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SOCIAL SCIENCE

Hunter–gatherer cooperation

A study of social networks in the hunter–gatherer Hadza people in Tanzania illuminates the evolutionary origins of humans' unique style of cooperation in groups. SEE LETTER P.497

JOSEPH HENRICH

The social behaviour of humans poses a significant evolutionary puzzle. Influenced by 'prosocial' motivations, we routinely help our relatives and friends in ways big and small, from donating kidneys to sharing food. Perhaps most puzzlingly, and unlike other primates, we also help strangers and cooperate in large groups by, for example, giving blood, going to war, recycling and paying taxes. Yet human prosocial behaviour varies dramatically between groups — from societies with little cooperation beyond extended kin to the vast scales of cooperation found in many modern states[1,2].

Among the key challenges to understanding the origins of human cooperation are the difficult questions of what the social lives of our Palaeolithic ancestors were like, and how they shaped our psychology. Studying modern foraging populations who depend on tools and resources similar to those of our ancestors is one of the few means we have of gleaning certain kinds of insight into the past[3]. On page 497 of this issue, Apicella *et al.*[4] give us a glimpse into the social dynamics of one of the few remaining populations of nomadic hunter-gatherers, the Hadza of Tanzania (Fig. 1).

With its practical implications, human cooperation stands as a central question that spans the behavioural sciences. From an evolutionary perspective, the conundrum is how individuals sustain cooperation in the face of the ever-present forces of self-interest; in other words, how could natural selection favour actions that benefit others, or one's group, but that also incur a personal cost? Theorists generally agree that the solution to this core dilemma requires assortative interaction, such that cooperators benefit other cooperators more than non-cooperators[5]. The challenge arises when one tries to delineate the processes that sustain such assortative interactions against invasion by 'free-riders' — non-cooperators who siphon off collective benefits.

Through the 1970s and 1980s, many researchers assumed that hunter-gatherers tackle this core dilemma by relying on a combination of kinship and direct reciprocity. By targeting kin on the basis of shared genetic inheritance, cooperators are more likely to deliver benefits to fellow cooperators. Similarly, by reciprocating help with help, unrelated individuals can sustain tit-for-tat cooperation. However, by the twenty-first century it had become clear that although kinship and direct reciprocity can each explain some aspects of human prosociality, many domains of cooperation, ranging from the sharing of meat within bands of hunter-gatherers to territorial defence, cannot be easily accounted for by these models[1].

To address this gap, researchers began to develop and apply new models. Gene–culture co-evolutionary models propose that, because social strategies are culturally learned, rapid cultural change tends to generate substantial variation in cooperation among groups while reducing variation within groups. In these models, cooperation is sustained by a process of cultural learning and the sanctioning of norm violators, which leads to the continuous reassortment of groups[6]. More cooperative groups tend to endure and expand, whereas less cooperative groups gradually break down. Another class of models, based on social selection, proposes that individuals cooperate competitively, as a means of attracting an inflow of partners who bring benefits[7]. A third approach proposes that cooperation can be sustained as individuals seek out those with different skills, resources or abilities. Here, assortment is based on complementarity rather than similarity[8].

To illuminate how the Hadza tackle the core dilemma of cooperation, Apicella *et al.*[4] gathered data on assortment and cooperative tendencies. The authors studied assortment within two social networks. To assemble the first (a campmate network), they asked adult Hadza from 17 different bands who they wanted to camp with when their next band formed. For the second network (a gift network), individuals received three honey sticks — Hadza love honey — and were asked to secretly specify who should get each stick. Finally, to measure cooperativeness, the researchers gave individuals from each band

PHOTOSTOCK-ISRAEL/ALAMY

Figure 1 | Helping hands. The Hadza people of Tanzania, such as these young men who are roasting birds they have caught, rely on hunting and gathering to obtain most of their food. By studying Hadza social networks, Apicella *et al.*[4] illuminate the population dynamics that underpin the evolution of human cooperation.

four additional honey sticks, and told them that any stick that was contributed to a common pool for their band would be tripled and the sticks distributed equally among band members. The Hadza could anonymously contribute any number of these four sticks (from zero to four), thereby pitting self-interest against the common good. Cooperators contribute sticks to the pool whereas egotists contribute nothing and free-ride on others' contributions.

Let's begin by considering those models that are not supported by the authors' results. They find that Hadza do not preferentially pick more cooperative individuals as future campmates or stick-receivers. They also do not preferentially network with those possessing complementary attributes, at least as indicated by age, food preferences or various physical measures. Thus, these findings do not favour existing models based on social selection or complementarity.

On the positive side, the most striking findings emerge when the variation in cooperative behaviours is partitioned within and among the 17 Hadza bands. There is substantially more variation among the bands, and substantially less variation within them, than would be expected by chance. Despite the fluidity of band membership, it seems that some combination of similarity-based association, social learning and sanctioning establishes differences in cooperative tendencies among different bands. This pattern is particularly interesting in light of experiments[9] showing that larger Hadza bands evince more fairness in anonymous interactions. Consistent with this, Apicella and co-workers' data from both the campmate and gift networks suggest that high contributors associate with other high contributors, and low contributors choose other low contributors. In fact, the gift-network results indicate that this extends to friends of friends: if your friend's friend is highly cooperative, you are likely to cooperate more, too.

As is the case in other primates[10], Apicella *et al.* also found that kinship and reciprocity contribute to assortment in Hadza social networks. No surprises there.

The crucial insight from this work[4] is that understanding distinct aspects of cooperation among these hunter-gatherers must incorporate an analysis of the dynamic processes at the population level that influence association, cultural transmission and band formation, instead of focusing tightly on purely individual actions within bands — the emphasis of much previous work. ■

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NANOTECHNOLOGY

Shape matters

The ligand-mediated binding of colloid particles to each other is more effective if the particles are flat rather than curved. This finding opens up opportunities for the design of self-assembling materials.

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From the invention of the wheel to the stacking of cannonballs and the design of stealth aircraft, humans have long known that shape matters. On a much smaller scale, the shapes of molecules affect their ability to form crystals, and enzyme shape is central to the binding of their substrates. Writing in the *Journal of the American Chemical Society*, Mirkin and colleagues[1] report a way in which shape can also affect the binding forces that hold nanometre-scale particles together — a discovery that suggests new approaches for constructing potentially useful architectures from these tiny building blocks.

Metallic and semiconductor nanoparticles grow as tiny crystals from solutions of precursor ions. Facets arise naturally from the anisotropic (directionally dependent) growth of the nanocrystals, producing particles that have a range of convex and concave shapes. These nanocrystals can be stabilized by coating them with small organic ligand molecules, or modified by the attachment of larger molecules such as DNA. Ligand coatings can conspire with the atoms in nanoparticles to produce net inter-particle forces (either attractive or repulsive) through van der Waals, hydrophobic and electrostatic interactions. DNA modification can also confer specificity on inter-particle forces — particles to which single-stranded

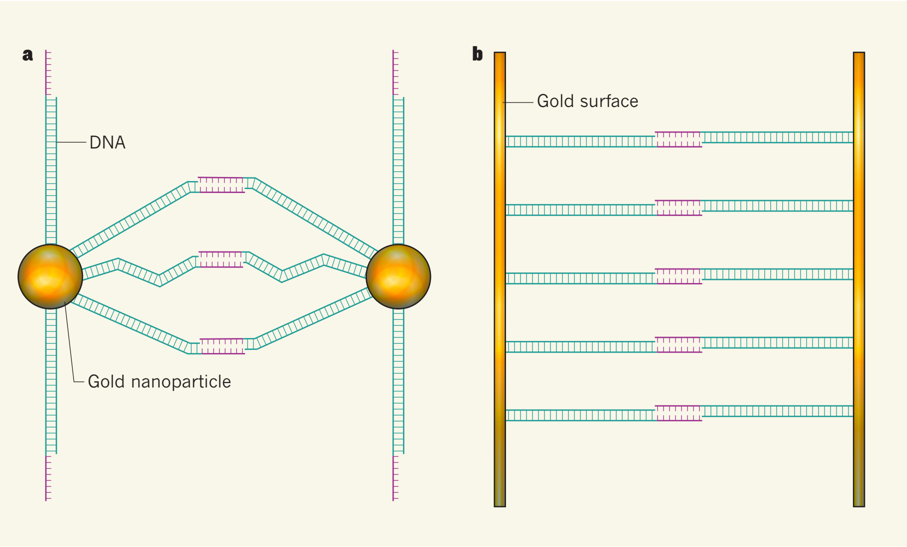

Figure 1 | DNA-mediated binding of nanoparticles. Mirkin and colleagues[1] prepared nanoscale gold particles of different shapes to which DNA molecules were attached. Although the main bodies of these molecules were duplexes (turquoise), the free ends of the DNA were single-stranded 'sticky ends' (pink). These could bind the particles together by forming duplexes with complementary sticky ends on other particles. The authors observed that particles with flat surfaces bound to each other more strongly than did spherical nanoparticles. This effect depends on how easily the sticky ends on different particles can approach each other. **a**, On spherical particles, relatively few sticky ends can come together to form duplexes, and the DNA molecules need to bend to allow duplex formation. **b**, When attached to flat surfaces, the DNA molecules can align so that more sticky ends form duplexes, without any bending.