Solving the mammal brain size puzzle

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A new study has revealed a surprising lack of support for widely-held explanations of why some mammals evolve larger brains than expected for their body size.

The research, co-led by Flinders University's Dr. Vera Weisbecker, argues that scientific understanding of mammalian brain size evolution may be seriously impeded by the impact of high brain growth costs.

"Humans have huge brains relative to their body size, and are highly intelligent compared to other mammals." says Dr. Weisbecker.

"However, there have been conflicting answers to the question of what behaviors and cognitive capabilities indicate "intelligence" and how these relate to the evolution of mammalian brain size in general."

The team homed in on the fact that large brains require a lot of energy to grow.

Orlin S.Todorov, a University of Queensland Ph.D. student who led the study published in *Proceedings of the Royal Society B*, says many behaviors associated with large brain size—for example, parental care—are also related to reproduction, and raising of offspring.

"There has long been a suspicion that these associations might only reflect the diverse ways that mammals cover the costs of feeding their offspring's brain growth."

To get a clearer view of the issue, the team studied brain size evolution in relation to fourteen behavioral, ecological, life-history and physiological traits in a group of mammals with very little diversity in reproduction—marsupials. They include Australian and South American possums, opossums, kangaroos, wombats, and Tasmanian devils.

"Marsupial newborns are all tiny—at most the size of a jellybean—and receive a very similar type of milk from their mothers. Compare this to placental mammal newborns, which are helpless like kittens, or can be feeding by themselves within a few days, like guinea pigs.

This makes marsupials far less confusing in studies of behavior and brain size," Dr. Weisbecker said.

As expected, the team found no evidence that any of the traits tested among marsupials were associated with larger brain sizes.

"This is an exciting indication that we need to pay a lot of attention to the costs of large brains. Unfortunately, it also means that we still have a long way to go in understanding what causes the evolution of larger brains in mammals," said Mr Todorov.

Tellingly, marsupial species with larger litters tended to have smaller brain sizes, Dr. Weisbecker said. "This is a well-known effect—if a mother has to feed more young, there will be less energy to go around for everyone's brain. So again, it seems to be all about cost."

The team are highly confident of their results. Aside from collating the largest dataset of marsupial brain sizes to date, Mr Todorov used a new, sophisticated pipeline including a technique that produces highly realistic estimates of missing values. "This allowed us to analyze complete datasets with all species represented, which was previously not possible."

The team stress that their results do not invalidate other studies on mammalian brain size evolution.

"It is possible, in fact likely, that traits associated with brain size increases sit on both sides of the equation—they can be complex behaviourally and related to offspring nutrition at the same time," Dr. Weisbecker said.

"The challenge will be to understand which is which. In addition, we need to be honest about how little we know about the relationship between brain size and intelligence—to date, there is no real way of confirming that relatively large brains are in all cases smarter."

More information: Orlin S. Todorov et al. Testing hypotheses of marsupial brain size variation using phylogenetic multiple imputations and a Bayesian comparative framework, *Proceedings of the Royal Society B: Biological Sciences* (2021). DOI: 10.1098/rspb.2021.0394

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