numbers') and the development of quantitative mechanistic theory to explain how these structures evolved, theory that must be derived from the first principles of physics, chemistry, and biology, and so internally consistent across the sciences. Now that we understand the ubiquity of network structures in human social organization, we need to explore what this means for understanding the ecological and evolutionary dynamics of human systems, and the role of more fundamental scientific processes in these dynamics.

References

Arenas, A., Danon, L., Díaz-Guilera, A., Gleiser, P. M. & Guimerá, R. 2004 Community analysis in social networks. *European Physical Journal B* 38, 373-380.

Oltvai, Z. N. & Barabasi, A.-L. 2002 Life's Complexity Pyramid. *Science* 298, 763-764.

Ravasz, E. & Barabasi, A.-L. 2003 Hierarchical organization in complex networks. *Physical Review E* 67, 026112.

Paul Hooper: *Socioecology of Networks*

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Dunbar's article provides a quick trip through major historical transitions in the structure of human social networks. He addresses continuity and change in network structure between traditional small-scale human societies, on the one hand, and modern urbanized societies on the other. He argues that while the total size of co-resident populations (i.e. towns, cities) has grown, the number of close relationships maintained by each individual has remained roughly the same. At the same time, modern networks are less transitive[1] than traditional networks, as long-distance communication allows us to maintain geographically dispersed social ties, despite high rates of residential mobility between regions.

Fieldwork with traditional human groups—in my case, the Tsimane' of lowland Amazonia—supports Dunbar's characterization of traditional

[1] Network transitivity is defined as the probability that an individual's partners are also connected to each other (Newman 2003).

networks in terms of nested hierarchies of interconnected clusters of individuals, increasing in breadth (i.e. number of individuals) but decreasing in strength (or intensity) as one moves up in scale. Dunbar emphasizes the relative constancy across societies of the size of clusters at each scale, which he argues reflects the binding constraint of species-typical cognitive abilities. I would also advocate that, to the extent that we build social relationships because they accomplish something valuable, the structure and scale of networks should also be patterned according to socioecological variation in the benefits and costs of relationships of different types and intensities.

We know that socioecology is useful in understanding the scale of residential communities. Tsimane' settlements in the early 20th century, for instance, tended to be smaller and more geographically dispersed than in the present day. The more recent introduction of novel public goods—schools, soccer fields, and religious missions—has driven geographically denser, more nucleated settlement patterns. Those villages with the greatest contact with the outside Spanish-speaking world have grown to 300–500 individuals, whereas more remote villages have remained smaller, usually with fewer than 100 individuals. Against this background of variation, the mean size of present-day Tsimane' villages is 126 individuals (± 97 SD), which remains roughly consistent with Dunbar's hypothesized natural community size.

We also know that the nature and volume of traffic on networks in traditional settings vary as a function of the benefits and costs of interaction. Among foragers and horticulturalists, who smooth risk through food sharing, foods with higher variance in return rates (e.g., hunted game) tend to be shared across significantly broader networks than low variance items, such as fruit or cultivated produce (Gurven 2004). Likewise, individuals in groups facing high levels of uncorrelated risk in production tend to share food more widely than those for whom production is more predictable (Kaplan & Gurven 2004). The negative effect of geographic distance on the intensity of sharing indicates that the strength of ties is also sensitive to transaction costs. The cost-benefit logic of endogenous network formation is in fact nicely articulated by Dunbar and colleagues in Sutcliffe et al. (2012; see also Jackson 2008).

By Dunbar's account, the breadth of social networks in modern industrialized societies remains roughly the same as those in traditional societies, despite an increase in the size of settlements, making us strangers to most of our neighbors. Mobility has broken down the transitivity of our networks, which he suggests undermines cooperation, norm enforcement, and civic engagement. There are other noteworthy aspects of modern institutional settings that are likely to shape the structure and content of networks. With monetary currency and developed markets, the exchange of goods no longer requires the establishment of trust in long-term social relationships. Contracts can be formalized and enforced by courts. States monitor and sanction violations of social norms that are coded into law. The control structure of

firms and organizations prod us to work hard and work together. Storage, savings accounts, and market-based insurance have reduced our dependence on close friends and family to carry us through crises. These modern institutions and markets may substitute for much of what traditional social relationships are meant to accomplish, transforming, if not the size of our networks, at least the flow of goods across them (Bowles & Gintis 2002, Seabright 2010).

It is interesting to consider Dunbar's statement that the willingness to enforce social norms has declined in pace with the disintegration of modern communities in light of the results of Henrich et al. (2010). Henrich and colleagues conducted economic experiments across societies ranging from hunter-gatherers to West African and US cities, and found a positive relationship between the size of the residential community (ranging from 20 to 4600) and willingness to punish stingy partners by withdrawing resources in anonymous ultimatum and third-party punishment games. This appears to run counter to Dunbar's hypothesis. Shouldn't modern city-dwellers be less willing to enforce a norm of fairness in exchange? Perhaps not: perhaps these inclinations are appropriate for a society dominated by anonymous market exchange, but less so for one in which exchanges are nearly always embedded in a history of long-term interaction. It would be instructive to know how rates of cooperation and punishment amongst regular social partners in every-day life compare between traditional and modern settings. Needless to say, more research is in order.

Dunbar concludes by posing the question of how to restore the strength of our communities, considering (and rejecting) brain modification and top-down control as potential solutions. A third alternative may be to simply live more locally. In many domains of interaction, higher scales of integration sometimes provide very little benefit at significant cost. High regional mobility may be efficient in terms of income maximization (on the part of individuals) and profit maximization (on the part of firms), but may entail sacrifice of other, non-monetary inputs into well-being, such as social connectedness. If we were to weigh this trade-off differently, perhaps we could be happier.

References

Bowles, S., and Gintis, H. (2002). Social capital and community governance. *The Economic Journal* 112, F419-F436.

Henrich , J., McElreath, R., Barr, A., Ensminger, J., Barrett, C., Bolyanatz, A., Camilo Cardenas, J., Gurven, M., Gwako, E., Henrich, N., Lesorogol, C. , Marlowe, F., Tracer, D., and Ziker, J. (2011). Costly punishment across societies . *Science* 312, 1767-1770.

Gurven, M. (2002). Reciprocal altruism and food sharing decisions among Hiwi and Ache hunter-gatherers. *Behavioral Ecology and Sociobiology* 56, 366-380.

Jackson, M. O. (2008) *Social and Economic Networks*. Princeton University Press.

Kaplan, H., and M. Gurven. 2005. The natural history of human food sharing and cooperation: a review and a new multi-individual approach to the negotiation of norms. In *Moral Sentiments and Material Interests: The Foundations of Cooperation in Economic Life*. H. Gintis, S. Bowles, R. Boyd, and E. Fehr, eds. MIT Press, 75-113.

Newman, M. E. J. (2003) The structure and function of complex networks. *SIAM Review* 45(2), 167-256.

Seabright, P. (2010) *The Company of Strangers: A Natural History of Economic Life (Revised Edition)*. Princeton University Press.

Sutcliffe, A.J., Dunbar, R.I.M., Binder, J. & Arrow, H. (2012). Relationships and the social brain: integrating psychological and evolutionary perspectives. *British Journal of Psychology* (in press).

Daniel N. Finkel: *Social Cognition in a Digital World*

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In his excellent target article, *Networking Past and Present*, Dunbar argues that though contemporary personal networks are often geographically dispersed and not densely interconnected, the number of personal relationships individuals can maintain has not changed since our origins in tribal communities. He further suggests that despite the hype surrounding Internet social networking sites (SNS's), they have also not increased the number of real relationships the average person is able to maintain from around 150. Instead, the online environment may have exacerbated the social problems that arise from living among strangers in urban environments, such as decreased interpersonal altruism, cyber-bullying, and the reluctance many feel towards enforcing moral norms. While my commentary will not dispute these main points, there are several additional factors to consider when examining the mismatch between the evolutionary constraints on the size of our social networks and the modern/urban environments in which many of us live today.

First, it has been argued that reputational concerns are one driving force that promotes prosocial behavior, and indeed there is experimental evidence supporting this idea (Di Cagno and Sciubba 2010). This is likely one reason