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COMMENTARY

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The social brain hypothesis – thirty years on

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The social brain hypothesis, and its use to predict a natural grouping size for humans (Dunbar's Number), was established empirically thirty years ago (Dunbar 1992, 1993, 1998). Over the decades since, we have established that: (1) there exists an extremely robust statistical relationship between the typical size of a species' social group and the size of its neocortex, derivative of selection for specialised cognition required for group-living in primates, ungulates, carnivores, bats, cetaceans, and birds (Pérez-Barbería et al. 2007; Shultz and Dunbar 2007, 2010a, 2010b, 2022; Dunbar and Shultz 2017, 2021; Fox et al. 2017), (2) this relationship actually consists of a set of four grades arranged in a fractal series that explains the multilevel structure of primate (and human) social systems (Zhou et al. 2005; Hill et al. 2008; Sutcliffe et al. 2012; Dunbar and Shultz 2021), (3) the grades differ in group size, brain size, social complexity, cognitive competences, and ecological context (Dunbar and Shultz 2021; Dunbar 2024), (4) the core group size of ~150 for modern humans predicted by the regression equation for the social brain relationship (Dunbar and Shultz 2023) has been confirmed by 23 studies of personal social networks and ethnographic communities (median sample size 5457 individuals, largest sample 61 million) from a wide range of cultures and historical periods over the last 2000 years (Dunbar 2020), (5) this grouping is nested within a fractal series of network layers (a Dunbar Graph) with very specific values (1.5, 5, 15, 50, 150, 500, 1500, 5000) that we find in the face-to-face world (Bird et al. 2019; Dunbar 2020; Wang et al. 2020), on digital social media (telephone calling, texting, Facebook and twitter) (Arnaboldi et al. 2015; Dunbar et al. 2015; MacCarron et al. 2016) and even online multiplayer game environments (Fuchs et al. 2014), (6) this fractal series forms a set of 'attractors' in the form of criticalities (or optima) in the efficiency of information flow in networks (though we don't understand why) (West et al. 2020, 2023), (7) these same numbers reappear in both the distribution and their internal structure of primate, carnivore and cetacean social groups (Hill et al. 2008; Dunbar and Shultz 2021; Dunbar 2024), (8) at least in humans, the fractal structure is the product of a trade-off between the time costs required to maintain different kinds of relationships and the benefits these provide (Sutcliffe et al. 2012; Tamarit et al. 2018) and (9) although the population average for human personal social networks is always ~150, there is considerable variation between individuals due to gender, age, personality and social circumstances (Roberts et al. 2008; Dunbar 2018; Tamarit et al. 2018).

In addition, (10) upwards of 20 neuroimaging studies of humans and three of monkeys have shown that the size of an individual's personal social network is highly correlated with the size of core elements in its neocortex (prefrontal cortex, temporo-parietal junction and temporal pole, plus the subcortical amygdala and cerebellum, and the massive white matter connections between them known as the default mode neural network) (Dunbar 2018; Kwak et al. 2018; Kiesow et al. 2020). (11) Several neuroimaging and comparative studies have shown that mentalising, self-control and other advanced cognitive capacities supported by these brain regions act as the intermediate bridge between brain size and group size (Powell et al. 2012; Dunbar 2018). (12) the brain's endorphin system plays a central role in creating the bonded relationships that underpin these networks in both primates and humans (and now, it seems, birds too!) (Pearce et al. 2017; Dunbar 2021). Finally, (13) the ape equation has been used to examine the shape of the hominin social trajectory during the time since the last common ancestor.

All but five of 50+ published analyses using different datasets and a wide variety of statistical methods show that brain size predicts group size. Why have a small minority of papers found contradictory results? The answer turns out to be that they all fall prey to the same set of interesting statistical fallacies (Dunbar and Shultz 2023). First, they test an hypothesis about the outcome of a past adaptation as though it was a contemporary baby-counting exercise, thereby falling foul of Dobzhansky's Dictum. Second, they view the problem as a simple psychological mechanisms question (which variable best predicts the outcome variable?) instead of adopting a biological systems approach, thus falling prey to Tinbergen's "Four Why's" by confusing constraints with causes. Third, due to limitations in the design of multiple regression, they assume they are testing the same hypothesis that all other papers have done ("what constrains group size?") when in fact the hypothesis they actually test is "what constrains

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brain size" (diet, of course…. not too surprisingly). For well known statistical reasons, regression is the wrong method. They should have used path analysis (which considers all possible permutations of the variables and identifies the set of causal pathways that best explains the data). Four separate path analyses have been published, and all show that group size selects for large brains and large brains then select for changes in diet so as to fuel brain expansion. Fourth, and perhaps most serious, they ignore the presence of grades in the data (the Yule-Simpson Paradox). Doing so dramatically lowers the regression slope. Fifth, in trying to determine whether the primate brain size/group size regression can predict a meaningful group size for humans, they invariably set a regression through all the primate data, when they should be using a regression for the (ape) grade to which humans belong. The difference is considerable. All of these issues were discussed in the original 1992 analyses, and it is difficult to understand why studies continue to fall prey to them. The failure to read the original papers (never mind the ~280 papers we have published on the topic since then) is irksome. In the last 30 years, we have uncovered a very great deal about the social brain. Of particular interest is the fact that these findings have been widely applied in business organisation (Webber and Dunbar 2020; Camilleri et al. 2023), are widely used to underpin the design of most social media (Moon 2022), and have even been used to design bot-detection algorithms (Beskow and Carley 2018; Berry et al. 2019) and trust software for use in cellphone networks (Sorniotti and Molva 2010).

In sum, we have been able to provide a unified explanation for the evolution of sociality in mammals (and maybe birds as well) that integrates neuropharmacology (the endorphin system) with neuroanatomy (the default mode network), energetics, cognition, a variety of social behaviours and network structure in a remarkably coherent, unified, systems-based framework.

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