# The roots of intelligence: What the study of whales and dolphins can reveal about the basis of human intelligence

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The study of the origins and development of human cognitive abilities is a fascinating and vitally important field of research. The results of an investigation recently published in the journal *Nature, Ecology & Evolution* ("The social and cultural roots of whale and dolphin brains," Fox, Muthukrishna, and Shultz, November 2017) seeks to elucidate the basis for intelligence in another advanced group of mammals—cetaceans, which encompasses whales and dolphins—and to assess the implications regarding humans.

It has long been theorized that advanced intelligence in primates, especially humans, is based on their complex social structures. This is known as the social brain hypothesis (SBH), and suggests that a dialectical interaction between members of a social group is required to enable each individual to "model" in their own minds the anticipated behaviors of other group members, including the consequences of their own actions, thereby acting and reacting in a potentially appropriate manner. This is called "theory of mind."

Obviously, as the numbers of individuals in a group increases, the complexity of the dialectic expands exponentially. When the effects of individual and group behaviors on the external environment are also factored into the equation, each individual's mental model must become increasingly sophisticated in order for the group as a whole to survive. Failure to do so would represent a severe selective disadvantage.

Cetaceans and humans both have exceptionally large and anatomically sophisticated brains as well as complex behaviors, including cultural transmission of knowledge and hierarchical social organizations. Anatomically, cetaceans have the largest nervous system of any animal group. The possible correlation between social behavior and neurological development was the focus of the study by Fox and colleagues.

Many cetaceans exhibit behaviors that have analogs among humans. "Cetaceans show overwhelming evidence for sophisticated social and prosocial behaviour (including complex alliance relationships; social transfer of hunting techniques; cooperative hunting; complex vocalizations including regional group dialects, vocal mimicry, and 'signature whistles' unique to individuals; interspecific cooperation with humans and other species; alloparenting [i.e. shared parenting]; and social play)…" This makes them highly suitable for conducting comparative studies with humans.

The researchers "compiled a comprehensive dataset for body mass, brain mass, group size and social organization characteristics" for 90 species. They then conducted a number of comparisons, such as relationship between group size and brain size, controlling for body size, and evaluated correlations between body size, brain size, and indices of sociality.

The results included the finding of a strong correlation between social categories and brain size: "Cetaceans found in mid-sized social groups had the largest brains (in both absolute and relative terms), followed by those that form large communities (mega-pods); those predominantly found alone or in small groups had the smallest brains." The authors suggest that this indicates a relationship between social cognition and brain size.

Through further analysis, they defined a "social repertoire" based on "the presence of within-group alliances, caregiving or alloparenting, interspecific cooperation, group hunting, social defence, social play, social learning and complex vocalizations for each species." This led to the conclusion that "the relationship between social structure and brain size is partly driven by increasing social-behavioral flexibility: a diverse repertoire of social behaviors pays the greatest dividends when all individuals are recognizable to one another and interact regularly." It is not merely group size, but the quality of social interactions that correlate with brain size. These are similar to behaviors likely to have occurred in early hominin groups.

The study also found that "species with larger relative brain size had richer diets" and tentatively suggest that "large-brained cetaceans are more ecologically flexible." The diversification of early hominin diets, by the exploitation of a greater variety of food resources, especially the increased proportion of meat (including fat) obtained by hunting, is strongly thought to have provided the nutritional support necessary for brain enlargement that was a key part of human evolution.

The authors observe that, aside from anthropoid primates (humans, apes, and monkeys), these correlations found in cetaceans have been identified in no other mammalian groups.

They conclude that "our results are consistent with theoretical models that predict how culture, behavioral richness and cognition are intertwined and can create a positive feedback loop or ratchet: larger brains can support a larger social repertoire and a larger repertoire can support a greater carrying capacity, potentially offering learners greater opportunity and variety for learning. A large social repertoire combined with sufficiently high-fidelity transmission between conspecifics [i.e., the passing down of cultural information] could have triggered the emergence of the cumulative culture characteristic of the past few million years of human evolution."

Based on our current understanding, when early hominins (humans and their evolutionary predecessors after the split with their common ancestor with chimpanzees) were forced from forested environments onto the open savannah of Africa, they were anatomically ill-prepared to cope with this new ecological setting. However, hominins had two principal resources. First, they had already relatively developed cognitive abilities, based on the complex social interactions of their forest-dwelling ancestors. Second was their increasing ability to manipulate objects with their hands, due to an existing trend toward bipedalism, which reduced their reliance on upper limbs for locomotion, as indicated by the early hominin fossil *Ardipithicus ramidus*.

The dialectic between these two pre-existing characteristics, coupled with the intense selective pressure imposed by life in a new and harsh environment, led to hominins following a novel evolutionary trajectory—reliance on increasingly sophisticated technology and the concomitant development of abstract, symbolic thought and language.

Cetaceans have the first, but not the second. Their ability to physically manipulate and modify their environment is highly limited. Therefore, whereas humans employed their pre-existing theory of mind to create cognitive models of the "behavior" of the external world, with which they were in constant, dialectical interaction (i.e., making and using tools), the possibility of such a path for cetaceans was effectively blocked due to their pre-existing adaptation to marine life.

The sophisticated social interactions and interdependencies among early hominins are likely to have been key to the cultural development of technology and, consequently, their survival and unique evolutionary development.