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Scaling up: Material culture as scaffold for the social brain

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ABSTRACT

Many other species besides *Homo sapiens* are tool-users and even tool-makers, but one aspect of material culture still sets modern humans apart: our emotional and social engagement with objects. Here I argue that this engagement acted as a crucial scaffold for the scaling-up of human social networks beyond those of our closest relatives the chimpanzees to the global 'small world' of modern humans. Material culture plays a vital role in conveying social information about relationships between people, places and things that extend geographically and temporally beyond the here and now – a role which allowed our ancestors to off-load some of the cognitive demands of maintaining such extensive social networks, and thereby surpass the limits to sociality imposed by neurology alone. Broad-scale developments in the archaeological record of the Lower Palaeolithic through to the early Neolithic are used to trace the process by which hominins and humans slowly scaled up their social worlds.

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1. Introduction: the small worlds of humans

Homo sapiens are perhaps the most successful mammal species ever. Over 7 billion humans are currently spread, albeit unevenly, across every terrestrial habitat on Earth. However, despite this huge number and vast geographical distribution, humans remain a remarkably densely interconnected species. The concept of 'six degrees of separation' popularized by the eponymous play and film (Guare, 1990, 1993) – the idea that our social networks connect us to everyone else on the planet via an average of only five intermediaries ('the friend of a friend ... of a friend') – originally derived from sociological studies conducted by Milgram (1977). Although these have since been criticised (Kleinfeld, 2002), more recent work has provided some qualified support for the figure (Watts and Strogatz, 1998; Leskovic and Horvitz, 2007), and indeed provided even smaller figures, e.g. a figure of 4 from email chains (Dodds et al., 2003), 4.74 from Facebook data (Backstrom et al., 2012) and 3.435–4.67 from Twitter (Bakhshandeh et al., 2005; Cheng, 2010). Regardless of the precise figure itself, it is clear that even in a mind-bogglingly large and complex social world, humans live in 'small worlds' of their own creation.

The implications of this observation are huge. The dense interconnectivity of human societies means that information, genes, diseases and goods of all kinds flow readily between individuals

and groups, criss-crossing the globe. On the negative side, such interconnectivity means that the December 2013 outbreak of ebola in Guinea, West Africa, reached Europe and the UK in just nine months. On a more positive note, it also means that researchers from multinational companies based in the US, Europe and Australasia have been able to develop vaccines hoped to be in global use within only two years of the initial outbreak (http://www.who.int/medicines/emp Ebola_q_as/en/). Although this is a deliberately dramatic example, it helps demonstrate that such a dense and interconnected social structure is unlikely to be evolutionarily neutral. I will argue here that strategies and mechanisms for large-scale networking are a major novel evolutionary trait that evolved in the hominin line specifically in order to extend social networks' geographical and temporal reach. I suggest that, as with so many other human behaviours, at first our networking skills depended on specific cognitive adaptations, but a neurological bottleneck ultimately led to our advanced social networking skills being enhanced by a range of externalized behaviours increasingly relying on material culture, leading to the globally networked modern day society we are so familiar with today.

2. Why network?

Humans are a highly social species, a characteristic inherited from our primate ancestors. Many other species from lions (Packer, 1986) to cetaceans (Lusseau, 2003) by way of meerkats (Madden et al., 2009, 2011; Drewe et al., 2009) and goats (Stanley and

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Dunbar, 2013), also live in complex social groups, suggesting that it is a highly adaptive strategy in many circumstances. Many evolutionary ‘payoffs’ have been identified for group living, including the potential benefits of co-operative foraging, vigilance and defence against predators, easy access to mates and alloparenting (see e.g. Van Schaik, 1983; Chapman and Chapman, 2000; Kramer, 2010 for discussion and references). However, social living is not all positive, and costs include increased competition for mates and food, an increased food budget for the group as a whole, the increased social stress of group living, which may significantly impact fertility (particularly for low-ranked individuals; see Coward and Dunbar, 2014 for references) and the ever-present threat of the social ‘free-rider’, taking what s/he can get from the group without contributing back (e.g. Dunbar, 1999).

A range of strategies help balance these costs and benefits. In particular, enhanced social ‘monitoring’ skills mitigate the negative effects of free-riders by enabling individuals to keep track not only of their relationships with one another and the payoffs of those interactions (were sacrifices reciprocated?), but also others’ relationships with each other, thus allowing the ongoing ‘monitoring’ of others’ reputations (Dunbar and Shultz, 2010, pp. 778).

Forging supportive coalitions and cliques is another such strategy, allowing individuals to mitigate the increased competition and social stress of life in large, complex groups (Dunbar, 1993). However, it could be argued that this is less a strategy than a logical by-product of expanding group size. In any network, a linear increase in the number of nodes results in an exponential increase in the number of potential connections between those nodes. In a real-world, ecological context such connections – potential relationships – are not resource-neutral. Maintaining relationships requires both time and energy (Roberts, 2010), and as groups expand in size, keeping track of individual relationships imposes significant cognitive costs (Dunbar, 1993; Lehmann et al., 2007).

For many primates, and certainly for our closest living relatives the chimpanzees (*Pan troglodytes* and *Pan paniscus*), the primary mechanism by which relationships are negotiated and maintained is fingertip grooming. Grooming maintains hygiene, but also produces neurochemical rewards which cement relationships between individuals who are subsequently more likely to support one another in disputes (Dunbar, 2010). However, such personal, one-to-one interactions take up time and energy in budgets that are already stressed by the increased time required for feeding in larger groups with more stomachs to feed. Thus, as Dunbar and colleagues have argued, grooming as a strategy for bonding groups quickly imposes a significant threshold for group size (Dunbar, 1992).

Thus as group size increases, individuals must increasingly select only a small fraction of the potential whole on whom to focus their networking efforts. The size of ‘cliques’ or ‘clans’ formed of individuals who groom one another regularly therefore decreases, the number of such cliques increases, and the density and connectivity of the group as a whole drops (Kudo and Dunbar, 2001; Lehmann et al., 2010). Unless relationships are maintained between those cliques, the group will fission rather than expand.

The question is, how have some primates managed to overcome these constraints to maintain larger, increasingly fragmented groups? Indeed, I will argue that hominins and particularly humans have turned such fragmentation into an adaptive trait in and of itself.

The hypothesis forwarded by the ‘Social Brain Hypothesis’ (SBH) is that more complex forms of social cognition are required among species that must negotiate not only *more* social relationships, but also – crucially – the increased social fragmentation and hence more complex relationships with individuals that are not part of your immediate clique (e.g. ‘friend of a friend’) that inevitably result from increased group size (Dunbar, 2003). This more complex

social environment, the SBH contends, is associated with larger brain size (or indeed, vice versa).

Thus, in larger groups the social network that individuals must construct via the relationships s/he pursues, among all the many potential relationships available, necessarily comprises a series of hierarchical levels. The number of individuals at each level increases, while emotional intensity (and time and energy demands) decreases. At the most intimate level, the most time and energy is expended on just a handful (~5) of members of an individual’s intimate network, on whom most of the networking time budget is lavished and from whom most support is received. At a more distant remove, a ‘sympathy group’ or effective network of around 15 individuals take up a significant amount of time and resources, though fewer than the intimate network, and provide proportionally less support in return; more distant still in social space are the members of an individual’s ‘band’, comprising around 50 individuals (see Coward and Dunbar, 2014, pp. 387 for references). Of course, the individual members of these levels are not fixed, but change throughout life as individuals’ situations (and those of the others with whom they interact) change (e.g. Roberts, 2010; Roberts and Dunbar, 2011).

Network levels of almost identical size and composition have been identified among both chimpanzees and cross-culturally among humans; our larger social group sizes are not different in kind, but simply in terms of the number of hierarchical levels of social distance we are able to maintain. Most famously, atop the ‘band’ level, humans have added an ‘active network’ of around ~150 individuals. Known as ‘Dunbar’s number’, this is the number of individual relationships, it is argued, that the size of our brain (or, more accurately, the proportion of total brain size accounted for by neocortex) allows us to track. Empirical research by proponents of the SBH demonstrates this is an extremely significant threshold in human social groupings even today (Dunbar, 1993; Zhou et al., 2005; Hamilton et al., 2007). However, it is also clear that contemporary humans routinely maintain networks with many more members than this, at commensurately lower levels of input of time, energy and emotional investment. An ‘expanded network’ of ~400 individuals is frequently identified, and arguably further levels exist beyond this, right up to the 7 billion figure with which we started, connecting all humans into a giant globalized ‘small world’ in which we can connect ourselves to almost any other individual via only ~5 intermediaries.

If the SBH is correct that cognitive evolution, as manifest in brain size (or specifically, relative neocortex size) explains humans’ ability to operate easily in groups of up to ~150 individuals, a question mark remains over how to explain the continued scaling-up of our social networks beyond this threshold. Arguably the outermost levels of this global network have only been added relatively recently – in the last few thousand or even hundred years. Nevertheless, the biggest increase in brain size/neocortical proportion that occurred during hominin evolution in fact occurred well before the speciation of modern humans, around 2–1.5 mya among early hominin species such as *H. erectus* and *H. heidelbergensis* (Gamble, 2010, Fig. 2.1; see also data in Miguel and Henneberg, 2001). Indeed, *Homo sapiens*’ brains are absolutely smaller than those of our cousins *Homo neanderthalensis* (Miguel and Henneberg, 2001), although brain shape and organization may have changed (Bruner, 2008; Pearce et al., 2013).

Thus the global expansion of *Homo sapiens* (beginning ~160–70,000bp; see below) post-dates any brain expansion: likewise, the development of long-term communities of considerably more than ~150 individuals dates only to the early Neolithic (~12,000–9,000BCE). During this period some communities are estimated to have increased in size from around 18–59 people in the Late Natufian, to 1170–3822 in the Pre-Pottery Neolithic C

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