SOCIALITY, TRUST, KINSHIP AND CULTURAL EVOLUTION

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Abstract: Pre-history human economic development, it will be argued, was the result of significant increases in sociality, that itself was a product of the evolution of a human temperament associated with much more interpersonal tolerance and trust which facilitated kinship recognition and significantly expanded social network size. All this made possible in humans, an ongoing cultural evolutionary processes not seen in other animals. Though our close cousins the chimpanzees and some other animals display forms of culture, there is little evidence of significant ongoing cultural evolution in nonhuman animals. The expansion of human social networks increased the rate of cultural evolution, in part, by increasing the fixation rate of new components of culture.

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1 Introduction—the Evolution of Big Brains and Language and Culture

Homo sapiens' cognition and culture did not come about independently, but rather they evolved jointly via a complex process of gene-culture co-evolution. (Richerson and Boyd 2005) Interestingly, recent evidence from primatologists and anthropologists supports the proposition that the evolution of big brains, language, and ongoing cultural evolution was a product of spontaneous order, that can be explained by significant increases in human sociality. This increase in sociality was itself a product of increases in trust, social capital and institutions, and kinship recognition. In modern development studies, a comparison between developed countries and an under-developed one can shed light on the factors that resulted in the difference in outcomes. Similarly, an examination of the different evolutionary pathways of primates and, in particular, chimpanzees and *Homo* can contribute to an explanation of why *Homo* evolution resulted in big brains relative to chimpanzees as well as in ongoing cultural evolution that is not seen in nonhuman primates. (Whiten et al. 1999, Tomasello 1999 and Tennie et al. 2009) Important *Homo* versus chimp differences in evolutionary outcomes that will help explain the differences in brain size and culture include the evolution of a human temperament associated with much more interpersonal tolerance and trust, pair bonding and biparental provisioning of the young, and significantly increased sexual specialization in provisioning activities. Further important *Homo/*chimp evolutionary differences that will be examined include significantly enhanced kin recognition, an egalitarian social structure,[1] intergroup pacification, leading to significantly expanded social networks and human life history changes, including, a long pre-adult development period, longer maximum life expectancy coupled with lower mortality rates, higher fertility rates and significantly more complex learned behavior.

[1] Where egalitarian in this context means, equal opportunity, not equal outcome and both political and economic individual autonomy and freedom.

The products of cultural innovation in small isolated groups are often lost; the significant expansion of human social network size helped to increase the fixation rate of new components of culture and thereby increased the rate of cultural evolution. Further, both biological and cultural evolution can be thought of as trial and error/experimental learning processes; over time, *Homo* has come to rely more and more on cultural learning processes rather than biological ones. Failure of a biological experiment—in the form of a harmful mutation—often results in the death of the individual carrying that mutation, failure of a cultural experiment usually does not result in the death of the cultural innovator. In other words, failure of biological experiments can result in the death of individuals, failure of cultural experiments usually only results in the death of ideas. Importantly, in our human ancestor's large social networks, information, coordination and governance proceeded from the bottom up, from the individual and the family up to the more aggregated social units, which facilitated taking advantage of the Hayekian notion that knowledge is widely dispersed and local. It also helped preserved individual autonomy and freedom necessary for the maintenance of interpersonal trust.

Seemingly, smarter is better, but the problem is that the big brains necessary to make us smarter are extremely costly. "[T]he energy consumed by the brain forms roughly 65% of a baby's total consumption and no less than 20-25% of an adult's, even though brain tissue accounts for only 2% of adult body mass." (Potts, 2011, p. 43) The benefits of being smarter must exceed these high energy costs, so an explanation of the evolution of our large brains is found in detailed examination of the benefits of big brains.

Commonly, our large brains, language and culture are claimed to be a product of the evolutionary pressures of living in social groups because social animals must develop complex forms of social knowledge to predict the behavior of other members of their social group, manipulate that behavior, and ultimately foster the complex cooperation that makes our culture and complex social networks possible. This idea is often referred to as the Machiavellian intelligence hypothesis (MI) (Byrne and Whiten 1988, Whiten and Byrne 1997). In fact, our large brains evolved because they enabled our ancestors to suppress their Machiavellian tendencies by facilitating solutions to the various problems associated with social living. The evolution of three capacities that are necessary for complex cooperation and culture drove increases in human brain size over that of our social but less cooperative cousins the chimpanzees. These closely related capacities are theory of mind, the sharing of attention, and the sharing of intentions: they helped allow our ancestors to contain their Machiavellian tendencies.

As we will see, complex cooperation requires tight social bonding, which requires trust. For trust to evolve our ancestors must have 1) overcome the incentive to defect when involved in cooperative activity, and 2) suppressed the proclivity to use violence to take resources from conspecifics, as is seen in nonhuman primates. Large brains and language were, in part, necessary for the evolution of mechanisms that suppressed our Machiavellian tendencies, and by doing so they greatly facilitated cooperation. Given all this, it seems that *Homo sapiens*' cognitive capacity evolved to deal with the free-rider problem. Our enhanced cognitive capacity facilitated a level of cooperation not seen in non-human contexts, and this is what made complex culture and its ongoing evolution possible. Greater cognitive capacity fostered the evolution of social rules of governance and implicit institutions that suppressed free riding, provided rules of orderly behavior that increased cooperation by making individual behavior predictable, and also protected the property rights of individuals. Though the social living hypothesis suggests that our big brains were not a product of the advantages of producing and using complex tools or an ability to exploit hard-to-acquire and varied food resources, these abilities were an important byproduct of the evolution of language, big brains, hyper-cooperation and ongoing cultural evolution. In the next few sections, we will examine some of the various evolved mechanisms and capacities that allowed our ancestors to overcome their Machiavellian tendencies.

2 The Evolution of Cooperation and the Transitivity of Trust[2]

The evolution of other-regarding preferences coevolved with the solution to the MI problem. Explaining the evolution of other-regarding preferences and cooperation in biology usually starts with reciprocal altruism, or direct reciprocity (DR), to explain cooperation between non-kin (Trivers 1971) and kin selection, i.e., nepotism or inclusive fitness to explain cooperation among kin (Hamilton 1964). Reciprocal altruism coupled with tit-for-tat strategies involves a group of individuals in long-term social relationships where a sacrifice made to benefit another individual today will be more than made up for by a benefit provided by that individual in the future. A key requirement for this strategy to work is that the players have sufficient brainpower to remember the past performance of those they have cooperated with in the past. Consequently, tit-for-tat can be considered a reputation model, where individuals cooperate with those who have cooperated with them in the past.[3] With kin selection, an individual may make sacrifices that benefit another if the following inequality (Hamilton's rule) holds: $Br > C$, where B is the reproductive benefit to the other individual, r is the average degree of relatedness between the two individuals, and C is the reproductive cost to the individual performing the altruistic act. For example: for sexually produced siblings, where $r = .5$, if an individual performs an altruistic act that yields a benefit to a full sibling or siblings that exceeds twice the cost it bears in performing

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[2] Portions of this section are based upon Gifford 2002.

[3] This is not to deny that some mammals, including primates and carnivores such as wolves and lions, hunt in groups larger than two. However, in these situations the payoff to all is the immediate product of a successful hunt. Here I am primarily concerned with non-simultaneous exchange situations that play out over time.

that act, its net fitness increases. This, of course, could be considered selfish behavior from a gene perspective, since it tends to increase the number of copies of the gene that promotes the altruistic behavior that are passed on to the next generation.

Richard Alexander (1987) has suggested that a much more extensive system of cooperation can be facilitated by indirect reciprocity. With DR, an individual cooperates with a conspecific that has cooperated with it in the past. Indirect reciprocity (IDR) includes cooperating with those that the individual knows have cooperated with others in the past. "Indirect reciprocity develops because interactions are repeated, or flow among society's members, and because information about subsequent interactions can be gleaned from observing the reciprocal interactions of others." (Alexander 1987, p. 77) Social relationships are much more complex when indirect reciprocity takes place compared to direct reciprocity. With DR, the individual need only keep track of its obligations to each of the other individuals in the group and theirs to it. With IDR, the individual must not only keep track of these, but the behavior of all of the other group members in transactions involving all the others. The complexity of the cognitive task is several orders of magnitude greater with IDR than with DR, but more importantly, the very nature of the problem is different. Indirect reciprocity has been studied from both a theoretical and an experimental perspective using the concept of image scoring. (Nowak and Sigmund 1998 and Wedekind and Milinski 2000) Each individual has an image score that measures the degree to which the individual cooperated with other group members in the past, which we may assume is known by all players, though not perfectly. The image score reflects the reputation and status of the individual within a social network and it requires joint intentionality—we all recognize that we are in this social network together and that reputations are subject to continual group assessment and reevaluation. Cooperation occurs in the context of repeated nonsimultaneous exchange, for example, as with meat sharing, which was an important component of the hunter-gatherer (H-G) social order. Nowak and Sigmund find that "[c]ooperation wins in a computer simulation of indirect reciprocity" (Nowak and Sigmund 1998, p. 573), but that individual cooperation "depends crucially on the ability of a player to estimate the image score of the opponent." (Nowak and Sigmund 1998, p. 575) The evolution of reciprocal altruism—direct reciprocity—requires that individuals have sufficient cognitive capacity to recognize other members of their group, distinguish between defectors and cooperators by keeping track of the outcomes of past interactions and by maintaining appropriate mental accounting that reflects its obligations to each of the others and theirs to it. A mental account based on an image score used with IDR is much more cognitively sophisticated than the accounts necessary to facilitate DR. In particular, the formation of mental accounts needed for indirect reciprocity requires that the agent use a "belief-desire" psychology and theory of mind[4] (TOM) to understand and predict the behavior of other players. Importantly, the evolution of IDR where individuals cooperate with those who cooperate not just with them but with others in the group, is a product of the evolution of transitive trust relationships, where individuals trust those that they know other members of the group trust. (Apicella et al. 2012) The evolution of the transitivity of trust was an important component of the processes that resulted in ongoing cultural evolution. Importantly, with IDR individuals not only keep tract of the past behavior of others as with DR, but using TOM, attempt to predict their future behavior as well.

Alexander (1987) also suggests that *indirect nepotism* (IDN) may have been an important force in the evolution of complex cooperation. Evolution of direct nepotism is driven by Hamilton's rule, $rB > C$. The increased fitness benefit of indirect nepotism, relative to direct

[4] More detail on mental accounting and theory of mind, is provided below.

nepotism is a result of the fact that, among three or more siblings, for example, helping another is a non-rival good. If sibling 1 provides benefit *B* to sibling 3, sibling 2 receives the same expected fitness gain as sibling 1, without having to bear the direct cost *C*. Genes that bring about altruistic behavior satisfying Hamilton's rule will be favored by natural selection. Hamilton's rule seems to determine the limit of altruistic cooperation driven by inclusive fitness. The non-rivalness of altruism among individuals carrying the same genes allows for a relaxation of the Hamiltonian constraint, thereby increasing the total fitness gains from altruistic cooperation. Of course, as with all public-goods situations, free riding is a constant possibility, because the free rider gains a benefit without bearing a cost. Doug Jones (2000) presents several models of indirect nepotism, suggesting that the free-rider problem can be solved by "conditional nepotism," where two of the siblings, for example, will agree to help the third using the simple rule: I will contribute "*if and only if*" you contribute. Use of this rule, as with IDR, requires that individuals are forward looking and that the individual understands the other as intentional, and unlike direct nepotism, requires TOM and conscious calculation on the part of the participants.

Direct and indirect reciprocity and nepotism are commonly used to explain the evolution of pro-social or other-regarding preferences; however, they are incomplete theories and, in fact, these mechanisms by themselves cannot generate cooperative behavior. What is needed are specific environments, in particular specific social environments for these processes to function; kin selection and reciprocity by themselves do not explain why some animals cooperate and others do not, nor do they explain why only our ancestors became hyper cooperators. Also, important in fostering cooperation—in part by creating an enabling social environment—was the imposition of punishment on rule violators to provide further incentives to cooperate. Over and above providing proper incentives, Hare and Tomasello (2005) argue that punishment played an important role in the formation of a moderate human temperament in our ancestors and that that temperament made cooperation and ultimately ongoing human cultural evolution possible. "[O]ne might seriously entertain the hypothesis that an important first step in the evolution of modern human societies was a kind of self-domestication (selection on systems controlling emotional reactivity) in which a human-like temperament was selected (e.g., individuals within a social group either killed or ostracized those who where over-aggressive or despotic)." [5] (Hare and Tomasello, 2005, p. 443) Hare and Tomasello find that "cooperation among chimpanzees is highly constrained by [high] levels of inter-individual [in]tolerance." (Hare and Tomasello, 2005, p. 442) Human temperament and tolerance were important adaptations that contributed to the evolution of extremely other-regarding preferences that enabled complex cooperation, culture and ongoing cultural evolution. Below we will examine the evolution of the social environment that made that process possible, in the next section will look at the importance of tolerance for ongoing cultural evolution.

3 Tolerance and Cultural Evolution

Complex cooperation, including the teaching and learning associated with accurate cultural transmission requires a high level of interpersonal tolerance. The dominance hierarchies of chimpanzees did not foster the egalitarian tolerance seen in H-G bands and modern societies.[6]

> [In chimpanzees] [t]he number of available demonstrators may … be limited by the disparity between development of advanced physical cognition and the social tolerance of potential demonstrators. Social tolerance can play an important role in the spread of new behaviors. Adults are highly tolerant of infants, allowing young chimpanzees to observe their mother and other adults in close proximity. Free-ranging chimpanzees typically become proficient at extractive tool use between the ages of 4 and 5.

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[5] Boehm (2012) provides a brief review of actual punishment practices in hunter-gatherer bands.

[6] This tolerance is a product of the evolution of egalitarian cooperation within relatively small groups that coexisted with an in-group/out-group dichotomy. Tolerance existed between group members, whereas members of other groups were very often not tolerated. Civilization advances have been facilitated by the expansion of the size of the number of individuals tolerated.

> Individuals who do not learn during these years do not become proficient later. The few instances of metatool use (e.g., an anvil prop used to level a surface on which to pound nuts) have been observed solely in individuals over 6.5 years. Such tasks involve not only manual dexterity and motor control, but also demand sophisticated physical cognition. It is possible that when chimpanzees reach an age at which they are physically and cognitively capable of performing these higher level techniques, they are too old to have access to sufficiently tolerant demonstrators. Price et al. 2009, p. 3382

Intolerance reduced the transmission of cognitively demanding components of complex culture across generations among chimpanzees. Tolerance in humans facilitated the transmission of information about cultural artifacts that required "sophisticated physical cognition," which is necessary for the cultural ratchet. Tolerance made possible the cultural evolution of (cognitively demanding) complex, multi-component, hierarchically constructed tools and, as such, likely co-evolved with large brains and generative language. Importantly, the intolerance of older adolescent chimpanzees and adults also prevents the close cooperation seen between humans. In the next section, we will examine an important human trait that was a product of the evolution of our large brains and language, one that is necessary for complex cooperation and cultural evolution: theory of mind.

4 The Mind and Social Interaction

"Human social interaction depends on our ability to understand and predict other people's actions in terms of the psychological states that produce behavior: chiefly beliefs and desires. Much like visual perception, action understanding proceeds unconsciously and effortlessly but is the result of sophisticated computations that effectively solve an ill-posed inductive problem, working backwards from sparse data to rich representations of the underlying causes." (Baker et al. 2009, p. 329) To use what psychologists call "belief-desire psychology" to predict others' behavior is to make use of theory of mind (TOM). Theory of mind is one of the cognitive building blocks of complex human cooperation, and it is necessary for the human capacity to share attention and intentions. "[I]ndividuals have theory of mind if they have mental state concepts such as 'believe,' 'know,' 'want,' and 'see,' and individuals with such concepts use them to predict and explain behavior. Thus, an animal with TOM believes that mental states play a causal role in generating behavior and infers the presence of mental states in others by observing their appearance and behavior under various circumstances." (Heyes 1998, pp. 101-102) In other words, individuals who have TOM understand that others have mental states that contain beliefs and desires and also that those beliefs and desires influence those others' behavior. Individuals with theory of mind can use their general understanding of the determinants of beliefs and desires to predict the beliefs and desires of others and use those predictions to predict their behavior, an ability Baron-Cohen (1999) calls mind reading.

"Explaining [and predicting] an agent's actions in terms of mental states requires inverting a model of its planning process, or inverse planning: working backwards to infer the desires and beliefs that cause the agent's behavior." (Baker et al. 2009, p. 330) Necessary to the successful use of TOM to predict others' behavior is the implicit use of what Daniel Dennett (1987) calls the principle of rationality. The principle of rationality is "the expectation that intentional agents will tend to choose actions that achieve their desires most efficiently, given their beliefs about the world." (Baker et al. 2009, p. 330) "[T]he inverse problem is ill-posed. Its solution requires strong prior knowledge of the structure and content of agents' mental states, and the ability to search and evaluate a potentially very large space of mental interpretations." [7] (Baker et al. 2009, p. 330)

[7] Baker et al. (2009) provide numerous cites presenting the results of several experiments consistent with the inverse planning view of goal inference.

Since the point here is to examine why humans and not other animals are able to become hyper-social and ratchet up culture, an obvious question is: Do other animals have theory of mind? The answer is that there is no evidence that even our closest evolutionary cousin, the chimpanzee, has full-blown human type TOM. Rather than human-like belief-desire psychology, according to Call and Tomasello (2008) chimpanzees have a more limited perception-goal psychology, meaning that they understand the actions of others “in terms of the underlying goals, and possibly intentions.” (Call and Tomasello 2008, p. 189) Chimps can use past experience, knowledge of what the other perceives, and their underlying goals to predict the other’s behavior: “chimpanzees, like humans, understand that others see, hear and know things.” (Call and Tomasello 2008, p. 190) Thus, according to Call and Tomasello (2008, p. 191) “[i]n the broad construal of the phrase ‘theory of mind’, …chimpanzees do have theory of mind.”

Call and Tomasello discussed the results of several experiments. These experiments showed that chimpanzees were able to use perception-goal psychology only in situations involving competition for an immediate reward, they did not use their perception-goal psychology to facilitate cooperation to secure a reward. Furthermore, chimps do not engage in forward thinking to any significant degree so that, unlike humans, they cannot use TOM to engage in extended cooperation over space and time. Chimpanzees also do not have a level of TOM that would allow them to form the intersubjective triangle, which, as we will see below, is necessary for the types of complex, ongoing cooperation found in humans. Full-blown human TOM very likely requires language. Additionally—and very important for cultural evolution—this limitation and intolerance prevents chimps from engaging in perhaps the most important cooperative activity: the teacher and student relationship. It is also important to note that increased tolerance facilitates increased trust, which made large complex social networks possible. In the next section, we will examine the underlying structure of complex cooperation in the context of the intersubjective triangle.

5 Culture, Cooperation and the Intersubjective Triangle[8]

To help in understanding why humans and not chimpanzees are so cooperative and also capable of ongoing cultural evolution it will be useful to examine what social interaction and culture are made of, how they are possible, and the relationship between the mind, culture, public information and institutions. A major component of the human environment is social; cultural evolution, by facilitating the construction of that environment, allows for the social creation of cultural entities such as trust, property, conventions and institutions, which are mental constructs that are components of our mental models of the social world.

We take a basic unit of social interaction as single a cooperative event, but to understand both cooperation and culture it is important to understand that cooperative interactions between two individuals are triads, not dyads. At a minimum, a cooperation event does not just involve two individuals, it involves two individuals and the activity, event or object(s), that is the purpose or goal of the cooperation, and these triadic transactional relationships are not as simple as they may seem on the surface. Each participant shares a common understanding with respect to the cooperative activity, *but also each is aware that the other shares that understanding*. Culture as a social construct owes its existence, evolution, learnability, and usability to the intersubjective triangle (IST).

The existence of this construct and its ability to function depends upon the knowledge, social habits, capabilities, and dispositions in the minds of its users. Significantly, each user

[8] This section are based upon Gifford 2009b, also see, Dupuy 2004, Tomasello 1999 and Tomasello et al. 2005

knows at least implicitly that the other has roughly the same social knowledge, social habits, conventions capabilities, and dispositions—knowledge that is a property of TOM. Culture can be thought of as involving a very large number of overlapping intersubjective triangles, where at least a significant portion of those triangles include all members of the social group or society. That is, all members share common explicit and implicit knowledge of the basic components of culture, property, and the advantages of cooperative productive activities such as hunting. The object of joint attention in the IST can be a good that will be traded or a heavy object that they will move together; it can also be something not present, involving cooperative hunting in the future, for example, as well as something more abstract such as social structure, institutions, rules and conventions.

The importance of *Homo sapiens*' ability to participate in the intersubjective triangle cannot be overstated. This triangle, and the capacity for collective intentionality upon which it relies, not only facilitates complex cooperation, it makes possible the scaling up of individual interaction into complex spontaneous orders such as the multi-level alliances that facilitate the large social networks that exist in tribal systems. The implicit and explicit cultural knowledge that individuals share facilitates the complex social orders, which *make possible the efficient decentralized use of both the explicit and implicit private knowledge of individuals,* including various skills, abilities and talents, production technologies, and preferences. In the next section, we will examine how TOM and the IST made an egalitarian society possible among our ancestors and by doing so facilitated increased tolerance and trust as well as ongoing cultural evolution and complex cooperation.

6 The Difference Between Chimpanzee and Hunter-Gatherer Social Coordination[9]

Here, it will be useful to briefly examine non-sedentary hunter-gatherer (H-G) societies and the governance structure of these societies used in social decision-making such as (e.g., decisions involving cooperative hunting, when and where to move camp), as well as important conventions about the assignment and enforcement of the various rights of individuals over property and themselves.

Further, in this section three aspects of the human cultural evolution story necessary for both complex cooperation and cultural evolution will be discussed: 1) more on the evolution of tolerance and trust, 2) the evolution of the ability to maintain complex mental accounting, and 3) mental time travel. The dominant political feature of recent hunter-gatherer societies, and presumably that of Paleolithic hunter-gatherer societies as well, was egalitarianism. Although a dominant tendency among recent H-G societies was to share large game, this egalitarianism was primarily political, not economic.

> The term *egalitarian* does not mean that all members have the same amount of goods, food, prestige, or authority. Egalitarian societies are not those in which everyone is equal, or in which everyone has equal amounts of material goods, but those in which everyone has equal access to food, to the technology needed to acquire resources, and to the paths leading to prestige. The critical element of egalitarianism, then is *individual autonomy*. Kelly 1995, p. 296

Aside from meat-sharing, the egalitarianism of hunter-gatherer societies was based on equal opportunity, not equal outcome, and a strong desire for individual autonomy

To maintain their egalitarianism, H-G societies form a moral community in which a significant amount of effort is expended in social control through preventing or modifying antisocial behavior. According to Christopher Boehm (1999), the social arrangement was a

[9] Portions of this section are based upon Gifford 2002.

reverse-dominance hierarchy, where the group as a whole used various methods to prevent upstarts from gaining dominance, as well as to enforce other components of the social contract. It was this high enforcement cost per capita that made it difficult to extend egalitarianism to the much larger groupings of individuals that came into existence with agriculture. The high enforcement cost was a product of the active nature of the mechanisms of control: it was necessary for each individual, in essence, to continuously consciously monitor every other individual, which required that they all more or less directly share experiences.

Hunter-gatherers form an intentional moral community, the maintenance of which requires the biological and cultural evolution of several closely interrelated adaptations: 1) theory of mind and the IST; 2) a significant reduction in the rate of time preference; 3) the ability to plan for a much more distant future than could the great apes; 4) the evolution of ability to maintain sophisticated mental accounts; and, closely related to this last point, 5) the evolution of what Boehm (1999) calls actuarial intelligence (discussed below). It is the lack of these characteristics that prevents the great apes from overthrowing the dominance hierarchy under which they live and from generating any form of sustained cultural evolution. The ability to recognize others as intentional beings, along with other components of TOM, are the prerequisites for the formation and maintenance of a moral community that helped facilitate significant cultural evolution.

All decisions are about the future, but humans alone can decide things involving an extended future. In fact, Daniel Gilbert suggests that "[t]he greatest achievement of the human brain is its ability to imagine objects and episodes that do not exist in the realm of the real, and it is this ability that allows us to think about the future. …the human brain is an 'anticipation machine,' and 'making the future' is the most important thing it does." (Gilbert 2005, p. 5) The ability to imagine an extended future, called mental time travel by Suddendorf and Corballis (2007), seems to be a trait unique to humans, whereas other animals perceive and make decisions about only a local future.[10] Language and mental time travel facilitated an important human trait that made possible enhanced cooperation and the construction of our social reality, a reduction in the human rate of time preference compared to the relatively present orientation of the other mammals. (Gifford 2009a) Theory of mind and the ability to think about and plan for the long-run future underlay the ability to maintain sophisticated mental accounts—accounts that allow for the much more generalized and complex cooperation made possible by indirect nepotism and reciprocity.

An important trait that facilitated the formation of complex social networks is what Boehm calls actuarial intelligence. This is an outgrowth of the ability to maintain complex mental accounts, and it is the cognitive capacity to make complex plans about the future and view the world in a causal way. Actuarial intelligence is "…the intuitive human capacity, seen abundantly in hunter-gatherers, to think stochastically and to understand rather complex systems on an intuitive but statistically valid, predictive basis. Regardless of what drove human brains to be so large, one product was the generalized capacity to understand and manipulate complex systems of various types." (Boehm 1999, p. 183) Actuarial intelligence, when applied to the social sphere, allows individuals to compute the long-term costs and benefits of complex social cooperation and to maintain the complex forward-looking mental accounts necessary for the

[10] Recent research has shown that western scrub jays (Raby et al. 2007) and apes (Osvath and Osvath 2008) flexibly plan for the future. The apes saved a tool that would allow them access to a highly preferred fruit drink in the future. The jays cached pine nuts in a room that they had been locked in previously without food, facilitating future availability. In both cases, the animals sacrificed current rewards to provide for future reward access. Importantly, though, the future time frame in both cases was short (70 minutes for the apes and overnight for the jays), and the focus of the planning was a primary reinforcer.

system to function.[11] The H-G social system is an intentional system, a social construct that works because the members implicitly understand the net benefits of the system and consciously maintain the relatively costly enforcement mechanisms necessary for it to function.

Weapons were also important in maintaining egalitarianism in the band. Among apes, the dominant one tends to be the biggest and strongest in the band, and he maintains his position through that strength, losing dominance only when a stronger ape comes along. But among human beings, weapons were a great equalizer that allowed the group as a whole to constrain or eliminate a domineering leader. (Boehm 1999, pp. 82-83) Weapons, then, were likely a key part of the process of human self-domestication and the evolution of the human-like temperament .

Language, TOM and the IST allowed humans to organize a coordinated response to a domineering upstart, and weapons allowed the group to dispatch the upstart at much less risk to themselves than a chimpanzee faces when challenging a dominant male. Another important constraint on potential dominators is the human capacity for foresight that accompanied the evolution of language and larger brains. Humans can observe the fate of upstarts and, using TOM, project into the future a similar fate for themselves if they try to usurp the power and autonomy of the group. This ability to calculate future consequences of particular behaviors is simply another component of the forward-looking moral community that reinforces the deterrent aspects of the moral code. Apes are good at calculating the short-term consequences of their social behavior, but they lack the ability and foresight to calculate possible long-term consequences of their actions.

The chimpanzees—with a brain size approximately one-third that of modern humans, lacking language, TOM, the IST and weapons, and having a very high rate of time preference—

[11] The ability to form and maintain complex mental accounts in social contexts is the foundation of the image score.

can maintain order only by using a dominance hierarchy. Though chimps may feel empathy and sympathy for other apes (de Waal, 1996), they are not capable of understanding the long-term abstract nature of a socially constructed world, and consequently they are unable to bring about a system of voluntary social group decision-making and enforcement—making a dominance hierarchy necessary. Like humans, if they cannot be dominant, apes and presumably our hominid ancestors, would at least prefer not to be dominated, but they do not have the cognitive capacity to bring about such a state of affairs. Increased cognitive capacity lowered the cost of the move to and the maintenance of political equality. Big brains, language, greater memory capacity, TOM, the IST and extended foresight made possible the type of social organization and coordination that permitted the group to suppress attempts by upstarts to dominate. Weapons lowered the cost of intimidating and eliminating intractable upstarts and contributed to the domestication of our human ancestors, which facilitated increased social bonding and increased tolerance and trust. Along with these mechanisms of equality that fall under the heading of voice, non-sedentary hunter-gatherers could also choose the option of exit—they could simply leave, and join or form another band.

7 The Social Environment, Bonding and Cooperative Behavior in Our Ancestors

Cooperation will only evolve in the right environment and, in particular, the right social environment. Shultz et al. 2011, explored the evolutionary process that likely brought about that social environment in our ancestors. They correlated the social structure of 217 primate species with their phylogenetic relatedness and found that similarities in social behavior across primate species had a strong genetic component, making it possible to trace the genetic pathway of enhanced prosociality. The increase in primate group social complexity begins with a transition from solitary nocturnal foraging (74 million years ago) to loosely structured multi-male/multi-female social aggregations that accompanied the shift to diurnal foraging (beginning 52 million years ago) and then on to more stable bonded groups. This shift to "[g]roup living has long been argued to provide anti-predator benefits, and the shift to diurnal social living in primates would have opened up a vast new adaptive space in a highly visible world." (Shultz et al. 2011, p. 221) This initial increase in sociality in our primate ancestors was driven by the increased protection that groups provide prey species. Similar prey protection grouping is found in ungulates. Importantly, this shift to group living created the social opportunities for the evolution of trust, tolerance and social capital to get started.

An important step in primate social complexity was the evolution of bonded stable multi-male/multi-female social groupings, a transition that "may be a key step toward facilitating cooperative social behavior." (Shultz et al. 2011, p. 222) This transition to closely-knit bonded social relationships resulted in close female bonds that enabled cooperative breeding which reduced the high cost of reproduction borne by individual females. Closer bonds between males facilitated cooperative hunting and defense of resources. The next important transition was a shift to male/female pair bonding. Pair bonding facilitated the transition to intergroup pacification as distinct from the intergroup hostilities that exist between nonhuman primate social groups. Intergroup pacification allowed for the much more complex social structure in which smaller groups are members of a higher level social organization, resulting in the metagroup or tribe. The shift toward more complex bonding was the evolutionary outcome of stable multi-male/multi-female social groupings which ultimately led to pair bonding, intergroup pacification and the tribal structure, brought about by the evolution of big brains, relative to those of chimpanzees, and language. Increased cooperation made possible by the increase in trust that was the result of increased social bonding ultimately made possible intergroup cooperation and trade and most importantly it made possible cumulative cultural evolution.

8 Social Bonding and a Reduction in the Cost of Big Brains

Social bonding was significant in the facilitation of the evolution of big brains. Not only are big brains very costly, growing big brains is costly, as well. Tight bonding among females in a group facilitated cooperative breeding, which reduced the energy expended by reproducing females freeing up energy for brain expansion. (Navarrete et al 2011, p. 92) Pair bonding also allowed for the reduction of the female reproductive energy load and helped increase the birth rate in humans. Male provisioning during pregnancy and after birth facilitated the development of costly big brains. Further, the males and females specialized in the provisioning of the young with males providing the high quality nutrients contained in meat, a high-variance resource, and the females providing lower-variance gathered food resources. The cooperative shared provisioning provided by both males and females in the group was important because growing big brains meant that children had a long childhood and adolescence and were not capable of fully self-provisioning until their mid to late teenage years. Chimpanzees, with brains 1/3 the size of modern humans, are weaned at 4 years of age, at which point they are fully capable of self-provisioning. The cooperative provisioning that made large brains possible was a significant evolutionary transition for an additional reason: it facilitated weaning at age 2, allowing for an increased birth rate. This increase in birth rate was an important fitness-increasing byproduct of the evolutionary development of big brains. Finally, extensive bonding co-evolved with increased tolerance. In the next section we will examine the importance of a diet high in nutrients for the evolution of large brains, cooperation and tolerance.

9 More on the Cost of Big Brains

Larger brains resulted in a cascade of events that are key to the evolution of culture. "[G]ross energy production is directly related to a body's size…." (Dunbar 1996 p. 124) For a given body size energy production is relatively constant, and in order for more energy to be made available for a larger brain, other organs must use less. There are not significant substitution possibilities with the heart, kidneys, or liver; the cheapest means of freeing up energy was the evolution of a smaller gut. (Dunbar 1996, p. 125) Though a smaller gut will itself use less energy, it will, other things equal, absorb less energy from ingested food. In order to maintain sufficient energy input with a smaller gut an animal must eat foods that are either higher in nutrient content or that contain nutrients that are more easily absorbed. (Dunbar 1996 p. 125) This brain-gut substitution is sometimes called the expensive tissue hypothesis. An important additional cost is the significantly increased prenatal and postnatal nutritional contribution by the mother that is necessary for the development of our large brain. "…[This] maternal investment hypothesis, proposes that most of the extra energy comes early in life—from mom, through the placenta during pregnancy and through breast milk between birth and age 4, when the human brain reaches 85% of its adult size." (Gibbons, 1998, p. 1345) The expensive tissue hypothesis argues that big brains are costly for the individual to maintain, while the maternal investment hypothesis argues that big brains are costly to develop.

Consequently, as brain size expanded, our hominid ancestors significantly increased their consumption of meat because of its high energy and nutrition content. (Dunbar 1996 p. 127, Mithen 1996 p. 103) The gains to more complex social groups resulted in selective pressure for increased brain size/body mass ratio, which in turn resulted in an increased reliance on meat. "The appearance of the first stone tools nearly 2.5 million years ago almost certainly correlates with a radical shift in foraging behavior in order to gain access to meat." (Deacon 1997 p. 386) The appearance of tools, marking the appearance of, *Homo habilis*, corresponds with the first great *Homo* encephalization, increasing brain volume from approximately 450 cc to 750 cc, which began about 2.5 mya (million years ago). This increase follows closely the break between the first man, *Homo habilis*, and the earlier australopithecines, whose 450 cc brain was about the size of that of a chimpanzee.

Meat eating by itself was not sufficient to facilitate the evolution of bigger brains beyond this first encephalization event. A raw food diet cannot provide enough energy to fuel *Homo sapiens'* large brain. In fact, it was only when our ancestors began to cook their meat and plant materials that our brains could expand beyond the size of the Hablines. Cooking gelatinizes starches and denatures proteins—weakening their internal bonds and causes the protein molecule to open up—and makes them more easily digestible. (Wrangham, 2009) By making meat and plant matter more tender, cooking significantly increases the amount of energy that can be extracted from these food sources. Wrangham (2009) argues that the shift "from habilines to *Homo erectus*…. happened between 1.9 million and 1.8 million years ago and involved much larger changes in anatomy than any subsequent transitions." (p. 97) This transition was associated with a "reduction in tooth size, the signs of increased energy availability in large brains and bodies, the indication of smaller guts and the ability to exploit new kinds of habitat all support the idea that cooking was responsible for the evolution of *Homo erectus.*" (Wrangham 2009, p. 98) The "…disappearance of the shoulder, arm and trunk adaptations that apparently enabled habilines to climb well…[indicates that] *Homo erectus* climbed no better than modern humans…." (Wrangham 2009, p. 98) The changes in their anatomy suggest "that *Homo erectus* slept on the ground, a novel behavior that would depend on their controlling fire to provide light to see predators and scare them away." (Wrangham 2009, p. 99) Habilines likely slept in trees (as do modern primates) and thus had protection from ground predators at night.

Pair bonding was either a direct result of cooking or it "solidified a preexisting version of married life that could have been prompted by hunting or sexual competition." (Wrangham, 2009 p. 154) "Hunter-gatherer women sometimes collect food and fuel, tend a fire and do cooking without any support from their husbands…who are often off hunting." (Wrangham, 2009 p. 154)

> Having a husband ensures that a women's gathered foods will not be taken by others; having a wife ensures that a man will have an evening meal. Husbands used their bonds with other men in the community to protect their wives from being robbed, and women returned the favor by preparing their husband's meal. The many beneficial aspects in labor efficiency, and creation of a social network for child-rearing, were additions consequent to solving the more basic problem: females needed male protection, specifically because of cooking. Wrangham, 2009 pp. 154-155

Cooking brought about an increased amount of specialization in provisioning and food preparation and a significant increase in the time available for other productive activities by reducing the cost and increasing the efficiency of the food processing. These gains were only possible as a result of the evolution of enhanced social bonds, and cooperation, which increased social capital and trust leading to even further economic growth.

Enhanced bonding, in particular pair bonding, made possible the egalitarian social contract of early humans that itself made possible a evolutionary trait necessary for ongoing cultural evolution—trust. Without increased interpersonal trust the social transmission of culture is significantly impeded. Pair bonding, by significantly expanding kinship, made possible intergroup pacification, a key step in the evolution of pro-sociality, which is a key component of ongoing human cultural evolution. In the next section will begin to examine the evolution of primate kinship.

10 Primate Kinship

In his book *Primeval Kinship* (2008), Bernard Chapais, argues that the "germ of government…was…present in embryonic form in the group-wide kinship structures of nonhuman primates." (p. 267) Chapais finds that by tracing the path of the evolution of kinship and bonding we can discover what he calls the "deep structure of human society." (Chapais 2008, p. 24) Expanded kinship relationships significantly increased the number and extent of stable long-term socially bonded relationships, which reduced uncertainty, facilitating trust, cooperation and cultural evolution. As we will see below, components of the primate kinship structure are in essence institutional rules, which form the "germ of government." Nonhuman primate kin relationships obviously do not involve a symbolic understanding of kin relationships such as brother, sister, mother, father, and so forth and nonhuman primates do not understand kin at the biological relationship level. "Thus the term does not imply that individuals recognize genetic relatedness and consanguinity per se. Nor does it mean that individuals have any conceptual understanding or kinship and kin categories. Kin recognition merely implies that individual primates perceive certain *correlates* of the consanguineal kinship in others with whom they interact on this basis." (Chapais 2008, pp. 32-33) Kinship in this context identifies a relative as simply "a long-term and disproportionately familiar associate whose behavior in various situations has become more or less predictable." (Chapais 2008, p. 33) Kinship, then, is a product of close long-term relationships such as between mother and child or siblings raised together. Primate kin can be recognized as those much more likely than nonkin to provide comfort and security in certain circumstances, to participate in mutual grooming, "and act as a reliable ally against certain opponents in certain social contexts." (Chapais 2008, p. 33) Kinship relationships form the substrate of enhanced social capital and trust in primate groups, and because trust is a transitive, tight bonding and trust can spread to individuals who are not close kin.[12] Actual primate kinship relationships are the evolutionary product of bonding relationships and incest avoidance behaviors that are themselves a result of biological evolution.

11 Primate Incest Avoidance

Incest reduces individual fitness and as a result there is positive selective pressure for the evolution of behaviors that reduce the probability of mating with close kin. An important primate incest avoidance behavior that plays an important role in primate kinships and the evolution of cooperation and big brains is sex-based dispersal, where one sex—in primates it is usually the male—leaves the natal group at puberty. “Changes in dispersal behavior may be important in the evolution of sociality because in its extreme form, philoparty, one sex forgoes dispersal and remains in the natal range, resulting in kin structured groups. A switch to sex-based dispersal could therefore facilitate kin selection and the emergence of cooperative social groups. The extension of the mother-daughter bond to groups of related females also has been proposed as the fundamental relationship underpinning mammalian sociality.” (Shultz et al. 2011, p. 221) According to Chapais (2008) sex-based dispersal rules form part of the deep structure of human society and as such are an important component of the “germ of government.” (p. 24)

Male dispersal and promiscuous mating on the part of males creates another major component of the deep structure of human society, what Chapais calls uterine kinship in multi-male multi-female primate social groups. Male dispersal results in tight female kinship bonds,

[12] Apicella et al, (2012), find that transitivity plays an important role in social networks cooperation among modern hunter-gatherers.

since mothers and their daughters stay together after puberty. These bonds facilitate cooperative breeding.

Chimpanzees, and likely the last common human/chimpanzee ancestor, "mate promiscuously, with both sexes having multiple short-term partners. They exhibit male residence and female transfer [female dispersal], a pattern that translates into extensive patrilines of males that include their fathers, grandfathers, uncles, and other male kin [all living in the same group]. However, promiscuous mating involving multiple short-term partners means that patrilineal kin do not recognize each other, so this genealogical structure is to a large extent 'socially silent.'" (Chapais, 2011, p. 1277)

The next important kinship bonding step was a product of pair bonding. Pair bonding significantly increased primate kinship. It enabled the recognition of fathers because it resulted in close long-term relationships not only with mothers but between fathers and their sons and daughters, as well. Pair bonding "brought about the multifamily composition of human groups, with enduring associations between mothers and fathers enabling children to recognize their fathers. This in turn, made it possible for children to recognize their father's relatives; that is, pair bonding would reveal the underlying genealogical structure and create bilineal kinship." (Chapais, 2011, p. 1277) Pair bonding allowed males to recognize their daughters living in other groups and to recognize their daughters' spouses (their affines) and their grandchildren, and refrain from attacking them. "Similarly, grandfathers, brothers and uncles would recognize their transferred kin and their affines [their mates] instigating a state of mutual tolerance." (Chapais, 2011, p. 1277) Chapais argues that the close relationship between men and their dispersed kin, initially daughters, facilitated intergroup pacification because they maintained post-dispersal contact. Increased brain size led to increased cooperation that fostered greater male tolerance and pair bonding. Pair bonding significantly increased primate kin recognition that, along with increased trust and tolerance, facilitated a reduction in intergroup hostilities mediated, according to Chapais (2008), by the relationships between fathers and dispersed daughters and their affines and children. Peaceful intergroup relationships—allowing peaceful contact between a much larger populations of individuals—increased the rate cultural evolution and the fixation of that evolution and accelerated the rate of gene/cultural coevolution.

Intergroup pacification (IP) was a necessary step for ongoing cultural evolution, chimpanzees react violently when they meet members of other groups: without IP, social interaction between groups is not possible. "…[M]athematical models suggest that large interaction networks may be required for culture to accumulate. In small populations cultural innovations can be lost because of infrequent interaction between potential models and imitators and/or stochastic events that eliminate models with particular cultural knowledge." (Hill et al. 2011, p. 1288) Examples of this are "…the Northern Ache, isolated from their ancestral core territory in the 19th century, were unable to make fire by the time they were contacted in the 1970s…[and] Tasmanians [who] failed to maintain previously known methods for fishing when their island was cut off from mainland Australia in the early Holocene…." (Hill et al. 2011, p. 1288) The next section will examine in more detail the key trait necessary for intergroup pacification—pair bonding.

12 Pair Bonding and the Evolution of Big Brains

The equality in hunter-gatherer groups extended to a more equal distribution of sexual access brought about by pair bonding between a single male and female, as opposed to the dominant-male polygyny of, for example, gorillas, or the promiscuous mating found among Chimpanzees—where the dominant male attempts to monopolize mating. Pair bonding, however, puts great stress on the entire social structure. A solution of some mammals is that the pair can physically isolate itself, with both sexes protecting their territory by fighting off rivals. (Deacon 1997 p. 387) But large multi-male multi-female social groups, where at any one time some of the males and some of the females are off engaged in their various economic endeavors, place a great deal of stress on the pair-bond relationship. If males cannot be assured of a relatively high probability of exclusivity, or if females have to worry about resources being diverted to other females, the social structure will fail.

Pair-bonded individuals living in large groups, a feat accomplished only by *Homos*, will be unstable without a mechanism to control cheating. "Sexual jealousy may have the same roots in humans and other species, but in humans it involves something more abstract than just threatening behavior. Though philandery, cuckoldry and desertion are common consequences of reproductive competition in other species, adultery is more than this. It involves betrayal and there can be no betrayal without prior explicit or tacit agreements." (Deacon 1997, p. 400) These agreements, necessary for the stability of pair bonding in large groups, represent an important long-term institutional relationship that was recognized as such by the participants.

Each step of the evolution of social bonding relationships, initially between females in matrilineal groups, involved increased cooperation that required larger brains to avoid free-riding. Bonded pairs in multi-male multi-female groups faced the most difficult challenge a bonded relationship can confront, because of the constant opportunities for cheating and the potential cost of cheating—something supported by the fact that only our human ancestors were able to accomplish this evolutionary feat. Our ancestors' large brains required a long childhood and adolescence to develop, the evolutionary cost of which would only pay off with increased life expectancy that co-evolved with our large brains. Bonded male-female pairs became the root social unit of what would come to be a nested social hierarchy. The significant increase in kin recognition—now both male and female kin are recognized, as well as their affines—increased bonding and trust and facilitated further and more extensive cooperation.

According to Kaplan et al. 2000, our large brains co-evolved with a longer life span, lower childhood mortality and higher female fertility compared to chimpanzees, all of which contributed to increased fitness in humans. As a result, the evolutionary investment in our large brains paid off. Humans' ability to flexibly and creatively exploit high quality difficult-to-acquire resources required "high levels of knowledge, skill, coordination, and strength." (Kaplan et al. 2000, p. 156)

> Humans are specialists in that they consume only the highest-quality plant and animal resources in their local ecology and rely on creative, skill-intensive techniques to exploit them. Yet the capacity to develop new techniques for extractive foraging and hunting allows them to exploit a wide variety of different foods and to colonize all of earth's terrestrial and coastal ecosystems. Kaplan et al. 2000, p. 156

The ability to exploit many different environments requires that learned behavior play a significant role in the human life history relative to innate behaviors. A prolonged development period and a longer life overall provide both the time for significant learning and the time for that investment to pay off.

13 Kin Recognition, Intergroup Relations and Cultural Evolution—Wrapping Up

Increased kin recognition facilitated by pair bonding, made large-scale social interaction possible by increasing the scale of interpersonal trust. Intergroup pacification facilitated in our ancestors a form of social organization that made possible the complex multi-level cooperation between individuals in different groups and ongoing cultural evolution not seen in other primates. Hill et al., make the point that

> Hunter-gatherer residential patterns are…critical for assessing models of cultural evolution. If friendly visiting between groups is common and social network sizes are large, frequent interaction allows for increased observation of rare innovations that are unlikely to be discovered by individual learning. Under these conditions, costly social learning mechanisms are more likely to evolve, and cultural traits are more likely to accumulate complexity and efficiency. Thus the emergence of metagroup social structure might explain why humans, but not other social-learning animals, evolved the cognitive mechanisms that produce cumulative culture and why *H. sapiens* were able to replace other hominins as they spread out of Africa. Hill et al. 2011, p. 1286.

The same forces, of course, facilitated inter-group trade.

Chapais (2011) identifies six aspects of humankind's deep social structure that are common to all humans and not present in other primate societies. This deep structure facilitated strong social bonds between individuals in large multi-level groups. These bonds, facilitated tolerance leading to trust that, in turn, allowed for the creation of multi-group level social networks. This trust-based social capital was necessary for early human economic development.

> First, …human societies [are] multilevel, nested structures of alliances. Human groups are always part of more inclusive social entities, which themselves belong to even more inclusive structures. In contrast, the vast majority of primate societies are independent, single group structures. Second, the vast majority of human groups are communities of families formed by conjugal partners, most of whom are monogamous, a remarkably unique pattern in the primate order. Third, in large mixed-sex primate groups, either the males or the females move to another group, losing contact with their natal group permanently; dispersal is strongly sex-based. In contrast, human residential patterns are much more flexible, with both sexes staying or leaving. Chapais, 2011, p. 1276

Large brains, TOM and language allow humans to recognize their kin as kin and, as a result, they do not need to rely on the sex-based dispersal patterns used by other primates for incest avoidance.

> Fourth, because of dispersal in [other] primates, relatives of different sexes, for example, brothers and sisters, stop interacting with each other around puberty. The

> human pattern is strikingly different: Dispersed kin maintain lifetime bonds.... Fifth, in large mixed-sex primate groups, individuals have preferential bonds with their matrilineal (mother's line kin), but patrilineal kin recognition is either absent or limited and fragmentary. In marked contrast, kin recognition in humans is bilineal and of an unparalleled extent. Sixth humans maintain preferential bonds with their affines, or in-laws (spouses' relatives and relative's spouses). Chapais, 2011, p. 1276

Hill et al (2011) examine the residency patterns of 32 present day hunter-gatherer societies, and their data support Chapais' propositions. They find that most individuals in residential groups are not closely related. (Hill et al. 2011, p 1286) This characteristic allows individuals to have kin spread broadly throughout many groups within a meta-group structure. Lifetime kinship bonds and strong bonds between affines coupled with the transitivity of both bonding and trust between individuals likely made possible large social networks of trust relationships forging strong social capital within a large meta-groups. This social capital made possible by the evolution of large brains and language, facilitated extensive ongoing cultural evolution and, as a result, primeval economic development.

13 Conclusion

Human cultural evolution has been responsible for the dramatic changes in human circumstances over the last few million years and, even though our close relatives the chimpanzees and some other animals display forms of culture, there is little evidence of significant ongoing cultural evolution in nonhuman animals. The ratchet effect seen in human cultural evolution and not in that of other animals can be explained by several differences between humans and other animals: increased patience, other-regarding preferences and increased tolerance and trust, theory of mind, the ability to construct a complex social structures and the capacity for collective intentionality. These capacities ultimately facilitated pair bonding, which significantly increased kin recognition. Increased kin recognition made possible intergroup pacification that significantly expanded the size of our ancestors' social networks. The transitivity of trust within the large networks fostered large-scale social interaction facilitating trade and the spread of culture. These large social networks made possible ongoing cultural evolution, in part by facilitating the fixation of new aspects of complex culture. The evolution of large brains and language ultimately resulted in social capital founded on trust that led to the ongoing cultural evolution, which brought about significant spontaneous economic development.

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