

Human Evolution and Human History: A Complete Theory

PAUL M. BINGHAM

Man is an exception, whatever else he is. If it is not true that a divine being fell [to earth], then we can only say that one of the animals went entirely off its head.
G.K. Chesterton

Is it not reasonable to anticipate that our understanding of the human mind would be aided greatly by knowing the purpose for which it was designed?
George C. Williams

Since Darwin we have been in possession of two superficially dissonant facts. On one hand, humans are merely one of millions of animal species, all products of common ancestry. On the other, humans enjoy a level of ecological dominance that is spectacularly, qualitatively greater than that of any other animal that ever lived, including our closest relatives. Moreover, this unique ascendancy results from a complex suite of attributes that are each individually also unprecedented, including cognitive virtuosity, complex language, and an expanded ethical sense.

Paul M. Bingham is an associate professor in the Department of Biochemistry and Cell Biology at the State University of New York at Stony Brook. Dr. Bingham's research interests include molecular genetics, cell biology, evolutionary biology, and the human origins/uniqueness problem. Other contributions by Dr. Bingham and his collaborators include discoveries of the P element transposon in *Drosophila*, of the role of transposons in spontaneous mutation, of novel properties of transcriptional enhancers, of autoregulation of gene expression at the level of pre-mRNA splicing, of properties of intranuclear RNA transport, and, most recently, of a novel approach to cancer chemotherapy. Dr. Bingham is currently completing a book describing the implications of coalitional enforcement for human origins and human history.
pbingham@ms.cc.sunysb.edu

Collectively, these facts constitute the human uniqueness problem. In spite of its importance, the superficial complexity of this problem has frustrated attempts to resolve it. Though a vast body of earlier work produced important isolated insights, no earlier theory has proven complete or convincing.

I briefly review here a new resolution of the human uniqueness problem.¹ This new hypothesis appears to be the necessary theory-of-everything. It ostensibly accounts parsimoniously for every major nonstochastic feature of the human story from the origin of *Homo* approximately 2.0 to 2.5 million years ago through the present instant.

I use secondary, review literature where possible here to improve interdisciplinary accessibility. As well, I apologize to the many investigators whose important work could not be directly referenced because of length constraints.

SUMMARY OF THE THEORY

On the theory, unique human attributes all derive from social cooperation with members of the same species (conspecifics) independently of genetic kinship. This allows cooperation to be substantially expanded, ultimately indefinitely. (Nonhuman animals, presumptively including the

extinct immediate ancestors of humans, cooperate almost exclusively with the highly bounded set of conspecifics consisting of close kin.) Paradoxically, the vastly enlarged social cooperation among humans arises as a straightforward consequence of a novel capacity for a unique form of violence against conspecifics.

The local population of bipedal apes (australopithecines) immediately ancestral to the first members of *Homo* 2.0 to 2.5 million years ago acquired the capacity to reliably kill or injure adult conspecifics from a distance—remotely. They were the first animals in the history of the planet to be able to do this. This capacity resulted from their evolution of unique human virtuosity in throwing and clubbing, skills that are displayed in American baseball.

This novel remote-killing capability may have initially arisen for any of a variety of reasons—a new local scavenging or hunting adaptation, for example. However, it inevitably led to an unprecedented social revolution: large-scale kinship-independent conspecific cooperation.

This social revolution results, inexorably, from the pursuit of individual self-interest by remote-killing animals, as follows. When multiple remote-killing animals kill or threaten simultaneously, they achieve an unexpectedly large decrease in the cost or risk of enforcing individual self-interest. This requirement for simultaneity means that this strategy is viable only when the common, congruent, and thus, cooperative self-interests of large numbers of individuals are engaged. Equivalently, remote-killing animals are uniquely able to suppress

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or "manage" individual conflicts of interest.

The resulting enforcement of cooperation by collections of self-interested remote-killing individuals is referred to as coalitional enforcement. Collections of animals (humans) who thus engage in the resulting kinship-independent cooperation will be referred to specifically as coalitions. The optimal achievable individually self-interested adaptive strategy for a remote-killing animal is to participate in and respond to coalitional enforcement of kinship-independent cooperation.

In this theory, coalitional enforcement of kinship-independent social cooperation is the fundamental thing humans do, in the same sense that flight is the fundamental thing birds do. Without exception, everything uniquely human—language, cognitive virtuosity, and so on—is either a facet of this foundational adaptation or a subsidiary adaptation allowed by it.

Moreover, human adaptive technical sophistication is expected to be directly proportional to the sizes of our cooperative coalitions. Human coalition size is predicted by the theory to expand on an evolutionary time scale under appropriate, well-defined circumstances. As a result, the theory accounts in detail for each of the successive dramatic improvements in human adaptive sophistication observed throughout our two-million-year history to the present.

According to the theory, human coalitional enforcement has an approximately two-million-year evolutionary history. Thus, we enforce kinship-independent cooperation and respond to this enforcement by others throughout our lives with unconscious virtuosity that is analogous to the "instinctive" virtuosity with which a cheetah runs or a dolphin swims. This is crucial. Our lack of conscious access to some of the details of our motivations and those of our ancestors should not be allowed to foreclose analytical access.

KINSHIP AND SOCIAL COOPERATION

Our understanding of evolution by natural selection has improved enor-

mously during the last 35 years, with especially important contributions from George C. Williams, William D. Hamilton and John Maynard Smith. To borrow Richard Dawkins' pithy description, organisms are transient "vehicles" built under the control of potentially immortal design information.² The sole teleological "purpose" of these vehicles is to compete with other vehicles to generate new copies of this design information which, in turn, builds new vehicles, and so on, ad infinitum.

Among the many consequences of this logic is the pattern of animal so-

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cial cooperation. Animals sometimes cooperate with close kin, who are likely to share identical design information. In contrast, they generally compete aggressively with non-kin conspecifics.³

In striking contrast to all other animals, humans cooperate with conspecifics extensively and independently of kinship under appropriate circumstances. Recognizing this human novelty is the indispensable first step in building a coherent theory of human uniqueness. In the fol-

lowing section, I will turn to how expanded kinship-independent or non-kin cooperation emerged in the first humans about 2 to 2.5 million years ago.

Four subsidiary points will enhance understanding of these issues. First, the genetic design information building individuals in typical animal populations is 50% identical by recent common descent in parents, offspring, and full siblings, 12.5% in first cousins, 3.125% in second cousins, and so on.⁴ "Relatedness" falls off very sharply as a function of pedigree relationship. Thus, only very close relatives are typically treated as "kin." Second, notice that even close kin have residual, though reduced, conflicts of genetic interest. I use the term non-kin cooperation for simplicity; however, these residual conflicts of interest between close kin are sometimes also managed as a de facto consequence of coalitional enforcement. Third, there are reports of occasional kinship-independent cooperation among nonhuman conspecific animals. However, the significance of these is controversial.^{3,5} Moreover, even if taken at face value, these do not remotely approach the levels of kinship-independent conspecific cooperation seen in even the simplest human societies. Fourth, genetic kinship continues to influence human social behavior as expected.⁶ However, the uniquely human scale of social cooperation is largely independent of kinship. Note that human cooperation based on remote or fictive/classificatory kinship—in "clans," "tribes," ethnic groups, and nationalities, for example—is, in fact, kinship-independent cooperation.

THE INEVITABLE LOGIC OF DEATH FROM A DISTANCE

The suggestion that human social cooperation evolved as a sole consequence of the adaptive advantages of reciprocity manifestly fails to account for human uniqueness.^{3,5} Further, it has been recognized for at least 2,400 years that social punishment or enforcement might be important to human social behavior.⁷⁻¹² However, all other considerations of this subject to date have been too narrowly focused,

too vague, or, in a few cases, too confused to be generally useful. Among many unresolved questions were why, how, and when humans first came to use punishment and enforcement, how unique this was to humans, and how important or unimportant it is to human evolution and history. The coalitional enforcement hypothesis ostensibly answers these and other questions, in turn producing a robustly useful, very general theory.¹

To fully grasp how humans solved the non-kin cooperation problem we must first conceptualize the problem more clearly. The only way to win at the game of cooperating with non-kin for non-human animals is not to play in the first place. To comprehend this we begin with the simple logic of conspecific social competition—"cheating," from a cooperative perspective.

Cheating during non-kin cooperation—taking all the proceeds of a cooperative hunt, say—is immediately adaptive to the cheater. The cheater not only gets the food, he also deprives non-kin competitors. Moreover, each animal "knows" this. All animals try to be cheaters and all try to avoid being cheated. The first is difficult: Potential suckers are wary. The second is easy—simply do not enter situations where being cheated is a strategically viable outcome. This is how nonhuman animals actually behave under almost all circumstances. They attempt non-kin cooperation only in those relatively rare cases lacking significant conflicts of interest.

In principle, this logic is not inevitable, however. It can be changed if the cheater is subsequently punished. Under these conditions, his immediate benefit is offset by a subsequent cost.

The crucial question, then, is why nonhuman animals do not punish cheaters and cooperate systematically.¹³ The answer lies in the cost of punishment. A would-be conspecific punisher is forced to close with a comparable animal. He must strike with tooth and claw against an animal precisely as well-armed. Lion, mouse, or elephant, the dilemma is inescapable. This creates a profound barrier. The average cost of punishment is actually the same to both cheater and cooperator. The cheater has a 50% chance of

being injured or killed, but so does the punisher. There is no differential cost to the cheater and, thus, no net advantage to the cooperator.

It might be imagined that an outraged cooperator would recruit the help of other cooperators previously outraged by the same cheater. However, as the situation develops, only one or a few of these cooperators could actually close with the cheater. There isn't room for more in an animal that kills by direct contact, proximally as, for example, a lion does.

All the risk of punishing the cheater is finally borne by one or a very few individuals, no matter how many others are also outraged. Thus, this "cooperative" punishment is illusory. It inevitably collapses into strategically incoherent individual punishment.

Remote killing competence allows many animals to attack a target animal simultaneously. Under these special conditions, the risk to individual attackers is reduced as the square of their number.

However, there is one circumstance, and apparently only one, in which punishment is strategically coherent in practice. This occurs when an animal can kill conspecifics remotely rather than proximally. To understand this crucial, foundational point, we first generalize a law from the science of contemporary mechanized warfare, Lanchester's Square Law.¹⁴ The generalized form of this law states that the capacity to kill or injure at a distance by any means whatever has an unexpectedly large consequence, as follows.¹

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attackers is reduced as the square of their number. The details are straightforward. When a large number of individuals—say n —simultaneously attack a single target, the risk to each is reduced by a factor of n because the target is incapacitated about n times faster. Moreover, during this n -fold shorter conflict, the risk to each attacker is further reduced by a second factor of n because the risk of return fire from the target is distributed across n attackers. Thus, the total risk to n remote attackers is reduced by n^2 . This is an enormous effect. For example, each of 10 individuals attacking simultaneously experiences a 100-fold reduction in risk and each of 100 experiences a 10,000-fold reduction.

Now consider in detail the problem of punishing cheaters for an animal that can kill remotely. One individual cheats a second in a potential cooperative interaction. The victim is angry and he remembers. However, at the moment, he cannot cost-effectively do anything other than avoiding further cooperation with the cheater. The cheater moves on and victimizes others. Over time, a set of angry, cheated victims—say 10—accumulates.

The cheater has achieved an individual competitive advantage over each of the 10 as a result of his earlier cheating. Thus, each of the 10 has an individual interest in reversing the cheater's advantage by imposing a new cost on him—that is, by punishing him. If the 10 were lions, for example, they would still not act under most circumstances because action would require an approximately 50% risk of death or serious injury to the individual who actually closed with the cheater at denouement.

But if they are remote-killing animals, the 10 can attack simultaneously, each experiencing a mere 0.5% chance of death or serious injury. A competent cheater might well accrue sufficient relative individual advantage over time to render it cost-effective for individual victims to take this now-small risk. This logic obviously applies as well to cases where a number of animals are victimized simultaneously.

Is it not still in the individual interest of each of our 10 victims to hang back and not take even the 0.5% risk

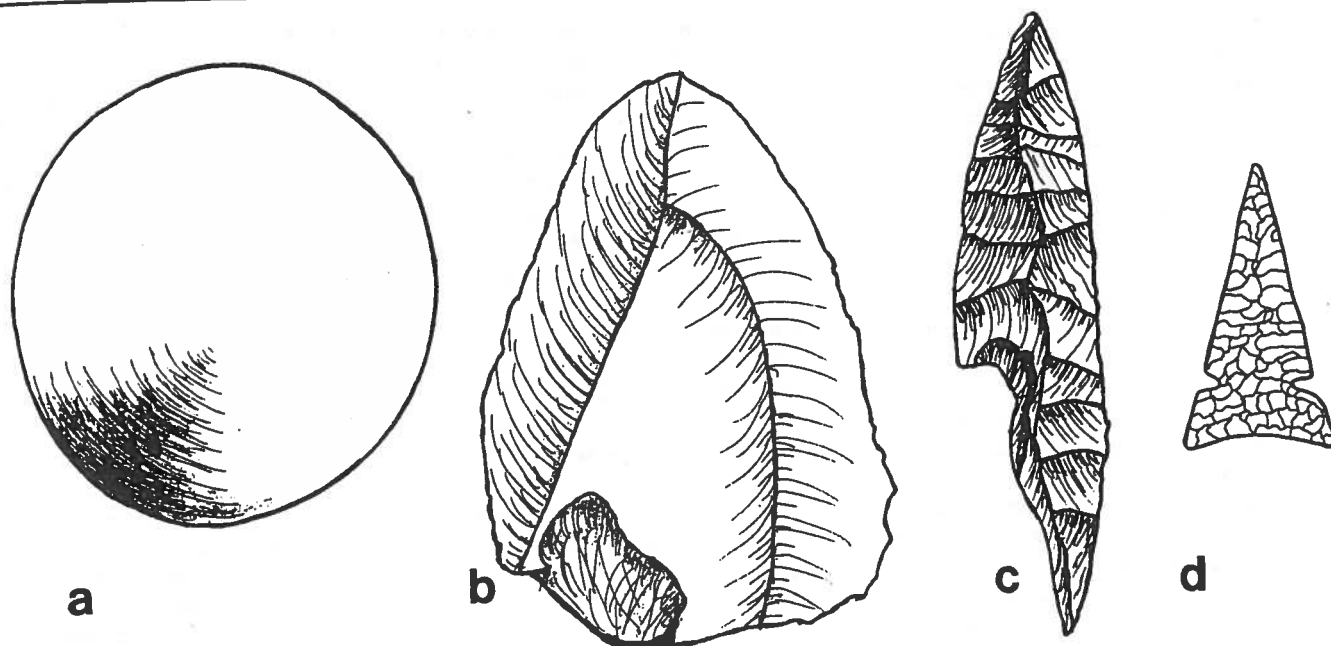


Figure 1. Stone tools: The first distance weapons. a) Water-polished cobble; b) Mousterian point from the Levant (ca. 55–65,000); c) Solutrian point made by behaviorally modern humans in Western Europe (ca. 18,000–22,000 ya); d) flint arrowhead from the American Midwest (ca. 1000 ya). Figures are approximately actual size. Humans have used weapons since the origin of *Homo* ca. 2–2.5 million years ago. All of these tools/weapons had multiple uses; however, on the coalitional enforcement hypothesis, their most fundamental use was in coercive enforcement of kinship-independent social cooperation.

involved in punishing? It would be, if he could get away with it. However, it is also in the individual interest of each of the remaining nine to coerce his participation, exploiting Lanchester's Square Law once again. Under these circumstances the original 0.5% risk of participating is vastly preferable to the nearly 100% risk of being punished for not participating.

Notice that for each of the 10 there is a corresponding set of 9 coercing his participation. As a result, each member of the ten actively participates in punishment as the optimal achievable or allowed individually self-interested strategy.

Notice the inevitable internal logic of this process. Cooperative punishment in a remote-killing animal evolves and is sustained entirely because of the moment-to-moment individual self-interest by each punisher. However, the only occasions on which individual self-interest can be thus pursued are when doing so is congruent with the interests of a large number of surrounding individuals, generally including remote kin or non-kin. Thus, the net effect of this very special set of individually self-interested ac-

tions is to generate a revolutionary new social environment: systematic kinship-independent cooperation.

According to the theory, the first animal in the history of the planet to develop this adaptation was precisely

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the animal that founded the *Homo* lineage about two million years ago. This animal acquired the first reliable means of killing adult conspecifics remotely when it evolved the human vir-

tuosity at throwing and clubbing and leading, in turn, to the inevitable social revolution. (See Figure 1).

THEORY AND EVIDENCE

Scientific theories are ultimately evaluated on two grounds, the economy with which they account for the empirical or experimental evidence and the level of precision of those accounts—parsimony and power. There is a large body of evidence that the coalitional enforcement hypothesis is highly robust by these criteria.^{1,15} I will briefly synopsise a few examples.

Language, Intelligence and Ethics

Before turning to explicit, material evidence from paleontology, archaeology and history, it is useful to consider contemporary human behavior and capability. The coalitional enforcement hypothesis accounts economically for human language. In principle, adaptively useful information can be acquired from other animals to great advantage. In practice, however, animals are expected to attempt to de-

ceive and mislead non-kin where possible.¹⁶ This is referred to as the hostile manipulation problem. As a result, information sharing with non-kin is like any other form of non-kin cooperation: The only way to win is not to play.

With the emergence of coalitional enforcement, the hostile manipulation problem becomes manageable for the first time.¹ Within coalitions, hostile manipulations such as lying can be cost-effectively punished, and providing reliable information independently of kinship can become common. This is a profound adaptive change.

Under these conditions, language is expected to evolve as follows in brief overview. Individual members of early *Homo* (about 1.6 to 2.0 million years ago) were the first animals to engage in coalitional enforcement. They exchanged substantially increased amounts of information as a result, using all available channels and modalities. Genetic adaptation continued to improve both generation of information (to mobilize potential cooperators) and comprehension (to coordinate with potential cooperators), culminating in the highly derived skills of contemporary humans.

Note that spoken human language may not be homologous to primate vocal calling.¹⁷ Moreover, spoken syntax might be based on the logic of symbolic gesture.^{18,19} Thus, spoken language could be a late, derived adaptation. If so, human virtuosity at information exchange through symbolic gesture¹⁹ and direct demonstration²⁰ could be significantly more ancient than speech, *sensu stricto*.

The coalitional enforcement hypothesis accounts for human intellectual and technological virtuosity in a straightforward way. To understand this argument it is necessary to add detail to the preceding discussion of the information controlling animal behavior. Mature animal minds and brains are complex adaptive devices built by design information. There are several sources of that information. First is genetic design information built by the trial-and-error of natural selection. Second are the information structures (memories) built during an individual's life by trial-and-error in-

teraction with the world (individual experience).

These two sources are powerful but finite, in the first case, in part, because of long response-time and mutational load limitations and, in the second, because of the costs and risks inevitable in interacting with the world. This last limitation can be overcome if information can be acquired from others who have already reality-tested it. Exchange of such information allows cost dispersal with concomitant increase in aggregate yield. However, in non-kin animals, most individuals from whom one could acquire this in-

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formation not only have no interest in providing it, but an interest in actively misleading: the hostile manipulation problem again.

As a result, nonhuman animals largely exchange information only with close kin. In the case of mammals, this is conspicuous in the "training" of the young by their genetic mothers, for example.²⁰ It has long been recognized that information of this form, acquired from some animals and transmitted to others, has some evolutionary properties that are similar to genetic design information.

I will thus refer to it here as extragenetic design information.

With the advent of coalitional enforcement of honest communication in early *Homo*, the number of individuals from whom one could acquire reliable information, now including non-kin coalition members, is expected to have increased substantially. Moreover, the reliability of information even from close kin is enhanced. These developments dramatically increased access to extragenetic design information; this is the basis of human intellectual and technological virtuosity.

Before leaving this subject, two second-order issues should be addressed that will be relevant later. First, the substantial costs, direct and indirect, of increasing brain size are strategically viable only with access to correspondingly increased amounts of design information. This can apparently only be provided through expanded social cooperation. Thus, increased brain size in the hominid fossil record indicates increased social cooperation.

Second, increases in individual human intellectual performance are ultimately limited by physiological, evolutionary, and obstetric constraints on brain size and structure: We can individually acquire and effectively use only a finite amount of extragenetic information. However, human adaptive sophistication can nevertheless continue to increase, potentially indefinitely. This results from another consequence of kinship-independent social cooperation, individual specialization and the capacity to exchange the products of extragenetic design information rather than the information itself. This provides indirect access to information.

This form of exchange is, of course, the central property of contemporary human economic systems. More generally, its importance in the following is that human adaptive sophistication is strictly limited by the size of the cooperative coalitions in which we live, which limit, in turn, our direct and indirect access to extragenetic information. Thus, all major increases in human adaptive sophistication will unambiguously require, and inevitably follow from, increases in coalition

size. This relationship not only emerges from first principles, but is also well supported by the archeological, ethnographic, and historical records,²¹ and will be essential when we turn to the coalitional enforcement hypothesis as a complete theory of history.

A conspicuous property of humans is our ethical sense. Nonhuman animals may, in fact, have a rudimentary ethical sense²²; however, the corresponding human capacity appears to be vastly more complex and powerful. The properties of the human ethical sense are very well predicted by the coalitional enforcement hypothesis.^{1,15} While the details of this complex story are beyond the scope of this brief review, two points are illuminating. First, moral outrage of characteristically human intensity, scale-of-reference, and time-frame arguably reflects precisely the psychological adaptation we would expect, supporting self-interested participation in coalitional enforcement. Second, the characteristically intense, abstract, and long-lived human sense of guilt is arguably the expected psychological adaptation for anticipating and avoiding becoming a target of coalitional enforcement.

The Hominid Fossil Record

The hominid fossil record provides strong support for the coalitional enforcement hypothesis.^{1,15} Indeed, the theory arguably represents the most coherent, complete account of this record currently available.

In brief, the argument is as follows. Within the limitations of the resolution of the record, the first animals whose remains show evidence for expanded social cooperation are the same as, or rapidly evolve from, the first animals whose fossil skeletons appear to be redesigned for human virtuosity at throwing and clubbing, as the theory rigorously requires and predicts.

First, expanded social cooperation can be scored in two interrelated ways. One is relative cranial volume. This increases significantly in *Homo erectus/ergaster* relative to the australopithecines immediately ancestral to *Homo* and continues to in-

crease for about 1 to 1.3 million years thereafter.²³⁻²⁶ On the theory, this is the predicted adaptation to the increased direct access to extragenetic information provided by non-kin cooperation. Moreover, independently of the theory, this is expected to result from increased social cooperation.^{27,28}

The other way increased social cooperation can be scored is through secondary altriciality, the derived adaptation of giving birth to highly dependent infants.^{27,28} Apparently, rapid fetal rates of brain growth are extended through the first 9 to 12 months of infant life to produce the enlarged brain size of *Homo*. However, this is also important here because successful rearing of such infants almost certainly requires ex-

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panded social cooperation; it clearly does in contemporary humans. Comparison of fossil pelvis (birth canals) and adult skulls indicates that the increase in brain size in early *Homo* involves increased altriciality.

Second, we can score "elite" throwing and clubbing in several ways.^{1,15} The human gluteus maximus muscle is an illuminating example.^{23,29,30} This muscle has been extensively enlarged and redesigned in us compared to our relatively under-endowed cousins, the chimps. Moreover, chimps throw and club with what is, by human standards, comic ineffectuality.

While the gluteus maximus muscle could be related to increased sophistication in bipedal locomotion, it appears to be rather over-powered and

badly designed for its relatively small role in this task. A telling question is when does this large muscle produce full output well fitted to its design? One of the very few occasions is when we throw and club.³⁰

The relevant features of this muscle are as follows. Imparting enough velocity to a thrown projectile to put a conspecific—a comparably sized animal—at risk from a distance is an extraordinarily demanding objective, which presumably is why this capacity did not evolve earlier in terrestrial history. Among other things, this effort requires the coordinated use of most of the body. The major parts of the body move in an extremely violent way. We drive forward off the back leg and then, in fierce, rapid-fire sequence, plant the front leg, rotate the hips, torso, and shoulders followed by whipping the arms and hands. The gluteus maximus muscles contract vigorously during these violent, rapid rotations of the trunk (See Figure 2).

The major portion of the gluteus maximus muscle attaches near the midline of the body close to the base of the spine (to the posterior portion of the iliac blade) and wraps around the hip laterally and downward, attaching to the outside of the leg at several points.²³ This is rather bad positioning for robust participation in the front-to-back leg movements of bipedal locomotion, but it is precisely appropriate for a muscle designed to produce the violent rotational acceleration and deceleration of the hips and torso involved in throwing and clubbing.

The theory predicts that the adaptation of the glutei maximi to throwing and clubbing should occur at or immediately before the rise of *Homo*. This appears to be the case. Based on fossil pelvic attachments, these muscles were enlarged in early *Homo* but not in the australopithecines.²⁹

The fossil records of possible transitional forms, including *Australopithecus garhi*, *Homo/Australopithecus habilis*, and *Homo rudolfensis*, are, as yet, too fragmentary to be fully illuminating here. However, the properties of these animals are apparently consistent with the requirements of the theory.^{1,15}

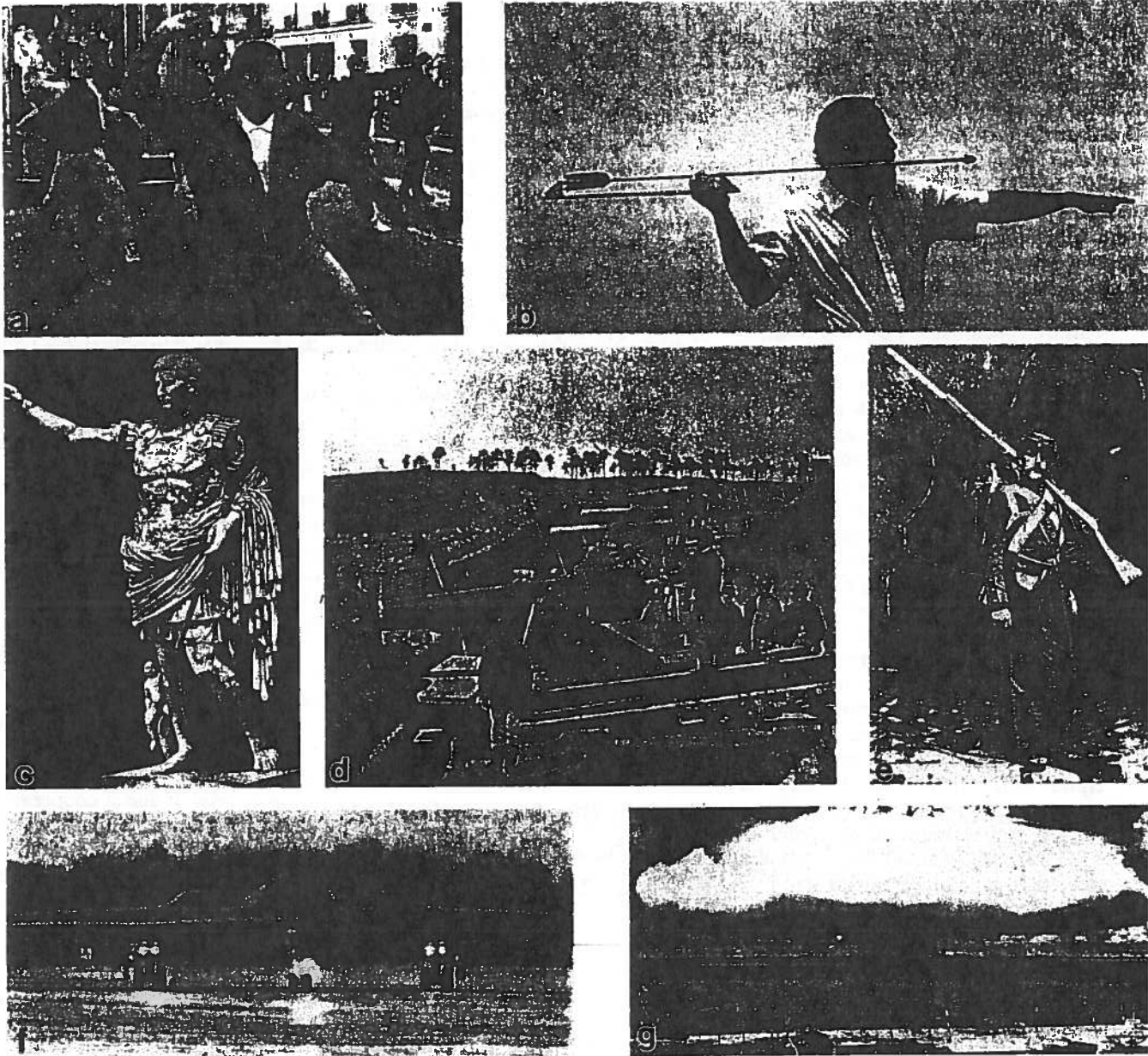


Figure 2. The evolution of distance weaponry. Distance weaponry permits the unique human adaptation of enforcement of kinship independent social cooperation. The range and performance of these weapons limit the size and internal structure of cooperative human coalitions. Using throwing and clubbing to cooperatively project threat for purposes of enforcing confluent interests in "political" conflict remains cross-culturally universal in contemporary humans (image a). The introduction and development of atlatls, spears, and sword characteristic of archaic states/empires (images b, c) and gunpowder weaponry (images d, e) ostensibly drove the consolidation of the modern nation-state. Further, the relationship between weaponry performance and human social structure apparently persists through the contemporary emergence of pan-global coalitions of nation-states driven by weaponry of planetary range and efficacy (images f, g). The introduction of atlatls or of advanced spears and body armor (images b, c) apparently drove various earlier changes in human coalition size and structure while gunpowder weaponry (images d, e) ostensibly drove the consolidation of the modern nation-state.

THEORY AND EVIDENCE: REPRISE

The coalitional enforcement hypothesis accounts not only for the hominid fossil record; it is apparently far more general. The theory ostensibly

accounts for the essential features of all major adaptive transitions throughout the entire two million years of human history through the present instant. These include the behaviorally modern human revolution, the diverse agricultural revolutions, and the rise of

the modern state, among others.^{1,1} On the coalitional enforcement hypothesis, the two-million-year human story is a series of adaptive revolutions: The rise of *Homo* was merely the first, but all of them have the same simple, fundamental logic.

NESTED HUMAN COALITIONS

To understand how the essential substance of human history emerges from our adaptation to coalitional enforcement, it is first necessary to consider how human coalition size can change.^{1,15} At first glance, it might appear that a single fundamental coalition form could increase indefinitely in size with time. However, it is clear on both empirical and theoretical grounds that this is not the case.

More specifically, various considerations limit fundamental coalition size. For example, the day-to-day management of conflicts of interest supporting non-kin cooperation requires monitoring of everyone in a human coalition by everyone else. This imposes costs that increase as a quasi-exponential function of coalition size. [In a coalition of n individuals, this monitoring burden is approximately $(n)(n-1)/2$ times a constant.¹]

Time and memory for monitoring are limited. Thus, fundamental coalition size is expected to increase to some sustainable maximum and increase no further pending a new circumstance. It is not clear on first principles what this maximal size is. However, empirical social science suggests an estimate of the order of 150 individuals.¹ It will be convenient to refer to a coalition of this size as a primary coalition. Because of the time-frame of monitoring, primary coalitions are relatively closed, exchanging members rarely. Cooperation therein is relatively fluid; reciprocity is frequently indirect and occurs only over relatively long time-frames.

Of course, contemporary human coalitions are immensely larger than 150 individuals—contemporary nation-states have populations up to about 1 billion, for example. The question is, what is the nature of these larger coalitions on the coalitional enforcement hypothesis?

It is possible to derive the answer from first principles.^{1,15} However, it is more transparent here to consider the wealth of empirical evidence. Specifically, large human organizations of all sorts—corporate, academic, military, religious, and political—are built by recursive nesting of modest numbers of subunits at each level. For example,

in the United States, small local institutions nest into cities or townships, these into counties or districts, these into states, and these into the contemporary American nation-state.

This recursively nested organization is largely controlled by extragenetic design information. Many layers or levels are relatively recent in origin. As a result, details are locally idiosyncratic. However, underlying patterns are robustly universal.^{1,15}

This nested organization overcomes various obstacles, including cybernetic problems. However, it does not inherently solve the monitoring problem. Rather, this is solved, in part, by requiring cooperation and exchange between individual members of different primary coalitions to be rigidly, instantaneously reciprocal and osten-

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tatiously public, dramatically reducing added monitoring with the addition of new organizational levels.

This much is relatively straightforward. However, enlarged, nested coalitional cooperation cannot evolve merely on its own merits for precisely the same reasons that extensive non-kin cooperation does not evolve in nonhuman animals. Understanding this is crucial to comprehending human history.

The logic and conflicts of interest of cooperation between different primary coalitions, for example, are robustly analogous to those of non-kin individual cooperation. This cooperation absolutely requires the capacity to punish socially parasitic behavior

in a way that is cost-effective for its individual human members. This, in turn, requires the technical means to exploit the generalized form of Lanchester's Square Law on the size scale of the number of individuals making up multiple primary coalitions. (It will be convenient to describe coalitions of primary coalitions as secondary coalitions, with secondary coalitions nesting into tertiary coalitions and so on.)

Simple human throwing, with an effective range of about 20 to 30 meters, is sufficient for enforcement on the scale of primary coalitions. However, the capacity to kill at much greater distance is necessary to allow all the individual members of multiple primary coalitions to share in the risks of punishing the members of a parasitic primary coalition, rendering secondary coalitions strategically sustainable. Moreover, for secondary coalitions to nest into tertiary coalitions a corresponding further increase in weaponry range and performance is required, and so on.

In fact, weaponry innovations are not merely permissive here. They actively drive the emergence of a new scale or level of social cooperation as the inevitable result of the individually self-interested actions of the members of their component coalitions, precisely analogously to the emergence of primary coalitions at the origin of *Homo*. Recall especially that humans are expected to be highly adapted to projecting coercive threat based on projectile weaponry.

Thus, the theory predicts a simple, unitary, inexorable logic to the entire human story. Kinship-independent cooperation at one organizational level emerges and is gradually refined to a quasi-stable steady state. Eventually, cooperation at this level, including access to increased extragenetic information, produces a novel weapon technology with substantially improved range and performance. This, in turn, drives a corresponding new expansion of the scale of social cooperation, and so on.

The paleontological, archeological and historical records are in remarkably robust agreement with this prediction of the theory, from the initial emergence of *Homo* to the contempo-

rary coalescence of a pan-global coalition of nation-states driven and sustained by weaponry of planetary range. One specific, illuminating example of this recurring process is described in more detail in the following section.

Before leaving this issue, I note two subsidiary points. First, the cost-benefit structure of acquisitive, offensive warfare is somewhat different from that for steady-state enforcement of social cooperation. However, social structures that are solely dependent on conquest and domination are inherently unstable, transient. Our interest here is in long-lived, quasi-stable social cooperation. Second, as the scale of human coalitions increases, two interrelated changes occur. Coercive violence is partially co-opted by larger organizational levels. Moreover, individuals can simultaneously be members of multiple cross-cutting smaller subunit coalitions, though they generally have membership in only one coalition at the largest or highest organizational levels.

PRECONTACT NORTH AMERICAN AGRICULTURAL AND ADAPTIVE REVOLUTIONS

During the last 10,000 years,³¹ various agriculture "revolutions" occurred at diverse locations around the world and at different times. Many questions arise. For example, we can ask "Why not 20,000 or 40,000 years ago?" and "Why 10,000 years ago in the Middle East and only 1,000 years ago in North America?" These represent examples of the many previously intractable explanatory challenges that now are susceptible to straightforward interpretation on the coalitional enforcement hypothesis.

Agricultural revolutions have traditionally been viewed as causes; they are presumed to result from some poorly understood accretion of expertise or material and, in turn, to drive further increases in social complexity.^{21,31}

According to the coalitional enforcement hypothesis, this view is essentially backwards. Agricultural revolutions were primarily effects, and only secondarily causes. More specifically, agricultural revolutions are

merely specific cases of the general phenomenon of net increases in adaptive sophistication produced by systematic increases in the size and scale of local human coalitions, which are driven, in turn, by weaponry innovation.

The late precontact North American record of the coming of the bow provides an especially illuminating example. The bow represented a substantial improvement in performance characteristics over its antecedent, the atlatl. The theory predicts that the bow will drive a significant expansion in social cooperation with a corresponding improvement in adaptive sophistication. This prediction is remarkably well fulfilled.

The bow apparently originated in North Africa or the Middle East.³² It spread outward from this area, apparently crossing the Bering Strait into

... weaponry innovations are not merely permissive here. They actually drive the emergence of a new scale or level of social cooperation . . .

the Western Hemisphere. The bow entered what is now the lower 48 American states around 400 to 600 AD.³³⁻³⁵

In the wake of the bow, dramatic local increases in adaptive sophistication, including, but not restricted to, agricultural revolutions, occurred throughout North America. For example, people in what is now the United States lived for many centuries with relatively simple adaptations, including hunting-gathering and simple horticulture. The last of these adaptations include, for example, the Hopewell in the Midwest³⁶⁻³⁸ and the early Basketmakers in the Southwest.³⁹

However, within several hundred years of the introduction of the bow, the vastly more sophisticated Mississippian adaptation, with field agriculture and large "towns," was estab-

lished in the Midwest.³⁶⁻³⁸ Similarly, the extensive agriculture and "public works" of the Hohokam and Anasazi in what is now the American Southwest rapidly followed the bow.^{33,39}

Moreover, nonagricultural adaptive revolutions also occurred elsewhere in North America with remarkably similar chronology. Estuarine fishers of southern Florida, buffalo hunters of the Great Plains, and salmon fishers of the Northwest are among striking examples.⁴⁰⁻⁴⁴

CONCLUDING REMARKS

Coercive violence exploiting the uniquely human capacity to kill remotely is apparently essential to all human social cooperation above the level of tiny kinship groups. According to the theory, this will remain so, inevitably and forever. At first glance this may seem grim, appalling. However, ultimately, it arguably is not. Indeed, it is precisely the contrary.

It is only because of this human capacity that our social lives are not overwhelmed by the trivial conflicts of interest that dominate, brutalize, and degrade the lives of nonhuman animals. The mobilization of coercive threat in defense of confluent human interests provides the only possible foundation for what we cherish most, our common humanity. This was and remains the sole sustainable selective force producing virtues like integrity, compassion, and justice among us.

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