Brain Size Takes an Evolutionary Backseat to Body Size

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Brain Size Takes an Evolutionary Backseat to Body Size

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Among a mammal's body parts, the brain stands out in size as well as in function. The metabolically expensive brain doesn't double with a doubling of body size, as do most other organs, but remains somewhat smaller. When a mammal like us ends up with a brain much larger than scaling rules would predict, the explanation usually involves selection for intelligence, or *neuronal capacity*.

But there is more than one evolutionary way to get a large brain, a phylogenetic analysis shows, and more often than not, it has to do with relatively greater changes in body size rather than in brain size. "It is clear that comparative correlations involving relative brain size cannot be interpreted as selection on neuronal capacity alone," Jeroen B. Smaers and his coauthors wrote in *The Proceedings of the National Academy of Sciences* last year (doi:10.1073/pnas.121218110). "Relative brain size is the compromise of two traits taking potentially different evolutionary pathways involving different combinations of brain–body adaptations."

Smaers, an evolutionary biologist, and his colleagues at University College London, in collaboration with Kamran Safi's computational ecology laboratory at the Max Planck Institute for Ornithology in Radolfzell, Germany, compared the brain–body size relationship in three groups of mammals. They began by acquiring body mass and brain mass measurements for 297 bat species, 169 primate species, and 187 carnivoran species, from published literature as well as museum specimens. When possible, they included measurements from fossil species. Then they pieced together the evolutionary relationships for each group, drawing on published phylogenies.

With the family trees in hand, they evaluated the rate of change of the brain–body size relationship between an ancestor and its descendent, in a method that Safi describes as "thinking around three corners." "You have to think about how differences in the rates of change can result in changes in relative brain size," he says. An increase in relative brain size, for example, can result when brain size increases faster than body size or when it decreases slower than body size.

For the human lineage, the analysis showed, relative brain size did increase at a rate faster than body size, in keeping with the view that natural selection favored hominins with more processing capability. But for other primates, relative body size was more important, according to the analysis. Gorillas, for example, experienced an increase in both brain and body size but more so in body size.

The same pattern held for carnivorans. "Body size [is] quite clearly the target of selection in three times as many carnivorans as brain size is," says mammalian paleobiologist and coauthor Anjali Goswami. In the case of aquatic carnivorans, such as the car-sized elephant seal, which has a brain a bit smaller than our own, seven times as many species showed higher rates of evolution for body size than for brain size. Male elephant seals bellow and battle for access to females in a breeding colony—a lifestyle in which brawn serves better than brains.

The diverse and numerous bat lineages also experienced faster change in body size than in brain size but in the opposite direction. With their abilities to fly and to echolocate, bats illustrate the evolutionary trade-offs that affect the brain–body size relationship. Like airline passengers who travel light to avoid baggage charges, bats have jettisoned whatever might cost them in their ability to take flight, but many have also retained the brain power that allows them to echolocate or to sniff out food. The result is that they've "undergone shrinkage," says Safi. "The brain stays large… but the body size gets smaller."

Whether brain size or body size plays the larger evolutionary role seems to be related to the way that an animal gets around, the researchers suggest—on the wing for bats, in trees for most primates, or on the ground for carnivorans. That the human lineage stands out from other primates in its outsized brain and outsized role of the brain in evolution may be related to the distinctive way humans move compared with other primates. Bipedalism allowed our ancestors to move out of the trees and onto the savanna.

The group's analysis enlarges understanding of brain size evolution beyond the usual focus on primates (and thus on ourselves). "The principal contribution of our approach is [in] showing the big patterns of brain and body size evolution across millions of years of evolution across different groups of animals," says Smaers.

The analysis also goes beyond examining encephalization on its own, by including changes in body size relative to brain size, says Robbie Burger, who is writing a dissertation on the evolutionary ecology of brain size as part of Jim Brown's research group at the University of New Mexico. "It's a significant contribution, one of the first that addresses the issue of how natural selection balances the energetic costs and benefits of more than one trait," he says.

Although the connection between brain size and intelligence remains unresolved, adds Brown, "The message is [that] it looks like there have been a number of routes to being relatively large brained, and it suggests that [many] explanations of intelligence are too simplified."

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