

an insight to THE DOLPHIN MIND

intelligence and cognitive skills

UAB
Universitat Autònoma
de Barcelona
Rita Rodríguez Ribas
Environmental Biology

AIMS&OBJECTIVES

The **aim** was to envision **how much dolphins do understand about themselves, others and their surroundings**, as well as considering the suitability of the term "intelligence" as a descriptor for animal cognition.

The **overall objective** was to **review and collect** the strongest data on dolphin (**bottlenose dolphin** *Tursiops truncatus*; Montagu, 1821) **behavior, cognition and neuroanatomy**. Understanding of neuroanatomical underpinnings and assessing behavioral responses to cognitive tests, leads to a posterior discussion on the how unique/human-like is dolphin cognition.

BRAIN STRUCTURE & EQ

- Spherical; the telencephalic hemisphere is rotated rostral and ventralward.
- Auditory field with hypertrophic auditory structures due to echolocation.
 - Adjacent to visual field = integration of acoustic and visual inputs.
- Olfactory components are reduced.
- Increased cerebral cortex + extremely folded neocortex. (Huggenberger, 2008)



- **Neurons**
 - Density (13.000 - 4.4200/mm³)
 - ~ Sizes similar to other social species
 - Total n° in the neocortex (5.800x10⁶)
 - ↑ N° synapses - similar to humans (0.87x10¹⁴ vs. 1.3x10¹⁴) (Oelschläger and Oelschläger, 2002)

- **Encephalization quotient (EQ):** difference in mass of a brain (relative to body mass) to the expected value for its body mass (Jerison, 1985).

bottlenose dolphin EQ = 4 - 5 ... Why is their brain 4 to 5 times larger than expected for their body mass?



Σ Social complexity hypothesis
Evolution of echolocation
Absence of pelvic girdle
Neutral drift

Emotions

Dolphins, and many other animals, possess **core emotions** (e.g. fear, lust) because they are produced in ancient parts of the brain and are an evolutionary advantage. Anecdotal evidence states dolphins show **empathy**, a **complex emotion**, that may rely on:

- genetic causes (social insects)
- complex cognition: self and others + theory of mind (i.e. ability to attribute feelings and beliefs to others).

>> It has not been further tested, but regardless, it is more parsimonious to state that dolphins rely on **complex cognition** for empathic behavior production (De Waal, 2008).

COGNITIVE SKILLS

Body-awareness

Knowing that one has a body that is separate from other objects, by unconscious proprioception (**body schema**) + conscious perception (**body image**) (Gallagher, 2009).

>> dolphins show conscious awareness of their body by recognizing and using body parts (including those they cannot see, i.e. melon) in novel situations.

BODY PART (transfer test): objects + 9 body parts + 4 actions (Herman et al., 2001)

Agency and ownership

Feeling that one controls one's actions (agency) and that one's body is undergoing an action (ownership; Gallagher, 2000).

>> dolphins show they can store and access mental representations of past events by constructing behaviors to be same / different from a previous one, by feeling agency and ownership of self and others.

Imitation and SELF-IMITATION (transfer tests):

repeat / don't repeat | create | repeat / any (Herman, 2011)

Self recognition

Ability to identify oneself in a mirror and match one's own body plan with the reflection.

>> dolphins and other social species (chimps, elephants, birds) can recognize themselves in a mirror. MSR is an evolutionary convergence. May it be a step to self awareness / consciousness / sense of self?

MIRROR SELF RECOGNITION Test (MSR):

"Δ" non olfactory mark on subject body
social behavior / explorative behavior (Reiss and Marino, 2001).

Symbol comprehension

Understanding semantic and syntactic features of an artificial trained language. Symbols are arbitrary representations of abstract (e.g. less/fewer) or concrete (e.g. ball, speaker) concepts, bearing no resemblance with reality.

>> dolphins can form abstract - real linkages, understand properties of, classify concepts (semantics) and extract meaning from word order (syntax), by succeeding in novel sequences and extracting feasible subsets (repair) from anomalous strings or rejecting to perform, selectively.
> rich mental representations useful for planning and problem solving..

MULTI-ITEM sequence (transfer tests):
(object 1) + location + object 2 + action
(location) + object 1 ⊕ (location) + object 2 + action
(Herman et al., 1984)

ANOMALOUS sequences (transfer test)
✗ object 1: movable element
✗ object 2: stationary element
Reject entire sequence - Repair anomalies
(Herman et al., 1993)

Self and sociality

Dolphins are **cosmopolitan** species with **natal philopatry**. Field studies in a dolphin community in Shark Bay Australia (Connor, 2007) show they live in complex social structures shaped by a **fission-fusion pattern**, where males, are related by **multi-level alliances** that may last for minutes or years + Individuals create and possess unique vocalizations called "**signature whistles**" they use similar to **human names**.

>> dolphins evolved large brains for complex cognition to hold emerging sociality and having a unique whistle supports they have a sense of self and others.

DISCUSSION&TAKE-HOME MESSAGE

The study of dolphin cognition has some **limitations**:

- *Tursiops truncatus* - show species + few and repeated subjects
- Associative learning ≠ true learning
- Tests need to bear species ecological + evolutionary requirements
- Human-like intelligence approach
- Lack of evidence from other taxa and scientific consensus on a framework.

Overall, our understanding on animals' minds is poor, they remain being a black box.

Dolphins are **as skilled as other animals** (rats, birds, octopuses, etc) in terms of consciousness, symbol use, imitation, social learning, etc (Gregg, 2013).
No evidence for human-like cognition in dolphins.

But, they possess a **flexible mind** to manipulate new information (Herman, 2010). **Uniqueness** relies on their **combination of skills** only comparable to primates and corvids, which shows they have **behavioral plasticity** in detriment of innate behaviors, and that alone is an **evolutionary adaptation** (Cantor and Whitehead, 2013).

1. Cantor, M. and Whitehead, H. (2013). The interplay between social networks and culture: theoretically and among whales and dolphins. *Phil Trans R Soc B* 368: 20120340.
2. Connor, R.C. (2007). Dolphin social intelligence: complex alliance relationships in bottlenose dolphins and a consideration of selective environments for extreme brain size evolution in mammals. *Philosophical Transactions of the Royal Society B* 362, 587-602.
3. De Waal, F.C.M. (2008). Putting the altruism back into altruism: the evolution of empathy. *Annual Review of Psychology* 59 (May 2007): 279-300.
4. Gallagher, S. (2000). Philosophical conceptions of the self: implications for cognitive science. *Trends in Cognitive Sciences* 4, 13-21.
5. Gregg, J. (2013). Are dolphins really smart? The mammal behind the myth. Oxford University Press.
6. Herman, L.M. (2010). What laboratory research has told us about dolphin cognition. *International Journal of Comparative Psychology* 23, 310-330.
7. Herman, L.M. (2011). Body and self in dolphins. *Consciousness and Cognition*, 21 (1), 520-545.

8. Herman, L.M., Kuczaj, S.A., Holder, M.D. (1993). Responses to anomalous gestural sequences by a language-trained dolphin: Evidence for processing of semantic relations and syntactic information. *Journal of Experimental Psychology: General* 122, 188-194.
9. Herman, L.M., Matas, D.S., Herman, E.Y., Jacobs, M., Pack, A.A. (2001). The bottlenose dolphin's (*Tursiops truncatus*) understanding of gestures as symbolic representations of its body parts. *Learning & Behavior* 29, 250-264.
10. Herman, L.M., Richards, D.G., and Wolt, J.F. (1984). Comprehension of sentences by the bottlenose dolphin. *Cognition*, 16, 129-215.
11. Huggenberger, S. (2008). The size and complexity of dolphin brains - a paradox? *Journal of the Marine Biological Association of the United Kingdom* 88 (6), 1103-1108.
12. Oelschläger, H.A. and Oelschläger, L.S. (2002). Brain. In Perrin W.F. et al. (eds) *Encyclopedia of marine mammals*. San Diego: Academic Press, pp. 133-158.
13. Reiss, D., and Marino, L. (2001). Mirror self-recognition in the bottlenose dolphin: A case of cognitive convergence. *Proceedings of the National Academy of Sciences*, 98, 5937-5942.