Seminar: Cognitive and Behavioral Neuroscience Seminar (603)

Meeting Date: January 24, 2002

Chairs: Herbert S. Terrace, Yaakov Stern

Speaker: Dr. Diane Reiss (Wildlife Conservation Society's Osborn Laboratories of Marine Sciences, New York Aquarium),

Topic: "Reflections on Mirror Self-Recognition in the Bottlenose Dolphin: A Case of Cognitive Convergence"

Abstract: Only humans and great apes have previously shown the capacity for mirror self-recognition (MSR). We tested whether two dolphins would use mirrors to investigate marked parts of their bodies. Both demonstrated responses consistent with MSR providing definitive evidence that this ability is not specific to large-brained primates and may be to more general characteristics such as a high degree of encephalization and cognitive ability. This represents a striking case of cognitive convergence.

Participants:
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Dr. Reiss defined Mirror Self-Recognition (MSR) as the ability to recognize oneself in a mirror. In order for self-recognition to occur, three things are required: 1) Selective attention -- an animal must be able to pay attention to the information in the mirror. Most animals don't do this; 2) Interpretation -- they have to be able to interpret the information such that they are able to determine the mirror image is self and not another animal; 3) Motivation -- The animal must be motivated to look in the mirror and to use it as a tool to view itself.

Dr. Reiss pointed out that MSR demonstrates one level of self-awareness that occurs along a continuum of possibilities. All animals must have some degree of self-awareness in order to distinguish parts of themselves from portions of the environment, and MSR probes one level along this continuum. Previously, MSR has been confined to humans and the great apes (common chimpanzees, bonobos, orangutans and gorillas). Although great apes show MSR, there appear to be differences in terms of the quality of this process: Gorillas react in a much more slow and subtle way than do chimpanzees, which suggests that one needs to take these species-specific differences into consideration when examining and defining self-directed behavior.

Although great apes (with the exception of gibbons) tend to show MSR, neither new world monkeys nor old world monkeys show MSR. Elephants and African Gray Parrots can use a mirror to guide their behavior (to obtain a food reward), but neither seems to show any sort of self-recognition when presented with a mirror. Why do great apes show MSR, but other species do not? One explanation may be that this level of self-awareness is an outgrowth resulting from highly complex social organizations in these species. Great apes also share an evolutionary history which may explain why other species do not show this ability.

The process of MSR tends to occur in three discrete stages: when a naïve animal is put in front of a mirror, the animal tends to produce a social response (as if it is encountering a conspecific). The second stage is called the "contingency testing" stage. During this stage, the animal engages in some type of behavior which seems to be a method of examining the "behavior" of the mirror image in response to its own movements. The final stage is called the "self-directed behavior" stage in which the animal appears to orient its body in such a way that it can see portions of its body that are normally visually inaccessible. Once the animal demonstrates this final stage, the mark test is introduced. The procedures for chimpanzees (for the mark test) include anesthetizing the animal, placing a mark on an area where the animal cannot see, and then observing whether the animal examines the marked area in the mirror.

Dr. Reiss argued that even though bottle-nosed dolphins have a completely different evolutionary history relative to the great apes; they have many social characteristics in common with them. For example, bottle-nosed dolphins have similar fusion/fission societies relative to chimpanzees and they have long-lasting bonds which can last for life. Bottle-nosed dolphins live in large groups divided into smaller subgroups that are primarily composed of age and gender related animals (a maternal group, a juvenile group etc.). Dolphins are also the only non-human animal that learns how to produce its vocalizations (humans, birds, and dolphins).

Bottle-nosed dolphins also share many cognitive abilities with apes -- They have sophisticated auditory/visual processing and memory systems that are similar to those of chimpanzees. They are capable of understanding symbolic codes such as gestures. They have the ability to learn associations between symbols, sounds, and objects without direct intervention or specific reinforcement. They are capable of classifying relationships between events in very sophisticated ways.

Dolpins have large and complex brains, but they are quite different from primate brains. This makes the dolphin an interesting subject for this kind of research because many have argued that it is the primate brain itself (frontal lobe structures) that is responsible for MSR capabilities. The dolphin brain is also second only to humans in terms of its encephalization quotient.

Because dolphins do not have hands per se, the marking procedure commonly used with chimpanzees had to be modified for dolphins. However, all other aspects of the procedure were maintained as closely as possible to those employed with chimpanzees. Baseline observations were made where dolphins were exposed to mirrors. Following this, dolphins were either given a "sham" procedure in which they were marked with water filled markers (no ink) or they were given the experimental procedure in which they were marked with non-toxic ink. The subjects were two male dolphins (aged 13 and 17 years), and they were marked in an area that they were unable to physically see without the use of the mirror.

In the first phase of the experiment, the dolphin pool had reflective surfaces of varying quality, and it was found that the dolphins would generally swim to the best reflective surface to view themselves after being marked. Similarly, when the best reflective surface was removed, the dolphins tended to go to the next best reflective surface. During the second phase of the experiment, there was only one reflective surface and it was located in an adjacent pool to the one where the dolphins were marked. The mirror could be oriented (or flipped) so that a non-reflective surface would be shown. The hypothesis being that dolphins would head directly for the reflective surface following the marking procedure. This hypothesis was confirmed.

Prior to initiating both studies, there were three criterion in place that needed to be satisfied in order to reach a valid conclusion that dolphins were engaging in MSR. First, the dolphins should not have shown any social responses toward the reflective surface. Second, the dolphin should have spent more time in front of the mirror when marked than

during any other condition. Third, dolphins should have shown shorter latencies to go to the mirror when marked than when simply handled (with no marking or sham marking), and that the first behavior at the mirror should have been one that exposed the marked part of the body to viewing (they had to do this within 10 seconds of being exposed to the mirror). All predictions and requirements were met in order to reach the conclusion that dolphins were showing MSR.

Dr. Reiss raised the question about the meaning of dolphin MSR performance given that dolphins represent the first non-primate species to demonstrate MSR. First, it suggests that MSR doesn't result from the unique dynamics of primate social interactions. Secondly, the dolphins' performance can't be the result of shared evolutionary history given that the most recent shared ancestor was approximately 95 million years ago. Third, given the differences between dolphin and primate neural organization within the brain, the MSR performance of the dolphins suggest that a primate-organized brain is not required for MSR. This therefore seems to be a case of cognitive convergence.

Dr. Reiss then proceeded to show a video clip of several different species in an MSR task.
Monkeys (in the video) do not show contingency testing when they are presented with a mirror, but rather treat the reflected image as a conspecific. Chimpanzees on the other hand, initially react as if they are encountering a conspecific, but after a period of time, chimpanzees enter a contingency testing phase. All animals that show mirror recognition also show a contingency testing phase. For several minutes, Dr. Reiss showed video of marked dolphins engaging in what appeared to be searching behavior in front of the mirror (in order to locate the mark).

Questions:

Question: It is possible that some species that fail to show MSR may lack the motivational component rather than the ability.

Dr. Reiss: I agree.

Herb Terrace: If one were to place a mark on a monkey (or dolphin) where it was plainly visible, would they attend much to the mark? If so, does this represent a different level in the self-concept relative to mirror recognition?

Dr. Reiss: I think that attending to the mark, or even scratching an itch represents some level of self-awareness.

Herb Terrace: What about scratching an itch in your sleep?

Dr. Reiss: There may even be some level of self-awareness in that case as well. Self-awareness is a continuum.

Herb Terrace: Why don't people train monkeys to work with mirrors?

Dr. Reiss: They have…

Participant: I have met with limited success training mirror-oriented responses. The effect was ephemeral, but it was real. However, when using the MSR task to assess abilities, it is important to keep in mind that this is but one very specific task that appears more or less readily in some species, but absence of evidence cannot serve as evidence for absence. It may be that this particular skill is not terribly relevant to the species-specific repertoire of any particular species.

Dr. Reiss: I am not sure why this is particularly ecologically relevant for a dolphin either though. It may be that this ability is an emergent property of a large brain capable of processing and integrating large amounts of information and may have very little to do with ecology.

Herb Terrace: I think it would be interesting to see if monkeys are capable of using information from a mirror as part of a problem solving process.

Participant #2: You don't have to train them, they do it spontaneously. This makes it all the more perplexing why they do not show any sort of mirror self-recognition.

Participant #3: Given that chimpanzees show social responses when initially presented with the mirror, why did you predict that dolphins wouldn't? You actually made this a requirement for defining MSR in dolphins.

Dr. Reiss: During our previous study, the dolphins did initially show socially directed behaviors, but the dolphins do not necessarily have to show social behavior prior to MSR. These dolphins had prior exposure to mirrors, and so we didn't expect them to show socially-directed behavior.

Participant #4: Is it possible that the dolphin was able to see the mark without the use of a mirror?

Dr. Reiss: Dolphins have very good peripheral and downward vision, but they cannot see upward very well. So, they shouldn't be able to see where we marked them.