FOCAL COORDINATION AND LANGUAGE IN HUMAN EVOLUTION* by Roger Myerson, July 2023, revised November 2023 https://home.uchicago.edu/~rmyerson/research/focalang.pdf

Abstract: We study game-theoretic models of human evolution to analyze fundamentals of human nature. Rival-claimants games represent common situations in which animals can avoid conflict over valuable resources by mutually recognizing asymmetric claiming rights. Unlike social-dilemma games, rival-claimants games have multiple equilibria which create a rational role for communication, and so they may be good models for the role of language in human evolution. Many social animals avoid conflict by dominance rankings, but intelligence and language allow mutual recognition of more complex norms for determining political rank or economic ownership. Sophisticated forms of economic ownership could become more advantageous when bipedalism allowed adaptation of hands for manufacturing useful objects. Cultural norms for claiming rights could develop and persist across generations in communities where the young have an innate interest in learning from their elders about when one can appropriately claim desirable objects. Then competition across communities would favor cultures where claiming rights are earned by pro-social behavior, such as contributions to public goods. With the development of larger societies in which many local communities share a common culture, individuals would prefer to interact with strangers who identifiably share this culture, because shared cultural principles reduce risks of conflict in rival-claimants games.

1. Introduction

The development of language was an essential step in the evolution of humanity from apes in Africa to a species capable of dominating the entire world. Language has enabled humans to coordinate with each other and to trust each other in ways that go far beyond the capabilities of other social mammals. Game theory is a basic methodology for analyzing such fundamental problems of coordination and trust, and so this paper considers some simple gametheoretic models to see what insights they may offer into the evolution of our species.

When a game has multiple equilibria, anything that focuses the players' attention on one equilibrium may lead them to expect it, and thus to rationally play it, according to Schelling's (1960) focal-point effect.¹ When the players in a game are animals without language, these focal factors must be conditions in the environment that are evident and salient to the animals; but in many interactions there may be no way to find natural environmental cues for coordinating attention on any but the simplest equilibria. The introduction of language greatly expands the ability of groups to jointly focus their attention on alternative plans of action. When players

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¹ As defined by Nash (1950), an equilibrium in a game is a prediction of one feasible strategy for every player such that each player's predicted strategy maximizes his own expected payoff against the others' predicted strategies.

share a language, any equilibrium could be made focal by one or more individuals talking prominently about it, describing the equilibrium and publicly recommending that everyone should act according to this equilibrium. By definition of a Nash equilibrium, a belief that others will comply with this recommendation would make compliance a best response for each player.

So in a game that has multiple equilibria, the players' rational behavior can be influenced by mere words (cheap talk) when the players share a language in which alternative equilibria can be described. On the other hand, if a game has only one equilibrium, then the players can be rationally responding to each other in a mutually understood pattern of behavior only if that pattern is the unique equilibrium, regardless of what anybody might have said before the game. Thus, games with multiple equilibria provide our basic models of how language can help rational self-interested individuals to solve coordination problems.

However, much of the literature on game-theoretic models of human evolution (see for example Panchanathan and Boyd 2004, Choi and Bowles 2007, and Bowles and Gintis 2011) has tended to emphasize social-dilemma games or public-goods games which have a unique noncooperative equilibrium when the game is played once. These games have been seen as interesting models for studying the emergence of human cooperation, because cooperative behavior can be sustained in equilibria in infinitely repeated versions of these games. But the uniqueness of equilibrium in a one-stage social-dilemma game means that we cannot find a rational coordinating role for linguistic communication in the simplest version of these games.

Thus, before analyzing the development of cooperation in social-dilemma games, this paper starts from an assumption that social animals regularly play some games that have multiple equilibria, here formalized by *rival-claimants* games. These rival-claimants games can be interpreted as models of animal conflict, where two individuals confront a valuable prize that can benefit at most one of them, and a costly conflict will result if they both try to claim it. Such conflict models have been considered in the evolutionary theory literature since Maynard Smith (1974), but there has been less attention to the fact that the multiplicity of Nash equilibria in these games makes them situations in which players could find something useful to say when they develop language. In the symmetric equilibrium of the rival-claimants game, the expected benefit of the prize is cancelled out by the players' expected losses from conflict over it. But a capability for language could enable two individuals to break the symmetry of the game with statements such as "I saw it first, so you should let me have it," or "you took the last one, so now it's my turn to take this one." Furthermore, as will be shown below, rational cooperation in

social-dilemma games can be readily supported in a society where individuals have language and regularly play these rival-claimants games. By this analysis, we can show how the introduction of language may greatly expand the kinds of rational strategic behavior that cultural norms can support through Schelling's focal-point effect.

Even with language, however, the scope of the focal-point effect must be limited to behavior that satisfies the individual best-response property of Nash equilibrium. Rational players should be expected to reject the credibility of anyone's promise to act in a way that would not be in his best interest.² That is, for players to use a language in negotiating focal equilibria of games, not only must the players understand how different strategies of the game are described in the language, but also the players must have some ability to recognize and discredit any suggestion that someone would behave against his own interests.³ But even if this credibility question might seem to raise potentially daunting cognitive requirements for general games, it will be straightforward to verify in the rival-claimants games that are considered here.

2. Modeling social life as a system of rival-claimants games

So let us consider a simple *rival-claimants* game, which exemplifies a broad class of interactions among animals in which a coordination problem arises.⁴ The players of this game are two individuals of the same species who have encountered each other near some valuable resource (perhaps a morsel of food, or a mating opportunity) which can provide benefits to at most one of them. An individual who successfully claims the resource can get a payoff V, which measures the net increase of expected reproductive fitness that this resource can provide. But if both individuals try to claim the resource, then the resulting conflict will have a cost c to both of them. Here the parameters V and c are assumed to be given positive numbers (say V=9, c=1). An individual who defers, instead of trying to claim the resource, will get payoff 0 (no net increase or decrease in reproductive fitness). So when this game is played by two animals, whom we may call individual 1 and individual 2, their respective payoffs depend on their decisions to claim or defer as in Table 1. We assume that the payoffs here represent a measure

 $^{^{2}}$ This credibility question has been examined from the perspective of evolutionary anthropology by Scott-Phillips (2007), and a general game-theoretic formulation has been developed by Myerson (1989).

³ In fact, Dunbar (1998) reports evidence that brains of many social mammals may have evolved for some capability of understanding the behavior of others in their band or community, with larger communities requiring larger brains.

⁴ Such games have also been used for modeling the foundations of law and other institutions of human civilization. Rival-claimants games with the structure defined here have also been used by Myerson (2004, 2009), and similar hawk-dove games were used by McAdams (2000).

of the net increase of expected reproductive fitness that each player would get from each outcome of the game.

	2 claims	2 defers
1 claims	-c,-c	V, 0
1 defers	0, V	0, 0

1's payoff, 2's payoff

Table 1: A game among rival claimants to a valuable resource worth V.

This game has three Nash equilibria. There is an equilibrium in which player 1 claims and 2 defers, yielding payoffs V for player 1 and 0 for player 2. This equilibrium corresponds to the social understanding that player 1 "owns" the resource. But the game also has an equilibrium in which player 2 claims and player 1 defers, yielding payoffs 0 for player 1 and V for player 2, and this equilibrium is our model of player 2 owning the resource. In addition, the game has a symmetric equilibrium in which each player independently randomizes, claiming with probability V/(V+c), but deferring with probability c/(V+c), so that each player gets an expected payoff equal to zero (because $-c \times V/(V+c) + V \times c/(V+c) = 0$).⁵

Genetic variation within the species could induce some probabilistic variation in the potential behavior of such animals when they interact in this game. But if one of the alternative actions (claiming or deferring) would yield a higher expected payoff against the distribution of actions in the general population that an individual could encounter, then individuals who use this action would tend to reproduce more, so that this action would steadily become more common in the population. Thus, a distribution of actions in the population can be stable only if it forms an equilibrium of this game, where everybody uses a payoff-maximizing action.

This game is symmetric between the two players, each of whom just views the game as an interaction between itself and a rival, with no awareness of what label we have given it ("1" or "2"). So in the absence of any cues to break the players' symmetry in this game, they could only implement the symmetric equilibrium, where both get expected payoff 0, and so the expected

⁵ The rival-claimants model could be extended to allow that, if both players claim or both players defer then they will play again, repeating until a round when someone defers while the other claims. This repeated game has sequentially rational equilibria in which the players would act as in the symmetric randomized equilibrium at each round after the first, so that expected payoffs after the first round are zero. Then the game at first round is still essentially as in Table 1, with the same three possible equilibria for their first-round play.

cost of conflict among these animals would cancel out their expected benefits from the resource. But now imagine that there is another species or endogamous group of social animals that can exploit the same niche in this ecosystem but has ways of breaking the symmetry so that its members know which one should claim and which one should defer whenever they meet each other in such games. Then this new group would be able to derive positive net benefits from the resources that are the prizes in these rival-claimants games, and so, as these benefits denote increments to net reproductive fitness, its population could reproduce more and ultimately displace the original species.

So let us consider an environment in which animals regularly confront different situations that fit this rival-claimants game model, with each case involving two players of the same species; but in different cases over time, each individual could face different opponents in competition for different resources in different kinds of situations. In each case, the players' decisions about whether to claim or defer could depend on any aspects of the current situation and the past history that are known to the players. Then we may expect an evolutionary tendency for a successful species to reduce the costs of conflict among its members by developing norms or principles for determining which individual should defer to the other's claim in these games. The players' ability to apply these coordinating principles could be inherited genetically in their species, or these principles might be learned from parents and elders as part of the culture of the players' local community or band. In any case, the two players must be able to apply these shared principles to establish agreement about which one of them should claim the prize, and so the complexity of these symmetry-breaking principles cannot exceed the cognitive abilities of animals in this species.

Communication can have a role in this coordination. Consider a rival-claimants game involving players from a community where the coordinating principles stipulate that, when some condition X holds, individual 1 should claim the prize. While this condition X must be something that both of the players can observe, there might be some situation where 1 has observed condition X but is not sure whether 2 is also aware of X. Then 1 should want to use any available form of communication to indicate this condition X to individual 2. If X can be verified by looking at something in their immediate environment, then 1 could simply point at it; but if X depended on something that 1 and 2 did on the previous day, then 1 might need language to remind 2 about their previous interaction. Whether by gestures or words, 1 would want to let 2 know that 1 is expecting 2 to defer because condition X is satisfied. The credibility of such a

message would be easy to verify in this rival-claimants game, given that the socially prescribed coordination principles depend only on conditions that the players can jointly observe. Individual 2 should not doubt that 1 wants to claim when conditions indicate that 2 should defer, and 2 can verify the condition X from direct observation once it has been pointed out. A false assertion of X could be rejected; that is, if 2's observations did not verify 1's assertion of X, then 2 might simply believe that 1 was lying, that 1 knew the actual conditions to be as 2 perceived them, and that both should be expected to play the game according to this knowledge.⁶

Language enables players to negotiate more complex coordination strategies, including jointly randomized strategies which, in a rival-claimants game, could give each player a 50% chance of claiming without conflict. If two modern humans were to play a rival-claimants game, they might decide to let the allocation of the prize be determined by a fair coin toss, perhaps agreeing that 1 should claim if the coin is Heads, but 2 should claim if Tails. If the loser of the coin toss subsequently tried to argue that they should do it again and base their decisions on a second toss, the winner could reply that the first toss was what they had agreed to use, and that no other toss should be considered. So the winner could confidently assert a right to claim, and the loser would rationally defer. Thus, the verbal suggestion by one player to base their moves on a coin toss in this particular way, along with the other player's verbal acceptance of this suggestion, would create a shared self-enforcing understanding to implement this random allocation rule. But this result depends critically on the players having common knowledge of this shared understanding that their decisions should depend on this otherwise-irrelevant coin toss in this specific way. Without language, two animals might have nothing to guide them toward a shared understanding of how their decisions to claim or defer should depend on any such random observable event.

Nonetheless, animals with lesser cognitive abilities often do have ways of breaking the symmetry of games like the rival-claimants games, and a few simple principles are commonly applied. We may make a distinction between principles that assign claiming rights based only on the players' identities, independently of the prize, and principles where the assignment of claiming rights can depend on a player's prior relationship with the prize in contention.

If the selection of the asymmetric focal equilibrium depends only on the players' individual identities, then an expectation that individual 1 should defer to individual 2 in one

⁶ Furthermore, a reputation for falsehood and deception could reduce an individual's social rank, resulting in a loss of claiming rights in subsequent games. See also the discussion of bullying below.

rival-claimants game would imply that 1 should defer to 2 for every possible prize. This happens among social animals that develop a pecking order. That is, one simple way that a band or community of animals may reduce conflict in rival-claimants games is by developing a hierarchy of social ranks such that each individual would always be expected to defer when playing against anyone of higher rank. The criteria by which these animals establish their relative rankings could be described as political, as they effectively give higher-ranked individuals a power to command deference from their inferiors. Such political symmetry-breaking can create substantial inequality among the members of the community, with high-ranked individuals claiming the benefits of most resources.

The other common way to break the players' symmetry in these games is to assign claiming rights to the individual who has a longer association with the prize in question, as if prior association entails a right of economic ownership. This economic principle might not create so much inequality among individuals, if each individual has an equal opportunity to establish ownership over different resources. But cognitively limited animals may be able to establish such ownership-by-priority only for a very limited range of cases, such as when the prize has a fixed location that an individual can consistently and observably patrol, so that any newcomer would know that the incumbent was already there to claim the prize.

The terms *political* and *economic* have been used here to describe these two ways that animals commonly break the players' symmetry of rival-claimant games. If the distinction between economics and politics is fundamental in some meaningful sense, then it should correspond to some distinction that can be found in the study of other social animals. These two ways for social animals to reduce conflict, either by expecting deference to the claims of higher rank or by expecting deference to the claims of prior ownership, could indeed be considered as a biological extension of the distinction between politics and economics in human affairs.

A community of intelligent social animals could develop more complex conventions or norms for defining who should claim in any instance of a rival-claimants game, as long as these norms depend on conditions that the players can jointly observe and understand. These claiming norms could be part of a group culture that depends on what individuals learn from elders in their community as they grow up. For example, social norms might include an expectation that, in some class of situations, individuals who have repeatedly played similar rival-claimants games with each other previously should take turns claiming. That is, if individual 1 claimed and individual 2 deferred the last time that they met in such a rival-claimants game then, under this norm, 1 should defer and 2 should claim this time. Another possible convention might involve dividing the community's territory into sectors that "belong" to specific individuals who then have superior claiming rights over certain kinds of resources within their own sector. These norms can be self-enforcing as long as they are understood and recognized by all the players.

3. Evolution of manual skills for production and social norms for economic ownership

Thus, social intelligence and language can expand the forms of economic ownership that a community can recognize and enforce. Then economic ownership can be helpful for encouraging individuals to invest in improvement of their resources. These two points should be considered in relation to the development of bipedalism, which we know characterized the evolution of humanity's australopithecine ancestors after they diverged from other great apes. A primary advantage of walking on two legs would be to free the hands for making, manipulating, and transporting useful objects. So it seems likely that the development of bipedalism was followed by an increased reliance on things that individuals made with skilled manual craftsmanship, which could have included shelters, sacks, and garments, as well as weapons and tools.⁷ But whenever something is useful and requires effort to make, others could be tempted to take it for their own use without investing in its manufacture. So we may infer that, as our ancestors adapted to bipedalism, they would have also needed better social structures for supporting economic ownership of valuable manufactured objects.⁸

In a rival-claimants game where the prize is an object that one individual made, it is not hard for the players' symmetry to be broken in favor of the individual who made it, as an expectation that the manufacturer will claim it can deter others from trying do so. To support this equilibrium where the manufacturer has claiming rights, it is sufficient that everyone else knows that they did not make it. So a first evolutionary step toward human culture, even before the development of language, could have been an increased propensity to accept that the individual who crafted an object can have a special right to claim it. But then, in a society where this basic principle is regularly applied, the cognitive ability to understand who owns various

⁷ Our ancestors had been bipedal for a few million years when the oldest known stone tools were made, but other less durable items could have been manufactured earlier without leaving any observable traces today.

⁸ Lieberman (2002, 2006) observed that the neurological systems that humans use for learning language are closely related to systems that animals use for learning complex motor skills. So we may speculate that the first development of language could have involved a redirection of some enhanced cognitive capabilities that had initially developed for mastering more sophisticated tasks with our hands, as they were freed from the need to support locomotion.

useful objects can also be useful, as it opens the possibility of negotiating for rights to use these things without conflict.

The total social value of a manufactured item can be greater if others may also use it, and an individual could realize greater benefits from an investment in specialized manufacturing skills if the products of his skills can be offered to others in exchange for some valued compensation. A transaction that could be facilitated by having at least a rudimentary language is lending a useful object for a limited period of time, in exchange for some other valuable gift or favor. If individual 2 wants to borrow something that individual 1 made, they could be setting themselves up for a costly conflict if they do not have a shared understanding about when 1 will reclaim his artifact. With language, 1 could clarify the terms of a rental agreement by saying "thanks for that nice egg; you can borrow my hand-axe now but please return it tomorrow." If this is expressed, then it is common knowledge that 2 can use the hand-axe today without conflict but must not keep it beyond the next day. With this shared understanding, it is rational for each to comply with the terms of the agreement, because an attempt by 1 to reclaim the handaxe today would cause conflict with 2, but an attempt by 2 to keep it beyond tomorrow would also cause conflict with 1. However, it seems unlikely that genetic evolution would ever produce a species with an innate understanding that the gift of an egg can buy the use of a hand-axe for one day. Instead, genetic evolution eventually produced a species with a general ability to communicate in languages that could be rich enough to include statements that would make such rental terms commonly understood by individuals who heard them and indicated their assent.

For a community of intelligent social animals to maintain a culture with complex rules for claiming rights, it must be something that young members of the community are ready to learn from their elders. In such a community, it would be adaptive for individuals to be born with an innate inclination to learn about their society's cultural conditions for claiming rights. That is, in addition to having an innate desire for the prizes in question (whether food or mating), a young individual should also be very sensitive to its elders' approval or disapproval of its youthful efforts to claim these desirable prizes. In growing up, an individual should feel driven to learn how to claim good things only when doing so would meet with social approval. For this purpose, it would be adaptive for the innate desire to claim good things to be moderated by an innate desire to avoid disapproval by others (shame).

The evolutionary development of such innate feelings in a species of intelligent social animals would facilitate the cultural development of more sophisticated principles for claiming

rights in different communities of this species. Then competition among communities can favor those with cultural principles which have advantages for increasing total reproductive fitness (Boyd and Richerson 2009, Boyd 2018). Conversely, as cultural adaptation increases in importance, it can induce a corresponding increase in the selective pressure for individuals to be born with a fundamental curiosity about when claiming is socially appropriate.

In this way, adaptations for cultural development of complex claiming rules in systems of rival-claimants games can give rise to a species where children want to learn the principles that determine when they can appropriately claim things that they desire. In such a species, the ability to communicate abstractions would become particularly valuable, as children would actually want to hear from their parents about why their claiming in some situation would be right or wrong. Furthermore, once an individual has learned the principles that determine claiming rights in his society, he would also benefit from the ability to communicate in ways that help to focus others' attention on conditions that favor his own claims. Thus, a system of rival-claimants' games could create evolutionary conditions that are conducive to the development of greater abilities for abstract language.

4. Claiming rights as inducements for pro-social cooperation

Some kinds of social norms for claiming rights could serve to create incentives for other useful behavior in the community. For example, there could be a class of rival-claimants games where everyone understands that the one who should claim is the one, among the players, who has the longer record of doing a certain kinds of observable actions in the community. If these observable actions are actually beneficial to the community, such as actions to confront and drive away dangerous predators, then the right to claim certain kinds of valuable resources would effectively become a social reward for helping others in the community. As competition among communities will favor those with cultural principles that have advantages for increasing total reproductive fitness, we may expect such social norms for rewarding pro-social behavior to become more prevalent in the species.

In a community where individuals regularly play rival-claimants games with each other, a dependence of socially recognized claiming rights on publicly observable past actions can be used to support cooperation in social-dilemma games, such as games where valuable public goods require costly individual efforts. To illustrate this point, consider a community of intelligent social animals which frequently play rival-claimants games with each other but also

have occasional opportunities for a group of m individuals to hunt some large prey. Hunting the large prey might require several individuals to cooperate by stealthily converging on the prey from different directions. Let us assume for simplicity that, for any number k between 2 and m, if k individuals cooperate in hunting this large prey then the probability of a successful hunt would be k/m, and success would yield benefits B to each of the n individuals in the community, where n>m. But each individual who cooperates in the hunt incurs an expected cost D that represents the risk of injury from the large prey. We assume that

nB/m > D > B/m,

so that an individual's cost of participating in the hunt is greater than his own benefit from the increased probability of success that his participation contributes; but each individual's participation increases the total payoff (in some measure of reproductive fitness) for the whole community. That is, the total payoff value for the whole community when k cooperate in the hunt is nBk/m–kD, which is maximized by k=m. However, the payoffs in this game on its own are not sufficient to motivate any group of m individuals to cooperate in the hunt because, while each could get an expected payoff B–D from such cooperation, each could increase his own payoff to B(m-1)/m by unilaterally shirking or defecting from the hunt.

On the other hand, the cooperation of m designated individuals in such a hunt could be sustained in a wider social equilibrium if anyone who shirked from his duty in the hunt would then expect to lose claiming rights in at least (D-B/m)/V subsequent rival-claimants games (while in disgrace for some period). But this threat to change how the community would treat an individual who shirked in a hunt requires a shared prior understanding of what each individual was expected to do in the hunt, so that his observed actions in the hunt can ultimately be compared with this expectation. A threat of social punishment can effectively motivate individuals to play different parts in a complex and dangerous operation only if each individual knows what he should do to avoid punishment. Such a general understanding can be easily achieved when the individuals share a language that enables a leader to specify, for example, which m individuals should join in a hunt and from which direction each of them should approach the prey. But without language, if the hunt failed because the prey fled in a direction which nobody was blocking, it might be difficult or impossible to identify who should have been blocking this direction. Furthermore, communication with language (gossip) could be essential for spreading knowledge of an individual's shirking and consequent loss of claiming rights to everyone in the community. Thus, an ability to sustain cooperation in dangerous activities like

hunting large prey may have been one of the primary benefits from the development of language.

More generally, any kind of observable action could be socially mandated by a threat of ostracism for noncompliance, as long as an individual's cost of doing this action would be less than the individual's expected discounted value of claiming in future rival-claimants games as a socially respected member of the community. But now suppose that the norms for allocating claiming rights can be culturally defined within each community, with children in each generation having an innate predisposition to learn from their elders about socially mandated behaviors and norms for claiming rights. Then we may expect an evolutionary tendency toward the spread of community's overall reproductive fitness (Boyd and Richerson 2009; Boyd, Richerson, and Henrich 2011). And within these communities, any individual who deviated from the local norms could expect to suffer from losses of claiming rights or increased costs of conflict that ultimately reduce the deviator's reproductive fitness.

The problem of bullying may deserve particular consideration. We can define a bully here as one who consistently claims in situations where he has no socially defined right, but his hope is that a reputation for such bullying could cause others to revise their expectations and start deferring to him in more interactions. If there were no chance of developing such a reputation then bullying could not be profitable, because claiming where one is expected to defer would just create costly conflict (with payoff -c) that could have been avoided by deferring (for payoff 0). But an individual who has developed a reputation for bullying (say by inappropriately claiming in more than a certain number of games) could then be punished by other social sanctions of the community. Even within our simple model of individuals who just interact in various rivalclaimants games, an effective punishment would be to treat a recognized bully as an outcast who should be expected to defer in any game with anyone else in the community. That is, the bully could be ostracized and denied any further opportunities to claim resources without conflict in the community. A more sophisticated model of social animals might include other potential punishments, such as driving away an outcast by threats of physical attack, perhaps with an expectation that attacking an outcast could be rewarded by claiming rights in more games.

Like hunting, fighting against rival groups is also an operation in which a community's chances to survive and grow can be improved by having members act as a disciplined cooperative team in the face of serious individual risks. In the terms of our model, a community could promote such martial discipline by making valor in battle an essential condition for

individuals to earn and retain a high social rank that commands deference from others in some broad class of rival-claimants games. Indeed, this is an area where humans differ notably from our chimpanzee relatives. While individuals in all kinds of human societies have regularly recruited volunteers for military activity that entails serious risks of injury and death, chimpanzees have only been observed joining groups for raids in which none of the attacking group were killed or seriously injured (Zefferman and Mathew 2015 p51; see also Gintis, van Schaik, and Boehm 2015). While deference based on social rank may regularly determine the allocation of food and mating opportunities among chimpanzees (De Waal 1982 ch4, De Waal 2005 ch2), they apparently do not earn higher rank by taking risks in combat against outsiders.

5. Development of multi-band human societies

Language is not needed for chimpanzees to understand that competition for the position of top-ranked (alpha) male in their community could require rivals for dominance to accept some risk of costly conflict with each other, but even this risk may be minimized by a well-adapted system of chimpanzee politics. De Waal (1982 ch2) has observed that a campaign to become the dominant male in chimpanzee community may involve a long sequence of provocative but carefully limited challenges to the incumbent's authority, while gradually building a coalition for accepting the challenger's leadership.

Coalition formation is vital in competition for dominance among adult male chimpanzees, because even the strongest individual could be defeated by a two others if they cooperated against him in an attack. But we should consider how the formation of these coalitions could be transformed by the introduction of language.⁹ The primary reward (in terms of reproductive fitness) for being the dominant male in a chimpanzee community is the recognized privilege of claiming the largest share of mating opportunities, and this privilege may be exercised with all the fertile females in the community, even when they have their own preferences. With language, however, a candidate for leadership might try to recruit a supporter by expressing appreciation and respect for his special relationship with one particular female in the community. Such negotiations could result in the formation of a winning coalition in which the leader has promised to respect each male supporter's right to claim mating opportunities with

⁹ See also Wrangham (2021) for an alternative view about how language could affect coalition formation.

one designated female, while the top leader claims priority with the other females.¹⁰ In this way, the introduction of language could cause the hierarchical promiscuity of chimpanzee societies to transform into a system with more pair bonding, which is indeed a general characteristic of human societies (Chapais 2008, Newson and Richerson 2021). This transformation might be the most important example of how language can help to reduce social inequality by enabling a community to recognize more kinds of individual rights and privileges (in marriage or in economic property) that do not simply depend on social rank.

Social animals can avoid inbreeding by having at least one gender (females among chimpanzees) that regularly leave the local community of their birth to find a mate in another community. Then language and pair-bonding can enable individuals to recognize kinship relationships with individuals in other communities (Chapais 2008). In particular, language would enable a female to suggest possibilities for cooperation between her husband and her brother, who are both genetically related to her children, even though, as otherwise unrelated males in different communities, they might have viewed each other as dangerous rivals. If this prior mutual suspicion made it impossible to bring the husband and brother together without violent conflict, then suggestions of cooperation between them could be initially expressed only with the remote-reference capability of language.

This recognition of kinship relations across communities enabled the ancestors of humanity to form multi-band societies or tribes, which could include many local communities that all shared a common culture. The ability of widely separated individuals to share ideas and build cooperative relationships is understood to be a key factor in the rise of humanity (Richerson and Boyd 1999, Chapais 2008, Moffett 2013 and 2018, Newson and Richerson 2021). In terms of our model, sharing a common tribal culture would mean that two individuals from different local communities could meet in a rival-claimants game and, if they are from the same tribe, their shared culture should enable them to agree on which one should claim and which one should defer. In this sense, individuals could feel confident about accepting opportunities to play such games with others of the same tribe, even if they have never seen each other before (as the only negative payoffs in Table 1 are in the corner where both claim). In contrast, interactions between individuals from different tribes would involve a risk of conflict, as each player's tribal culture might lead him to believe that he should have claiming rights

¹⁰ With a numerical balance among males and females in the community, the leader could still keep a harem for himself after promising one female to each member of a minimal majority coalition among the males.

which the other might not recognize.

For individuals from different communities to trust each other in social-dilemma games, a multi-band tribe would need a language in which each individual can be meaningfully named. We may assume that, even with the simplest forms of language, individuals who grew up together in a small band or community would have local names for each other. Then it would only be necessary to have a way of naming each local community in the tribe, so that any individual could be uniquely identified by the community where he grew up and his local name in that community. Once an individual's name and community are known,¹¹ if he were to defect or shirk in a social-dilemma game anywhere in the tribe, then his misbehavior could be reported back to his native community, and then reports of his disgrace and loss of rank could follow him anywhere else in the tribe. Thus, although the partition of the world into territorially extensive nation-states is a relatively recent development of human civilization, the existence of social structures that could facilitate constructive relationships between individuals from widely separated communities may be much more ancient in the evolutionary history of humanity as a species with a capability for language.

6. Conclusions

We have considered rival-claimants games as models of common situations in which social animals can avoid conflict over the benefits from a scarce resource only if one individual's right to claim these benefits is recognized and accepted by others in the community. These games have multiple equilibria which create a rational role for communication, and so they may be good models for the role of language in human evolution. Many social animals avoid conflict by simple dominance rankings, but intelligence and language allow mutual recognition of more complex norms for determining political rank or economic ownership. Respect for such norms can become a strictly stable equilibrium in a community where individuals regularly play rivalclaimants games, because a deviator who violated the prevailing social norms would incur greater costs of conflict in these games.

We argued that, in human evolution, sophisticated forms of economic ownership would have become more advantageous when bipedalism allowed the hands to be adapted for making

¹¹ In these terms, a stranger's allegation about his identity could be verified by asking him detailed questions about his alleged native community, and by asking others from that community what they know about someone with his alleged name. An attempt to misrepresent one's identity might be punished by ostracism from the tribe.

useful objects, as specialized manufacturing skills can make economic transactions more valuable. For a species of intelligent social animals to maintain a complex system of economic rights, the young must have an innate interest in learning about when they can appropriately claim desirable objects, so that principles for determining ownership rights can become part of a community's culture that is passed from one generation to the next. Then competition across communities would favor cultures where claiming rights can be earned as rewards for pro-social behavior in other transactions, such as cooperation in social-dilemma games and contributions to public goods. With the development of larger societies in which many local communities may share a common culture, individuals might be more willing to interact with strangers who identifiably share this culture because shared cultural principles reduce risks of conflict in rival-claimants games.

Game-theoretic models of human evolution offer simple perspectives on the basic fundamentals of human nature. Other studies that emphasized models of repeated social dilemmas (such as Choi and Bowles 2007, and Bowles and Gintis 2011) have suggested that evolutionary forces could have cultivated a basic human tendency to parochial altruism; that is, we may have an innate willingness to take costly actions that benefit other members of a social group with which we identify. The approach here, emphasizing models of rival-claimants games, has suggested instead that evolutionary forces could have cultivated a basic human tendency to contentious compliance; that is, we may be innately ready to accept that our claims to valuable resources must comply with social norms but also ready to argue for favorable interpretations of these norms in any specific instance. Of course, a long evolutionary history of living in various forms of human society for thousands of generations could have advanced the development of many innate behavioral tendencies that are socially adaptive, including parochialism, altruism, compliance, and contentiousness. The question for evolutionary modeling is which of these innate characteristics could have been fundamental for the first development of complex human society. In the story that has been sketched here, behaviors that seem altruistic or parochial were derived as later developments. The fundamentally difficult step in our evolutionary story was the initial development of an innate readiness to accept complex social rules for claiming rights, together with sophisticated communication skills for promoting a shared social recognition of how these rules should apply in the conditions of daily life.

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