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2014 : WHAT SCIENTIFIC IDEA IS READY FOR RETIREMENT?

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The Bigger An Animal's Brain, The Greater Its Intelligence

The bigger an animal's brain, the greater its intelligence. You may think the connection is obvious. Just look at the evolutionary lineage of human beings: humans have bigger brains—and are cleverer—than chimpanzees, and chimpanzees have bigger brains—and are cleverer—than monkeys. Or, as an analogy, look at the history of computing machines in the 20th century. The bigger the machines, the greater their number-crunching powers. In the 1970's the new computer at my university department took up a whole room.

From the phrenology of the 19th century, to the brain-scan sciences of the 21st, it has indeed been widely assumed that brain volume determines cognitive capacity. In particular, you'll find the idea repeated in every modern textbook that the brain size of different primate species is causally related to their social intelligence. I admit I'm partly responsible for this, having championed the idea back in the 1970's. Yet, for a good many years now, I've had a hunch that the idea is wrong.

There are too many awkward facts that don't fit in. For a start, we know that modern humans can be born with only two thirds the normal volume of brain tissue, and show next to no cognitive deficit as adults. We know that, during normal human brain development, the brain actually shrinks as cognitive performance improves (a notable example being changes in the "social brain" during adolescence, where the cortical grey matter decreases in volume by about 15% between age 10 and 20). And most surprising of all, we know that there are nonhuman animals, such as honey bees or parrots, that can emulate many feats of human intelligence with brains that are only a millionth (bee) or a thousandth (parrot) the size of a human's.

The key, of course, is *programming*: What really matters to cognitive performance is not so much the brain's hardware as its onboard software. And smarter software certainly does not require a bigger hardware base (in fact, as the shrinkage of the cortex during adolescence shows, it may actually require a smaller—tidier—one). It's true that programs to deliver superior performance may require a lot of *designing*, either by natural selection or learning. But the fact is that, once they've been invented, they will likely make less demands on hardware than the older versions. To take the special case of social

intelligence, I'd say it's quite possible that the algorithm for solving "theory of mind" problems could be written on the back of a postcard and could be implemented on an iPhone. In which case, the widely touted suggestion that the human brain had to double in size for humans to be capable of "second-order mind-reading", makes little sense.

Then why *did* the human brain double in size? Why is it much bigger than you might think it needs to be, to underpin our level of intelligence? There's no question that big brains are costly to build and maintain. So, if we are to retire the "obvious theory", what can we put in its place? The answer I'd suggest lies in the advantage of having a large amount of *cognitive reserve*. Big brains have spare capacity that can be called on if and when working-parts get damaged or wear out. From adulthood onwards humans—like other mammals—begin to lose a significant amount of brain tissue to accidents, haemorrhages and degeneration. But because humans can draw on this extra reserve, the loss doesn't have to show. This means humans can retain their mental powers into relative old age, long after their smaller brained ancestors would have become incapacitated. (And as a matter of fact the unfortunate individual born with an unusually small brain is much more likely to succumb to senile dementia in his forties).

True, many of us die for other reasons with unused brain power to spare. But some of us live considerably longer than we might have done if our brains were half the size. So, what evolutionary advantage does *longevity* bring, even the post-reproductive longevity typical of humans? The answer surely is that humans can benefit—as no other species could do—from the presence of mentally-sound grandparents and great-grandparents, whose role in caretaking and teaching has been key to the success of human culture.

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