Quick guide

Dolphin cognition

Lori Marino

What is a dolphin? When you think of a dolphin you probably picture a bottlenose dolphin, *Tursiops truncatus*, the familiar star of oceanaria. But bottlenose dolphins are only one among sixty-seven living species in the fully aquatic mammalian order Cetacea and the diverse suborder Odontoceti ('toothed whales'). In addition to possessing adult teeth, the many types of toothed whale are distinguished from their baleen-bearing relatives, the suborder Mysticeti, by the use of echolocation to perceive their environment. One of the misconceptions about dolphins that held sway until studies in the 1980s and 90s was that they are auditory specialists with poor vision. But we now know that — with the exception of the nearly blind river dolphins — bottlenose dolphins and other toothed whales are highly multimodal animals, easily integrating information about their environment from audition and vision, and probably also other senses such as touch.

Dolphins are brainiacs. Dolphin brains are organized differently from human brains, but the highly convoluted brains of many dolphins and other odontocetes are also significantly larger than the human brain. The average human brain weighs about 1.3 kg, but the bottlenose dolphin brain, averaging 1.7 kg, is about 25% heavier. Furthermore, the largest brain in the animal kingdom, at a hefty 7.8 kg, is possessed by yet another odontocete — the sperm whale. The larger brains of dolphins and whales might be due to their larger bodies. So, a more meaningful measure is to compare actual brain size with that expected for the species' body size. This metric is known as encephalization quotient (EQ): brains with EQs larger than 1 are larger than the expected size, while those with EQs less than 1 are smaller than the expected size. Modern humans have the highest EQ: about 7, so our brains are about 7 times the size one would expect for an animal of our body size. But many dolphins possess EQs in the 4–5 range, tantalizingly close to the modern human level, and significantly higher than all other animals. Like humans, dolphins are, without a doubt, brainiacs of the animal kingdom.

What is dolphin cognition? The word 'cognition' comes from the Latin root 'cognoscere' meaning 'to come to know' and refers to all the mental activities associated with thinking, knowing and remembering. So dolphin cognition refers to how dolphins think, know, and remember. The overwhelming majority of experimental research on dolphin cognition has been based on the adaptable, highly social bottlenose dolphin, with a smaller subset of studies on the killer whale, the beluga whale and a tiny proportion of other odontocete species. These studies demonstrate that the dolphin's high EQ is matched by its sharp cognitive abilities.

Our cognitive cousins. The eminent dolphin researcher Louis Herman coined the term 'cognitive cousins' to refer to the fact that bottlenose dolphin cognition appears to be at a level also typical of great apes and humans. This similarity may be surprising, as primates and dolphins are only very distantly related. But the two groups share other characteristics indicative of complex intelligence and cognitive ability, especially high encephalization levels, long juvenile periods and complicated social lives.

Controlled experimental studies on bottlenose dolphin cognition have been carried out in the domains of memory, conceptual processes, vocal and motor mimicry, behavioral innovation, 'language' understanding, mental representation and self-awareness. Not surprisingly, bottlenose dolphins have exceptional short-term and long-term memory for visual, auditory and multimodal information, as well as abstract concepts.

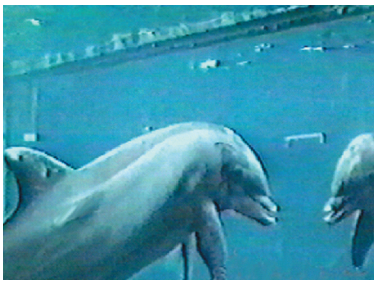

Figure 1. A bottlenose dolphin examining a mark on his head in a mirror.

Bottlenose dolphins exhibit a level of behavioral flexibility, innovation and imitative-ability that is rare, if not unique, among nonhuman animals. This means that dolphins are able to mentally represent and form analogies between their own body and that of another individual — even improvising when that other individual doesn't look much like a dolphin! These propensities of dolphins undoubtedly contribute much to the human passion for interacting with them.

The bottlenose dolphin is one of a very limited group of nonhuman species — great apes and parrots are the others — that have demonstrated compelling capacities to understand a rule-based symbolic artificial 'language'. Louis Herman and his colleagues have shown that dolphins are capable of semantics (comprehending visual and auditory symbols as 'words') and syntax (understanding that changes in word order change the meaning of a sentence). Dolphins even understand symbolic references to objects that are absent. Out of sight — not out of mind!

Finally, one of the most intriguing domains of research on dolphin cognition is that of self-awareness. Self-awareness is the ability to comprehend and think about oneself in the physical and mental realms. Although relatively unstudied, the few experiments in this realm show that dolphins have capabilities that are exceedingly rare in the animal kingdom. Bottlenose dolphins have been shown to be aware of their own behaviors and body parts and their own levels of subjective uncertainty during a difficult memory test. In

2001, my colleague Diana Reiss and I reported conclusive evidence that — along with only great apes and humans — bottlenose dolphins are capable of recognizing themselves in a mirror and using a mirror to investigate their own bodies (Figure 1). This intriguing line of research awaits much more extensive exploration.

The dolphin mystique.

Throughout the ages, an enduring mystique has developed around dolphins. Even today some people continue to impute dolphins with mystical abilities such as extra-sensory perception and, in alternative medicine circles, special healing powers. An entire industry in 'dolphin-assisted therapy' has been founded on the idea that dolphins have the capacity to heal illnesses through the use of their sonar or by touch. There is no scientific support for any of these outlandish claims. But our appreciation of dolphins does not need to depend on their having supernatural powers. What we know about dolphin cognition from scientific research is immensely more exciting than any myths could be. Scientific research continues to add to our factual understanding of dolphins as highly intelligent, complex and communicative animals that are very different but intriguingly similar to ourselves.

Where do I find out more?

Herman, L.M. (2002). Exploring the cognitive world of the bottlenose dolphin. In: The Cognitive Animal, M. Bekoff, C. Allen, and G.M. Burghardt, ed. (Cambridge, Mass.: MIT Press), pp 275–283.

Marino, L. (2002). Convergence of complex cognitive abilities in cetaceans and primates. Brain Behav. Evol. *59*, 21–32.

Reiss, D., and Marino, L. (2001). Mirror self-recognition in the bottlenose dolphin: A case of cognitive convergence. Proc. Natl. Acad. Sci. USA *98*, 5937–5942.

Schusterman, R.J., Thomas, J.A., and Wood, F.G. (1986). Dolphin Cognition and Behavior: A Comparative Approach. (Hillsdale, N.J.: Lawrence Erlbaum Assoc).

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Branch support

While trees can often seem dwarfed in significance by their surrounding human artefacts, in more rural areas they can acquire much more local prominence and, because of a lack of development, some can be of significant historical, cultural or ecological interest.

A new book, published last month, highlights many trees of outstanding significance in Britain ranging from the original Bramley apple tree in a private village garden in Nottinghamshire, the chestnut tree planted by David Razzio as a mark of his love for Mary Queen of Scots to the apple tree that is thought to have prompted Isaac Newton's work on gravity.

But the book has another purpose: to back the Tree Council's campaign for the preservation and maintenance of the country's 'green monuments' — the name they give to the trees linked with significant events in history. At present the protection of valued trees is divided between different government departments but all too often they have no protection at all. The fate of rural trees largely lies with landowners who increasingly may not have the resources to maintain heritage trees. "Astonishingly, many such trees are unprotected by law and could be felled tomorrow without contravening any regulations," says Pauline Buchanan Black, Director-General of the Tree Council.

The Tree Council's green monument campaign therefore aims to raise funds to help landowners to identify heritage trees and also to provide fencing and signage to protect them. They also wish to be able to provide the best information for landowners on maintaining them.

As Britain is one of the European countries with the lowest level of tree cover, protection of some key specimens linked to the country's cultural and scientific history can only help further woodland interests.

Fruitful insights: a falling apple from this tree is credited with triggering Isaac Newton's s thinking about gravity. (Photo: The Heritage Trees of Britain and Northern Ireland, published by Constable and Robinson, London.)