination of the discriminative stimulus used by monkeys to guide their choice to take or decline tests on other trials. The working hypothesis is that awareness of the memory serves as the discriminative stimulus. In order to evaluate this hypothesis, it is critical to determine whether there is some discriminative stimulus other than the absence of memory per se that controls the choice to decline memory tests. There are many such candidate alternatives. Events that might occur during the delay interval, such as noises, bouts of grooming or changes in motivation, could possibly distract the monkeys or disturb their memory processes, thereby resulting in forgetting. These events themselves could therefore cue monkeys to decline tests and yield a false impression that the monkeys attended to their own memory states. To eliminate the possibility that monkeys' decisions to decline tests were controlled by such external cues, monkeys were presented with infrequent, randomly distributed probe trials. These unpredictable probe trials were identical in every way to normal trials, except for the fact that no image was presented for study during the sample phase of the trial. When the absence of memory was experimentally controlled in this manner, an a priori prediction of which tests that the monkeys would decline was possible. After an inter-trial interval and a delay period equivalent to that in normal trials, animals were given the choice of declining or taking a memory test, just as they would on normal trials. If the absence of memory leads the monkeys to decline tests, they should decline tests on these no-sample probe trials, considering them to be like trials on which they have forgotten the studied image. If, however, the decision to decline tests is
controlled by some environmental or behavioural event, the subjects should decline normal and probe trials with equal probability because such events are evenly distributed among the randomly intermixed normal trials and the no-sample probe trials. In six test sessions with no-sample probe trials, both monkeys were far more likely to decline tests if no image was presented for study than they were on normal trials (Figure 3; Shepard: $t_s = 24.34, p < .01$; Gagarin: $t_s = 10.19, p < .01$). Shepard declined the memory test on 49% of the normal trials and on 100% of the probe trials where no sample was presented. Gagarin declined 18% of the normal trials and 63% of the probe trials. These results, following the experimental manipulation of memory, provide compelling support for the hypothesis that the choice to decline tests was based on the absence of memory per se, and not any external event that was correlated with forgetting.

Nonetheless, monkeys could have gradually learnt to make the decision to decline tests on the basis of some distinguishing feature of probe trials rather than on the absence of a memory per se. The first session of probe trials was therefore analyzed separately. Both the monkeys declined probe tests from the first session of testing (Figure 3, inset values in bar graphs; Shepard: $\chi^2(1, N$

![Figure 3.](image)

_Probability of declining tests on normal trials and on probe trials without the opportunity to study an image. Dark bars indicate the proportion of normal trials on which monkeys declined tests; the cross-hatched bars represent this proportion on probe trials. Error bars are standard errors. Inset in each bar is the percentage of each test type declined only in the first session of testing. These results indicate that it is the absence of memory that causes the monkeys to decline tests. If some other factor than the absence of memory per se, such as distracting noises, variation in motivation or fatigue, controlled the decision to decline tests, normal and probe trials would be affected equally._
\( \chi^2(1, N = 69) = 7.88, p < .01 \), indicating that learning did not occur after the onset of probe trials. Additionally, Shepard declined every probe trial presented, and could never have learnt the negative consequences of choosing a memory test on such trials. Therefore, the high probability with which the monkeys declined the no-sample probe trials reflects spontaneous generalization on the part of the monkeys from the trials on which the sample was forgotten to these probes trials (i.e. the monkeys considered the two trials as being equivalent). Another candidate alternative explanation is that monkeys might have used delay or a correlate of delay as a cue to decline tests. In these experiments, the computer controlled when the monkey could first respond, but after this point, the monkey could respond at any time. On some trials, the monkeys may complete the choice phase promptly, and at other times, they may do so slowly. Performance deteriorates as the delay before the memory test increases. Therefore, theoretically, it is possible that the monkeys produced the observed pattern of results by choosing to take the memory test when they completed the choice phase promptly and choosing to avoid the test when this phase was completed slowly. Indeed, the monkeys responded a little more quickly when choosing to take the test than they did when choosing to decline the test (Shepard mean difference = 0.29 s, \( t_s = 2.09, p < .10 \); Gagarin mean difference = 0.46 s, \( t_g = 3.7, p < .01 \)). However, these differences in response times of Shepard and Gagarin are only a fraction of a second and are added to mean delays of approximately 36 and 40 s respectively. Such small differences in delay intervals cannot explain the difference in performance between freely chosen and forced memory tests. Instead, it is more likely that this small difference in latency to complete the choice phase is reflective of a slightly longer decision process preceding the decision to avoid the memory test. Apparently, when the monkeys were confident of remembering, they quickly and confidently decided to take the test. However, when they were less certain, they took slightly longer to arrive at a decision. This difference may reflect a memory search conducted when the monkeys were choosing to take or decline the memory test. On trials in which a memorized item is recalled, the search was terminated and the monkeys chose to take the test. On trials in which the sample was forgotten, the search continued for a while without a memory being located. Eventually, the memory search was terminated and the monkey declined the test. Longer latencies are associated with a failure to find the item in memory (Briggs & Blaha, 1969; see Van Zandt & Townsend, 1993, for a review).

An important feature of this procedure is that it requires a prospective judgement of memory, that is, the monkeys had to decide whether to take or decline the memory test before being presented with the test. A prospective judgment addresses two issues. First, since the test stimuli are absent when the
judgement is made, the choice to decline tests cannot be based on familiarity or perceptual fluency of the correct test image (Verfaellie & Cermak, 1999; Wagner & Gabrieli, 1998). Second, a prospective judgment also precludes a decision to decline tests based on direct experience with the difficulty of a given test. Previous studies using pigeons as subjects indicated that the distinction between prospective and concurrent memory judgement can be critical (Inman & Shettleworth, 1999; Sutton & Shettleworth [personal communication, February 12, 2003]). Pigeons offered the option of declining tests concurrently with the presentation of the test display behaved as if they were aware when they remembered the sample. However, when these same birds were required to judge memory prior to the presentation of the memory test, they were unable to discriminate trials on which they remembered from those on which they had forgotten the sample.

**Looking Before Leaping: A Second Test of Memory Awareness**

The example of the human behaviour (recalling a phone number) described in the introduction was modelled using another method (Hampton, Zivin, & Murray, 2004). This experiment was based on a recent study conducted with human children and apes (Call & Carpenter, 2001). Monkeys were presented with four opaque tubes, one of which contained a hidden food reward (Figure 4, right panel) and were given the opportunity to select one. On *seen* trials, the monkeys saw the food placed in one of the tubes just before they were given the opportunity to choose a tube. On *unseen* trials the food was hidden while the tubes were out of the monkeys’ sight. Thus, on seen trials, the monkeys knew the location of the reward and on unseen trials, they did not possess this knowledge. The monkeys were fortunate that the opaque tubes were aligned such that they could, with some effort, look down the length of the tubes and determine the location of the food reward even if they had not witnessed where the reward was placed (Figure 4, left panel). It was hypothesized that monkeys with memory awareness would be able to detect whether or not they knew the location of the food reward on each trial and would behave differently depending on the presence or absence of that knowledge. Specifically, monkeys would make the extra effort to look down the tubes when they were unaware of the location of the rewards, but they would not waste the effort required to do so when they were already aware of its location (Figure 4).

Rhesus monkeys were tested using a specially constructed apparatus consisting of four tubes that were affixed to the tray using hinges. Pulling on a given tube caused that tube to tip upwards and a food reward, if present, to tumble out of the end nearest to the monkey (see Figure 4). Pulling any tube
triggered a latching mechanism that prevented additional choices on the same trial. The tray could be placed at one of five levels, the lowest position being aligned with the bottom of the monkeys’ cage and the highest position being aligned with the eye level of the monkeys when they were sitting normally in the transport cage. A clear screen and an opaque screen could be raised and lowered, either separately or together, between the monkey and the test tray. These screens prevented the monkey from reaching the tubes. Only the clear screen allowed visual access, whereas the opaque screen completely blocked the monkey’s view of the experimenter and the test tray. On unseen trials, the bait was placed in a tube while the opaque screen blocked the monkey’s view. On seen trials, only the clear screen stood between the monkey and the tubes, and the monkey could observe the food being placed in the tube. A closed-circuit video system permitted the experimenter to score the monkeys’ behaviour by watching the monitor rather than by looking directly at the monkeys.

Before beginning the main experiment, the monkeys were familiarized with the functions of the apparatus, for example that pulling a tube caused the contents of the tube to drop out of the end. All phases of familiarization were conducted so as to prevent monkeys from learning a relationship between the position of the opaque screen or other external stimuli to the need to look before choosing (see Hampton et al., 2004 for details).
In the main experiment, the monkeys were presented with a mixture of seen and unseen trials using the opaque tubes. These constituted critical trials since, for the first time, each monkey would now have the opportunity to engage in or refrain from engaging in looking behaviour, depending on the situation. The height of the test tray differed across these sessions. Since looking behaviour depended on the balance of costs (i.e. the effort of looking down the tube combined with the delay of the reward) versus benefits (i.e. the greater probability of obtaining a reward when the location was known versus when it was unknown) and because these differed among monkeys, a titration procedure was used to determine the appropriate tray height for each monkey. The titration procedure prevented ceiling and floor effects from masking differential looking behaviour on seen and unseen trials. In the first session, the test tray was placed in the middle position, which was aligned with the midpoint (between eye level and the floor of the transport cage). Half the trials were seen and the others were unseen, and these trials were presented in pseudorandom order. If the subject looked down the tubes on fewer than 6 of the 24 experimental trials, the tray was raised one position for the next session. If the subject looked down the tubes on more than 18 of these trials, the tray was lowered one position. Raising the tray made it easier to look down the tubes, whereas lowering the tray required more effort on the part of the monkeys. Test sessions continued until each monkey completed two consecutive sessions with 6 to 18 looks or two consecutive sessions with the tray at the lowest position.

All the monkeys looked down the tubes on at least some seen and some unseen trials (Figure 5). Seven of the 9 monkeys looked significantly more often on unseen trials than on seen ones. In contrast, none of the monkeys looked significantly more often on seen trials than on unseen ones (Figure 5). The two monkeys (F and G), whose looking behaviour was unaffected by trial type exhibited different patterns of behaviour. Monkey F looked on every trial except for one seen trial, even at the lowest tray position. On the whole, Monkey G looked much less often than did the other monkeys.

On seen trials, the monkeys chose accurately, but not perfectly (Table 1). On unseen trials, their choices were significantly more accurate when they looked through the tubes before choosing (84%) than on trials in which they failed to look (22%; Table 1; \( t_r = 11.26, p < .01 \); Monkey S was excluded because she looked on every unseen trial, precluding an estimation of accuracy on trials without a look). Performance on unseen trials without looks did not differ from chance (\( t_r = 0.951 \); Monkey S excluded). On combining seen and unseen trials, the monkeys were observed to choose accurately on 97% of the trials in which they looked down the tube containing the reward (Table 1).
Figure 5.
The proportion of looks made by each of the 9 monkeys on seen (solid black bars) and unseen (cross-hatched bars) trials. These proportions result from dividing the number of looks by the number of completed trials in the seen and unseen conditions for each monkey. Seven of the 9 monkeys were significantly more likely to look on unseen trials than on seen trials. Capital letters identify the 9 rhesus monkeys that were studied.

These results extend the study by Call and Carpenter (2001), who trained chimpanzees, orangutans and 2.5-year-old children to select the opaque tube that contained a reward under conditions similar to those just described. All three species were more likely to look down the length of the tubes and search for the reward when they had not witnessed the placement of the reward than on trials in which they had observed the placement of the reward. Apes and human children discriminated between trials in which they knew the location of the reward and trials in which they did not possess that knowledge, and they collected more information on the location of the reward when required. Humans, apes and rhesus monkeys apparently demonstrate a form of metacognition, namely, memory awareness, which is the ability to discriminate between knowing and not knowing. However, it is important to note that in these experiments, subjects made memory judgements in the presence of the test stimuli and not before the test was presented, as in the case of the experiments described earlier in this chapter (Hampton, 2001). Prospective confidence judgements may provide stronger evidence for memory awareness (Hampton, 2003).
Table 1. Strategic Use of Looking

<table>
<thead>
<tr>
<th>Monkey</th>
<th>K</th>
<th>C</th>
<th>S</th>
<th>G</th>
<th>F</th>
<th>B</th>
<th>R</th>
<th>H</th>
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<td>0.31</td>
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<td>1st look to reward on seen trials</td>
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<tr>
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<tr>
<td>Without look</td>
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Note. Capital letters indicate the individual rhesus monkeys studied. Chi-square values are from analysis of contingency tables, classifying the number of trials with and without a look into seen and unseen conditions. Aborted trials are those trials on which the monkey never selected a tube. The next row represents the probability that the monkeys' first look was down the tube containing the bait, if they looked at all, on seen trials. Accuracy on seen trials represents the averages of all seen trials on which the monkeys made a choice, irrespective of whether they looked or not. Accuracy on unseen trials displays accuracy as a function of whether or not the monkey had looked down any tubes before making a choice. The dash indicates that there were no unseen trials without a look for that particular monkey. Accuracy after seeing the reward represents the probability that monkeys chose correctly after they had looked down the tube containing the reward on either trial type.

Memory Awareness: Not Exclusively a Human Trait?

Considered collectively, these findings indicate that rhesus monkeys know when they know. In the first set of experiments, rhesus monkeys were observed to discriminate between the presence and absence of memory. This enabled the monkeys to make appropriate choices, that is, to choose to take memory tests when memory for the studied image was strong and to decline when memory was weak, thus increasing the total number of rewards received in a session. The monkeys' ability to generalize performance to the no-sample probe trials eliminates many simpler explanations for this behaviour, such as the discrimination being based on some external event rather than on attention to the presence or absence of memory per se. It appears that monkeys are aware of at least some of their memories.
These studies suggest that humans and apes are not alone in being aware of their memories. Instead, it appears that this ability is shared by at least some Old World monkeys. Tests using serial probe recognition provide additional support for the existence of memory awareness in monkeys. Two rhesus macaques selectively bailed out of trials involving middle-list items, for which memory is relatively poor (Smith, Shields, & Washburn, 1998). Like the monkeys in Hampton’s (2001) study, these monkeys selectively avoided taking tests when memory was poor.

The presence of memory awareness in both apes (Call & Carpenter, 2001) and Old World monkeys (Hampton, 2001; Hampton et al., 2004; Smith, et al., 1998) suggests that this cognitive capacity may have first evolved in a common ancestor of apes and Old World monkeys (Riley & Langley, 1993). Apes and monkeys last shared a common ancestor approximately 20 to 25 million years ago (Tomasello & Call, 1997, p. 15). If memory awareness is shown to be present in New World monkeys (capuchins or marmosets for example) or in prosimians (such as lemurs), it would suggest an earlier date for the appearance of memory awareness.

There do not exist any strong a priori grounds for presuming that memory awareness is limited to primates. However, the strength of the evidence for memory awareness in primates contrasts with the failure to find evidence for memory awareness in pigeons (Columba livia; Inman & Shettleworth, 1999; Sutton & Shettleworth [personal communication February 12, 2003]) using techniques similar to those that Hampton (2001) used with monkeys.

Finally, it should be noted that memory awareness is a limited type of self-awareness. It would be most useful to approach the broader problem of self-awareness incrementally, by focusing on the identification of specific elemental capacities that either reflect awareness or serve as precursors of awareness (Parker, 1998; Purdy & Donjan, 1998; Smith et al., 2003). The work described in this chapter represents such an approach. Since memory awareness represents just one aspect of the broader phenomenon of self-awareness, the present results do not necessarily conflict with those obtained from using a classic test of self-awareness, namely, the mirror test. While there is disagreement about what exactly the mirror test indicates about self-awareness (Gallup, 1994; Heyes, 1994), it is striking that no monkeys pass the test, while all great apes with the possible exception of gorillas (Gorilla gorilla) pass it (Gallup, 1994; Shillito, Gallup, & Beck, 1999). This difference suggests an abrupt discontinuity in cognitive capacities between monkeys and apes. The current tests for memory awareness and the mirror test may measure different elements in a suite of capacities collectively described as self-awareness.
Other Minds

The 'problem of other minds' refers to the difficulty in establishing empirical grounds for the inference of consciousness in other animals, including other human beings. What evidence can constitute the basis for the inference of memory awareness? A definition of memory awareness that centres on verbal reports of subjective experience precludes the experimental demonstration of memory awareness in nonhumans. However, the need for reference to private experience in order to distinguish among types of memory may be overstated. An alternative is to define memory awareness in strictly functional terms, as we have done here. In this chapter, memory awareness is defined as a cognitive process that permits an organism to discriminate between knowing and not knowing. Such a definition allows specification of the overt behaviour that would indicate when such a discrimination is being made. Far from eroding the essential meaning of awareness, a functional definition that focuses on what memory awareness accomplishes, rather than how it is experienced subjectively, may best capture the significance of this phenomenon.

Summary

Humans have at least two types of memories: implicit memories, of which we are unaware, and explicit memories, which are brought to conscious awareness. Humans can use memory awareness to determine whether relevant knowledge is available before acting, such as when we determine whether we know a phone number before dialing. Such metacognition, or thinking about thinking, can improve the selection of appropriate behaviour. Until recently, few studies had been conducted to test whether this ability exists in species other than humans. This chapter describes experiments that support the hypothesis that rhesus macaque monkeys are capable of at least some forms of memory awareness. Monkeys avoid memory tests when they do not know the correct response and seek more information when necessary knowledge is lacking. These findings suggest that the cognitive capacity for memory awareness may be widely distributed among primates.

References


Acknowledgments

The experimental work conducted by the author was supported by the National Institute of Mental Health Intramural Research Program. The preparation of this manuscript was supported by the Japan Society for the Promotion of Science and the Kyoto University Primate Research Institute while the author was in residence as a visiting researcher. Support was also provided by the Yerkes National Primate Research Center Base Grant RR00165 and by the Center for Behavioral Neuroscience STC Program of the National Science Foundation under Agreement No. IBN-9876754. In particular, I would like to thank Dr. Kazuo Fujita and Dr. Shoji Itakura for inviting me to Japan and initiating what I hope will continue to be a series of exciting and interesting collaborations with colleagues in Japan. Editorial assistance was provided by Heather Kirby.