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Focal Coordination and Language in Human Evolution

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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 prosocial 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.

Keywords Rival-claimants games · Multiple equilibria · Focal-point effect · Claiming rights · Contentious compliance

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

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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 game-theoretic models to see what insights they may offer into the evolution of our species.

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 the player's own expected payoff against the others' predicted strategies. 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. 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 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, e.g., Bowles & Gintis, 2011; Choi & Bowles, 2007; Panchanathan & Boyd, 2004) 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 game theory literature since Maynard Smith (1974, 1982), 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 a 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.[1] 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.[2] 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.

Gains of Coordination in 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.[3] 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 $V=2$, $C=3$). 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

[1] 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).

[2] 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. In the framework of Tomasello et al. (2005), an individual's ability to recognize how others' behavior would be guided by their interests is *understanding intentional action*, and communicating with others to coordinate on a preferred focal equilibrium is *shared intentionality*.

[3] Our rival-claimants games are very similar to the hawk-dove games of Maynard Smith (1982). Rival-claimants games with the structure defined here have been used by Myerson (2004, 2009) for modeling the foundations of law and other institutions of human civilization, and hawk-dove games were similarly used by McAdams (2000).

Table 1 A game between rival claimants to a valuable resource worth V

	2 defers	2 claims
1 defers	0, 0	0, V
1 claims	V, 0	–C, –C
	1's payoff, 2's payoff	

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

This game has three Nash equilibria. There is an equilibrium in which individual 1 claims and 2 defers, yielding payoffs V for individual 1 and 0 for individual 2. This equilibrium corresponds to the social understanding that individual 1 "owns" the resource. But the game also has an equilibrium in which individual 2 claims and individual 1 defers, yielding payoffs 0 for individual 1 and V for individual 2, and this equilibrium is our model of individual 2 owning the resource. In addition, the game has a symmetric equilibrium in which each player independently randomizes, deferring with probability $p = \mathrm{C}/(\mathrm{V}+\mathrm{C})$, but claiming with probability $1-p = \mathrm{V}/(\mathrm{V}+\mathrm{C})$, so that each player gets an expected payoff equal to zero (because $\mathrm{V}p - \mathrm{C}(1-p) = \mathrm{VC}/(\mathrm{V}+\mathrm{C}) - \mathrm{CV}/(\mathrm{V}+\mathrm{C}) = 0$).[4]

Genetic variation within the species could induce some probabilistic variation in the 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 cost of conflict among these animals would cancel out their expected benefits from the resource.

This wasteful conflict could be avoided, however, among players who shared some basic cognitive ability to find symmetry-breaking cues and coordinate on an asymmetric outcome where one of them gets the resource without conflict. For example, animals that can assess their relative sizes might use their sizes as symmetry-breaking cues for a coordination strategy of deferring if smaller but claiming if larger than

[4] 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, and then they stop. 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 the first round is still essentially as in Table 1, with the same three possible equilibria for their first-round play. With this interpretation, the payoffs in Table 1 are compatible with an assumption that one of these players will ultimately get the prize, but only after a potentially long war of attrition if their initial actions affirm the symmetry of the game.

the other player. This ability to exploit resources without conflict among members of their group could enable such coordinating players to attain a relatively higher reproductive fitness and thus increase their numbers. So Maynard Smith (1982, 1986) showed that a simple coordination strategy (which he called *bourgeois*)[5] can become evolutionarily stable in a hawk-dove game that is similar to our rival-claimants game.

To formulate Maynard Smith's argument in our framework, suppose that animals of some species regularly meet in randomly matched pairs to play rival-claimants games where, for each game, some aspect of the situation could identify one of the players as the "owner" and the other as the "intruder" for this game. Let Q denote the fraction of this population that recognizes these distinctions and applies the simple coordination strategy of claiming when identified as owner but deferring when identified as intruder. The remaining $1-Q$ fraction of population ignore these distinctions and can only use a simple strategy of claiming or deferring regardless of their situational identity. Let δ denote the fraction of ignorant players that are expected to defer.

Notice first that any player who defers gets payoff 0 in a rival-claimants game.[6] For any given fractions Q and δ, a coordinating player's expected payoff from claiming would be

$W(Q,\delta)=V-(1-Q)(1-\delta)(V+C)=[Q+(1-Q)\delta-p](V+C)$,

and then the coordinating players' overall expected payoff would be $W(Q,\delta)/2$ when random matching gives each coordinating player a probability 1/2 of getting the cue to claim. On the other hand, an ignorant player's expected payoff from claiming would be.

$U(Q,\delta)=V-[Q/2+(1-Q)(1-\delta)](V+C)=[Q/2+(1-Q)\delta-p](V+C)$.

Among the two strategic alternatives for the ignorant players, claiming or deferring, one alternative should vanish from the behavior of the ignorant population in equilibrium if it yields a strictly worse expected payoff than the other. So an equilibrium must have $\delta=0$ if $U(Q,\delta)>0$, but it must have $\delta=1$ if $U(Q,\delta)<0$, and it can have $0<\delta<1$ only if $U(Q,\delta)=0$. In fact, for any given Q, there is a unique δ that can satisfy these equilibrium conditions, but we must consider three parametric cases. When $Q\leq 2\min\{p,1-p\}$, the equilibrium conditions can be satisfied only by $\delta=(p-Q/2)/(1-Q)$, which yields expected payoffs $U(Q,\delta)=0$ for the ignorant players, and $W(Q,\delta)/2=(V+C)Q/4$ for the coordinating players. When $Q>2(1-p)$ (which can happen with $V<C$), the equilibrium conditions can be satisfied only by $\delta=1$, which yields payoffs 0 for the ignorant players and $W(Q,\delta)/2=V/2$ for the coordinating players. Finally, when $Q>2p$ (with $C<V$), the equilibrium conditions can be satisfied only by $\delta=0$, which yields payoffs $U(Q,\delta)=(Q/2-p)(V+C)$ for the ignorant players, and $W(Q,\delta)/2=(Q/2-p/2)(V+C)$ for the coordinating players. Notice that, as long as $Q>0$. the coordinating players get strictly higher average payoffs than the ignorant players in all three cases here. Thus, as higher payoffs here correspond to higher reproductive fitness, the coordinating players should be expected to

[5] We avoid the term "bourgeois" here because, in a search for the evolutionary roots of human nature, it would seem unhelpful to suggest, even implicitly by our terminology, that a fundamental strategic adaptation should be considered primarily as a characteristic of modern urban Europeans.

[6] This constant 0 payoff for deferring makes analysis of rival-claimants games a bit simpler than hawk-dove games.

reproduce more than the ignorant players, and so the fraction of coordinating players should steadily increase to Q = 1. In this way, the coordination strategy becomes a self-enforcing norm in the population.

So in environments where animals regularly confront situations that fit the rival-claimants game model, 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.

Different Principles for Assigning Claiming Rights

Before considering how a capability for language could enable humans to develop complex coordination strategies, we should consider the simple principles that animals with lesser cognitive abilities have commonly used to break the symmetry of games like the rival-claimants games. 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 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 the dominant 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. The potential of economic ownership criteria for discriminating among rival claimants was particularly emphasized by Maynard Smith (1982), by his use of the terms *owner*, *intruder*, and *bourgeois* in his discussion of hawk-dove games. 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 in 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.

Now consider the possibility of a population that mixes individuals of two types that apply two different criteria for identifying which player has claiming rights (or ownership), and suppose that these two criteria have probability β of designating different "owners" in any match. With random matching, an individual whose criterion is used by a Q fraction of the population would get expected payoff $[V-(1-Q)\beta(V+C)]/2$, which is increasing in Q. Thus, the expected payoff advantage accrues to the more common type, and its population share should then grow until it comprises the whole population. So any coordination strategy that these individuals can understand could become a stable self-enforcing equilibrium.

But once established, the prevailing criterion creates a further advantage for any adaptation that could increase an individual's probability of being identified as "owner" in a rival-claimants game. Thus, political coordination criteria may promote the development of attributes (such as size or strength) that can be helpful for asserting dominance over others, while economic criteria favor individuals who can invest more in establishing their right to specific resources. (See also Sherratt & Mesterton-Gibbons, 2015.)

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. Claiming rights could be different for different kinds of resources; and so a community might recognize a dominant individual's right to claim food from lower-ranked individuals, who might nonetheless have a recognized right to claim valuable tools that they made for themselves. Any such norms can be self-enforcing as long as they are understood and recognized by all the players.

However, the ability of intelligent social animals to use more complex coordination conditions may depend on their capabilities for communicating with each other. Consider a rival-claimants game involving players from a community where the coordinating principles would 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 intends 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.[7]

Correlated equilibria, which have been analyzed by game theorists since Aumann (1974), may involve complex strategies for joint randomization that would be difficult or impossible to negotiate without language. For example, 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 actions 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.

[7] 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 below of claiming rights as inducements for prosocial cooperation.

Coevolution of Manual Skills for Production and Social Norms for Economic Ownership

Thus, social intelligence and language can expand the forms of ownership that a community can recognize and enforce, and economic ownership can be helpful for encouraging individuals to invest in improvement of their resources. These 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.[8] 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. If a dominant individual could be expected to take anything useful from anyone else, the advantages that drove the development of skilled hands would be dissipated.

For example, consider a game where individual 1 first chooses whether to invest in making a useful object at some cost K. If 1 chooses to not invest then individuals 1 and 2 both get payoff 0. But if 1 invests then 1 and 2 play a rival-claimants game where this object is the prize, and the payoffs are as in Table 1, except that we must subtract the investment cost K from 1's payoff in all four cells. Suppose that $V > K > 0$, and both players would know that 1 made the object. Then this game has a strict equilibrium where 1 invests and then claims while 2 defers. But there is no equilibrium where 1 invests and then defers, because 1 could do better by not investing (as $0 > -K$). So this model suggests that the development of hands capable of sophisticated manufacturing would require some complementary development of social norms that support a manufacturer's rights to economic ownership of valuable manufactured objects.

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 implement 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 may have a special right to claim it. That is, along with bipedal locomotion and hands like our own, our early bipedal ancestors might have also developed a fundamental propensity to perceive hand-made items as belonging to individuals by a principle of prior association, even while such economic ownership might not have been recognized for many other kinds of resources. (See also Kanngiesser et al., 2020.)

[8] 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.

Individuals' rights to claim things that they have made for themselves can promote the development of general manual skills for making some basic kit of essential items; but the greater gains of technical specialization, which have been so important in human history, depend on broader social support for economic rights that are acquired by exchange. An individual can 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; but such exchange requires purchasers to have some confidence in their ability to retain use of an item that they did not actually make. In the framework of our rival-claimants games, the purchaser needs some way to communicate to any potential rival the message: "You should defer to my claim here because I bought this from the one who made it, and you did not!" So the development of specialized manufacturing skills depends both on some broad recognition of economic property rights and on some ability to communicate information about transactions in which rights to manufactured items are exchanged. Negotiation of terms for purchase agreements also require some ability to communicate mutually understood messages, such as about how many eggs one might offer to buy a hand-axe. Thus, rewards of skilled specialization could accrue to communities that developed a basic form of language.[9]

So in communities of individuals with specialized skills, claiming rights would necessarily depend on a complex system of exchanges, some of which might be understood as customary transactions and others as negotiated agreements between the transacting parties. For a community of intelligent social animals to maintain a culture where such complex rules can determine claiming rights, it must be something that young members of the community are ready to learn from their elders (Locke & Bogin, 2006). As we have seen, individuals who do not recognize the prevailing norms for ownership or claiming rights in their community will suffer higher costs of conflict. So an increasing complexity of culturally-defined claiming rules would induce selective pressures that favor individuals with greater inclination and aptitude for learning these social rules that define when it is socially appropriate for them to claim valued resources. That is, in addition to having an innate desire for the prizes in question, 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).

In this way, adaptations for 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

[9] Lieberman (2002, 2006) observed that the neural systems that humans utilize for understanding and producing language are closely related to systems that animals use for learning and executing complex motor skills. So we may also speculate that the first development of language could have involved a redirection of some enhanced neural capabilities that had initially developed for mastering sophisticated manual tasks.

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.

Claiming Rights as Inducements for Prosocial Cooperation

The evolutionary development of a species with a propensity for learning complex social rules for claiming rights sets the stage for cultural group selection in competition among communities. Norms that increase aggregate reproductive fitness in a community make it more likely to grow and generate new colonies (as observed by Soltis et al., 1995). A key point here is that norms that define claiming rights in rival-claimants games are intrinsically self-enforcing against individual deviations, because a minority who tried to claim where they were expected to defer would just suffer increased costs of conflict, and so migrants into a successful community may be expected to learn and adopt its norms. Under these conditions, as Boyd and Richerson (2010) have argued, cultural group selection can become the primary force for evolution of social behavior. That is, competition among communities can favor those with cultural norms and principles that have advantages for increasing total reproductive fitness. (See also Boyd & Richerson, 2009; Boyd et al., 2011; Boyd, 2018.)

So let us examine how social norms for claiming rights can create incentives for other useful behavior in the community. For example, there could be some 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 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 some valuable resources would effectively become a social reward for helping others in the community. Since competition among communities favors those with cultural principles that have advantages for increasing total reproductive fitness, we may expect such social norms for rewarding prosocial 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 individuals 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.[10] 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. (See also Bishop & Lerch, 2023.)

Norms for rewarding prosocial behavior may combine principles that are economic and political, in the senses defined above. For example, we may imagine a community where an individual's rank may be either high or low, and some valuable resources can be owned economically only by high-rank individuals. That is, in these rival-claimants games, a low-ranked individual would always be expected to defer to any high-ranked individual; but in matches between high-ranked individuals, the

[10] The shirker's loss of claiming rights is enforced by other members of the community claiming resources in situations where they would have deferred to him if he were not in disgrace. So this punishment is not costly to the enforcers, who actually gain by claiming when the disgraced shirker is expected to defer. Questions of costly third-party punishment become moot here because the shirker's disgrace changes equilibrium expectations for both sides of his rival-claimants interactions.

one who has the longer prior relationship with the prize is expected to claim, and others should defer. Now suppose that an individual can achieve high rank only by performing certain dangerous acts of valor for the community. If an individual without high rank could not hope to claim resources that are needed to attract a mate, then accepting some risk of death for the community could actually increase his expected reproductive success.

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 & Mathew, 2015:51; see also Gintis et al., 2015). While deference based on social rank may regularly determine the allocation of food and mating opportunities among chimpanzees (de Waal, 1982; Waal, 2005), they apparently do not earn higher rank by taking risks in combat against outsiders.

The problem of bullying may deserve some consideration here. We may define a bully here as one who consistently claims in situations where he has no socially defined claiming rights. A bully might hope 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). So the bully can gain only by establishing new social norms where others will defer to his claims. That is, the bully's aim must be to create a new political order in which he has higher rank than others. But if the existing social order includes leadership from individuals who attained high rank by taking risks to defend the community, then they may recognize that the bully's political goal implicitly threatens their status and so may naturally feel compelled to defend their community now against the bully.

Within the framework of rival-claimants games, the most extreme social punishment would be to deny an individual any further opportunities to claim resources without conflict in the community, that is, ostracism. Any kind of observable action could be socially mandated by a threat of ostracism for noncompliance, if the cost of this action is less than the expected discounted value of claiming in future rival-claimants games as a respectably compliant member of the community. Then with norms for claiming rights being culturally defined within each community, and with children in each generation having an innate predisposition to learn from their elders about these socially mandated behaviors and norms, we may expect an evolutionary tendency toward the spread of communities that have cultural norms which mandate prosocial behaviors that increase the community's overall reproductive fitness. And in 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.

Development of Multi-band Human Societies

One fundamental way that human societies differ from our nearest ape relatives is by the prevalence of pair-bonding, in which a couple forms an exclusive socially-recognized sexual relationship to establish a nuclear family where the children can know their father as well as their mother (Chapais, 2008; Newson & Richerson, 2021). Chimpanzee communities normally have promiscuous mating, so that paternity becomes obscure, but the top-ranked (alpha) male chimpanzee can generally claim the largest share of mating opportunities and expect lower-ranked males to defer to him, even when the females have different preferences (de Waal, 1982; Waal, 2005; Stumpf & Boesch, 2006; Wroblewski et al., 2009). From this perspective, the development of human pair-bonding looks like another example of claiming rights that depend on specific socially-recognized relationships, not just on an individual's general rank in society.[11]

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 (Chapais, 2008; Moffett, 2013, 2018; Newson & Richerson, 2021; Richerson & Boyd, 1999). 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 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

[11] But as noted above, some societies could have norms that prevent an individual forming any pair-bond with social recognition until he has attained a respectable rank, perhaps by performing some costly acts of social service.

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,[12] 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.

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 stable self-enforcing equilibrium in a community where individuals regularly play rival-claimants 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 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 prosocial 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

[12] 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.

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 Bowles & Gintis, 2011; Choi & Bowles, 2007) 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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References

Aumann, R. J. (1974). Subjectivity and correlation in randomized strategies. *Journal of Mathematical Economics*, *1*, 67–96. https://doi.org/10.1016/0304-4068(74)90037-8

Bishop, M. E., Brian, A., & Lerch (2023). The influence of language on the evolution of cooperation. *Evolution and Human Behavior*, *44*, 349–358. https://doi.org/10.1016/j.evolhumbehav.2023.04.003

Bowles, S., & Gintis, H. (2011). *A cooperative species: Human reciprocity and its evolution*. Princeton University Press.

Boyd, R. (2018). *A different kind of animal*. Princeton University Press.

Boyd, R., & Peter, J. R. (2009). Culture and the evolution of human cooperation. *Philosophical Transactions of the Royal Society B*, *364*, 3281–3288. https://doi.org/10.1098/rstb.2009.0134

Boyd, R., & Peter, J. R. (2010). Transmission coupling mechanisms: Cultural group selection. *Philosophical Transactions of the Royal Society B*, *365*, 3787–3795. https://doi.org/10.1098/rstb.2010.0046

Boyd, R., Peter, J., Richerson, & Joseph Henrich. (2011). Rapid cultural adaptation can facilitate the evolution of large-scale cooperation. *Behavioral Ecology and Sociobiology*, 65(3):431–444. https://doi.org/10.1007/s00265-010-1100-3

Chapais, B. (2008). *Primeval kinship: How pair-bonding gave birth to human society*. Harvard University Press.

Choi, J. K., & Samuel Bowles. (2007). The coevolution of parochial altruism and war. *Science*, *318*, 636–640. https://doi.org/10.1126/science.1144237

de Waal, F. (1982). *Chimpanzee politics*. Johns Hopkins University.

de Waal, F. (2005). *Our inner ape*. Penguin.

Dunbar, R. I. M. (1998). The social brain hypothesis. *Evolutionary Anthropology*, *6*(5), 178–190.

Gintis, H., van Schaik, C., & Christopher Boehm. (2015). Zoon politikon: The evolutionary origins of human political systems. *Current Anthropology*, *56*(3), 327–353. https://www.journals.uchicago.edu/doi/full/10.1086/681217

Kanngiesser, P., Rossano, F., Fricket, R., & Michael Tomasello. (2020). Children, but not great apes, respect ownership. *Developmental Science*, *23*, e12842. https://doi.org/10.1111/desc.12842

Lieberman, P. (2002). On the nature and evolution of the neural bases of human language. *American Journal of Physical Anthropology*, *119*(S35), 36–62. https://doi.org/10.1002/ajpa.10171

Lieberman, P. (2006). *Toward an evolutionary biology of language*. Belknap Press of Harvard University.

Locke, J. L., & Barry Bogin. (2006). Language and life history: A new perspective on the development and evolution of human language. *Behavioral and Brain Sciences*, *29*, 259–325. https://doi.org/10.1017/S0140525X0600906X

Maynard Smith, J. (1974). The theory of games and the evolution of animal conflicts. *Journal of Theoretical Biology*, *47*, 209–221. https://doi.org/10.1016/0022-5193(74)90110-6

Maynard Smith, J. (1982). *Evolution and the theory of games*. Cambridge University Press.

Maynard Smith, J. (1986). Evolutionary game theory. *Physica D: Nonlinear Phenomena*, *22*(1–3), 43–49. https://doi.org/10.1016/0167-2789(86)90232-0

McAdams, R. H. (2000). A focal-point theory of expressive law. *Virginia Law Review*, *86*(8), 1649–1729. https://www.jstor.org/stable/1073827

Moffett, M. (2013). Human nature and the evolution of societies. *Human Nature*, *24*, 219–267. https://doi.org/10.1007/s12110-013-9170-3

Moffett, M. (2018). *The human swarm: How our societies arise, thrive, and fall*. Basic Books.

Myerson, R. (1989). Credible negotiation statements and coherent plans. *Journal of Economic Theory*, *48*, 264–303. https://doi.org/10.1016/0022-0531(89)90127-0

Myerson, R. (2004). Justice, institutions, and multiple equilibria. *Chicago Journal of International Law*, *5*(1), 91–107. https://chicagounbound.uchicago.edu/cjil/vol5/iss1/9/

Myerson, R. (2009). Learning from Schelling's strategy of conflict. *Journal of Economic Literature*, *47*(4), 1109–1125. https://www.jstor.org/stable/40651534

Nash, J. F. Jr. (1950). Equilibrium points in n-person games. Proceedings of the National Academy of Sciences, 36(1):48–49. https://doi.org/10.1073/pnas.36.1.48

Newson, L., Peter, J., & Richerson (2021). *A story of us: A new look at human evolution*. Oxford University Press.

Panchanathan, K., & Robert Boyd. (2004). Indirect reciprocity can stabilize cooperation without the free-rider problem. *Nature*, *432*, 499–502. https://www.nature.com/articles/nature02978

Richerson, P. J., & Robert Boyd. (1999). Complex societies: The evolutionary origins of a crude superorganism. *Human Nature*, *10*, 253–289. https://doi.org/10.1007/s12110-999-1004-y

Schelling, T. C. (1960). *The strategy of conflict*. Harvard University Press.

Scott-Phillips, T. C. (2007). The social evolution of language, and the language of social evolution. *Evolutionary Psychology*, *5*(4), 740–753. https://doi.org/10.1177/147470490700500405

Sherratt, T. N., & Mesterton-Gibbons, M. (2015). The evolution of respect for property. *Journal of Evolutionary Biology*, *28*(6), 1185–1202. https://doi.org/10.1111/jeb.12648

Soltis, J., Boyd, R., Peter, J., & Richerson (1995). Can group-functional behaviors evolve by cultural group selection? *Current Anthropology*, *36*(3), 473–494. https://doi.org/10.1086/204381

Stumpf, R. M., & Boesch, C. (2006). The efficacy of female choice in chimpanzees of the Taï Forest, Côte d'Ivoire. *Behavioral Ecology and Sociobiology*, *60*, 749–765. https://doi.org/10.1007/s00265-006-0219-8

Tomasello, M., Carpenter, M., Call, J., & Henrike Moll. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, *28*, 675–735. https://doi.org/10.1017/S0140525X05000129

Wroblewski, E. E., Carson, M., Murray, Brandon, F., Keele, Joann, C., Schumacher-Stankey, B. H., Hahn, Anne, E., & Pusey (2009). Male dominance rank and reproductive success in chimpanzees, Pan troglodytes schweinfurthii. *Animal Behaviour*, *77*(4), 873–885. https://doi.org/10.1016/j.anbehav.2008.12.014

Zefferman, M. R., & Sarah Mathew. (2015). An evolutionary theory of large-scale human warfare: Group-structured cultural selection. *Evolutionary Anthropology*, *24*, 50–61. https://doi.org/10.1002/evan.21439

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