



The evolution of war and its cognitive foundations

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ARTICLE INFO

Keywords:

War
Coalitional aggression
Cooperation
Cognition
Conflict

ABSTRACT

Coalitional aggression evolved because it allowed the participants to promote their fitness by gaining access to disputed, reproduction-enhancing resources that would otherwise be denied to them. Few species engage in coalitional aggression, even though the social conditions that would favor its evolution seem to be widespread. Why? Forming coalitions to exploit these opportunities requires individuals to solve highly complex and specialized information processing problems involving cooperation, coordination, and social exchange. The difficulty of evolving cognitive mechanisms capable of solving these problems—especially when the individuals involved are not kin—may explain why multi-individual coalitions are phylogenetically rare. We propose that humans and a few other cognitively pre-adapted species have evolved specialized cognitive programs that govern coalitional behavior, which constitute a distinctive *coalitional psychology*. To derive a preliminary map of this psychology, we started with a task analysis of the adaptive information-processing problems that arise during coalitional aggression. This exercise can shine light on our evolved psychology because algorithms that motivate and organize coalitional aggression would need design features that solve these problems well to be favored by selection. These problems include decisions about when to form a coalition or join one, when to initiate an attack, and how to allocate the costs and benefits that result from coalitional action. The *risk contract of war* identifies circumstances under which natural selection would favor decisions to initiate an attack. When the conditions of this model are met, mortality rates will not negatively impact the fitness of males in the winning coalition. This outcome has implications for the design of computational systems that motivate coalitional attacks; it may explain why warfare is so favored an activity among men, despite its risks to the participating individuals' welfare.

Author's note

John Tooby presented this paper, “The evolution of war and its cognitive foundations”, in 1988 at the Evolution and Human Behavior Meeting (a precursor to HBES) in Ann Arbor, Michigan. At that time there were few, if any, places you could publish a theoretical paper like this, so it has existed ever since in our files as *Institute for Evolutionary Studies Technical Report 88-1*. Once pdfs came into existence, we posted it on the *Center for Evolutionary Psychology* website; somehow people found it, to judge from its citation footprint. I'm delighted that it can finally appear in a journal. John and I could not have hoped for a better place than *Evolution and Human Behavior*.

The core idea is that our cognitive architecture includes a *coalitional psychology*: a set of neurocomputational systems that evolved to regulate within-group cooperation and between-group conflict in the vanished world of our hunter-gatherer ancestors. These systems regulate

motivations for participating cooperatively in coalitions, policing their boundaries, and interacting with outgroups. I remember the shock and wonder on John's face when he grasped the most counter-intuitive implication of this model: that motivations to initiate a coalitional attack could be selected for if certain conditions were met, *even if the probability of death was high*. He called these conditions “the risk contract of war”.

Our technical report was written when evolutionary psychology was new, before the idea that behavior is produced by information-processing mechanisms was common currency, and before most people realized that important, recurrent adaptive problems would select for cognitive mechanisms that are specialized for solving them. We could not take these points for granted in 1988. From the perspective of 2025, they seem superfluous, but I kept them in to preserve the manuscript's original flavor. The edits are light—some sentences were too long for human working memory, and others suffered from the curse of

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<https://doi.org/10.1016/j.evolhumbehav.2025.106687>

Received 30 March 2025; Accepted 2 April 2025

Available online 16 April 2025

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knowledge. So occasionally I added a few sentences to state the implications more directly.

Over the years, John and I wrote more extensively about some ideas from this paper. I annotated references to those later publications in a “further reading” section at the end (8). John wanted to write a book pulling together everything he had worked out about the social dynamics created by our coalitional psychology. He thought awakening people to these dynamics might help us—humanity—avoid some of the terrible suffering our coalitional instincts cause. Unfortunately, he ran out of time. Before he died, I promised him that I would try to do some of this for him. This is a first installment.

1. Introduction

Many evolutionarily-oriented researchers, including Darwin, have argued that war may have played a significant role in human evolution (e.g., Alexander, 1971, 1979; Alexander & Tinkle, 1968; Darwin, 1871; Tooby & DeVore, 1987; Wrangham, 1987a, 1987b). Nevertheless, there are few detailed analyses of the dynamics of selection on coalitional aggression (Wrangham, 1987a). Alexander and Tinkle (1968), followed by Durham (1976), provided the first extended attempts to synthesize modern evolutionary thinking with the phenomenon of war in humans. Both papers represented efforts to break with traditional approaches to war that have predominated in the social sciences: ones that see war as resulting from cultural and social processes that are divorced from any individual or biological function, or expression of individual psychology. Despite these efforts, warfare and its attendant behaviors have not yet been fully assimilated into Neo-Darwinian evolutionary theory. The gap between group-level behavior and individual adaptation is broad and difficult to close. Daly and Wilson (1982, 1988) and Chagnon (1988), in careful and illuminating work, began to close the gap by carefully building upward from individual behavior, with portrayals of group-level phenomena built up out of analyses of individual violence-related choices and actions. These studies reintroduced a welcome and much needed empiricism into the discussion of these questions.

However, many aspects of how aggression functions adaptively within the context of contending coalitions remain unexplored and even puzzling. For example, even the basic question of how coalitional aggression can be made fully consistent with the individual- or genic-level selectionist thinking of modern evolutionary biology remains unresolved (see, e.g. Boyd & Richerson, 1985). Moreover, war is dangerous and costly. Even where it is not mutually injurious or lethal to the participants, it is difficult to see why any sane organism, selected to survive and genetically propagate, should seek so actively to create conditions of such remarkable personal cost and danger. Yet studies of chimpanzees (Goodall, 1986; Nishida, Hiraiwa-Hasegawa, Hasegawa, & Takahata, 1985; Wrangham, 1987b) and humans (Chagnon, 1983, 1988; Durham, 1976; Fried, Harris, & Murphy, 1968; Otterbein, 1970) indicate that, with regularity, at least one coalition voluntarily chooses to initiate coalitional aggression. Even a cursory examination of human history reveals case after case where warfare is sought, prized, and glorified by at least some part of the local social group.

An evolutionary perspective leads one to expect that any behavior repeatedly manifested by a species is likely to have a significant adaptive basis. It seems likely that most proponents of an evolutionary perspective would judge that the adaptive significance of coalitional aggression was similar to the adaptive significance of individual aggression: victors participating in larger and more successful coalitions gained differential access to scarce resources denied to members of the losing coalition—resources that benefitted themselves or their kin. However, although analysis should certainly start from such a perspective, it cannot end there. War is not simply individual aggression writ large. Groups are not individuals: incorporating multiple individuals into an analysis of the dynamics of selection on coalitional aggression reveals both unaddressed problems and important differences from the case of individual aggression.

We propose that the distinctive and frequently surprising features of war stem from an underemphasized dimension: *cooperation*. A fight is an aggressive conflict between two individuals and involves no cooperation. But a war is an aggressive conflict between two *coalitions* of individuals and would not be possible unless each coalition were able to coalesce, function, and sustain itself as a group of cooperating individuals. We suggest that a detailed analysis of the evolutionary dynamics of cooperation in the context of coalitional aggression may explain:

1. Adaptive obstacles in the evolution of coalitional aggression
2. Why war is so rare among animal species, and
3. Why, nevertheless, it is so easy to generate conditions in which human males find initiating warfare psychologically appealing.

2. The evolution and natural history of cooperation and coalitional aggression

Recent theoretical and empirical advances in evolutionary biology and game theory (Axelrod, 1984; Axelrod & Hamilton, 1981; Maynard Smith, 1982; Trivers, 1971) have shown that, in the absence of kin selection, cooperation cannot evolve and function stably unless certain conditions are met:

1. Social or ecological conditions must create frequent and recurrent situations where there are enhanced payoffs to cooperation.
2. Cooperators must be able to identify when other participants are not reciprocally cooperating, and who these cheaters or defectors are.
3. Cooperators must be able to exclude cheaters (defectors) from taking the benefits of cooperation without having paid the costs or, failing that, they must be able to exclude cheaters from future cooperative interactions that they could exploit.

These principles describe the narrow envelope of preconditions that allow cooperation to evolve among social organisms. Instances of such cooperation, while not common, occur with regularity among various animal species, including social primates.

Not only do animals cooperate in such things as predator vigilance and foraging, but there is sometimes cooperation in aggressive competition as well (Packer, 1977; Packer & Pusey, 1982). However, it is a major puzzle why animals do not cooperate in aggressive conflicts far more often than they do. There frequently appear to be situations that would favor their doing so, but in which such cooperation is absent. Presumably, selection would favor the formation of aggressive coalitions whenever two or more males who are excluded from reproduction could physically cooperate to break another male's reproductive monopoly. For example, among elephant seals (Le Boeuf, 1974) or Hanuman langurs (Hrdy, 1977), single males are often able to defend and monopolize groups of females against large numbers of male competitors. Why don't excluded males who cannot singly best the resident male form aggressive coalitions, and through cooperation gain access to reproductive opportunities otherwise denied to them? This set of conditions seems widespread, and yet far fewer species manifest coalitional aggression than would be expected on the basis of the actual distribution of social conditions that would favor its evolution. (The special selection pressures on social insects require that they be analyzed separately.)

When one restricts the focus to vertebrate species where *multi-individual* coalitions of males aggressively compete, reports are rarer still, and only two species are known to exhibit warfare, defined in this fashion, as involving coalitions with more than four individuals: common chimpanzees (Goodall, 1986; Nishida et al., 1985) and humans. Recent findings suggest that bonobos (Kano & Mulavwa, 1984) and dolphins (Wrangham, pers. comm.) may also belong in this group.

3. Cooperation depends on sophisticated cognition

The observation that many expected coalitions do not exist parallels Sherlock Holmes' observation of "the dog that did not bark": the absence of the phenomenon indicates an important and neglected aspect of the problem. The phylogenetic distribution of these species suggests an answer to why coalitional aggression is so rare: humans, common chimpanzees, bonobos, and dolphins are arguably the most cognitively sophisticated social animals known. With certain exceptions stemming from ecologically enforced anti-cheating causal webs (e.g., a cleaner fish you have eaten cannot subsequently clean you of ectoparasites), cooperation depends on the ability to detect, identify, and exclude cheaters. The exploitation of such opportunities depends on the solution by individuals of highly complex and specialized information processing problems of cooperation and social exchange (Cosmides, 1985; Cosmides & Tooby, 1989).

Cognitive mechanisms regulating reciprocation and social exchange cannot be explained by invoking "culture", "intelligence", or any other purely domain-general form of learning. They must be adaptively designed information processing systems that are specialized for these functions—what Cosmides called Darwinian algorithms (Cosmides, 1985; Cosmides & Tooby, 1987, 1989; Tooby & Cosmides, 1989). Following the method adopted by Chomsky to show that operant conditioning could not explain language production or acquisition (Chomsky, 1957), it can be shown that cognitive mechanisms thought to be general purpose (operant conditioning might be an example) cannot account for many kinds of cognitive performance. Indeed, a human being equipped solely with generalized cognitive abilities could not survive, and would not be produced by evolutionary processes in the first place (Cosmides, 1985; Cosmides & Tooby, 1987).

Recent empirical studies confirm that humans do indeed have Darwinian algorithms specialized for reasoning about social exchange (Cosmides, 1985, 1989). Hunter-gatherer studies (Lee & DeVore, 1968), paleontological evidence (Isaac, 1978), and behavioral ecological considerations (Tooby & DeVore, 1987) all indicate that dyadic cooperation and reciprocity have been persistent features of hominid sociality for several million years. Through a series of experiments manipulating the materials subjects were asked to reason about, the existence of specialized Darwinian algorithms for reasoning about dyadic cooperation was verified: they include a subroutine specialized for detecting cheaters (Cosmides, 1985, 1989; see also Cosmides & Tooby, 1989).¹

When the coalition includes more than two individuals, the cognitive problem becomes far more demanding. Tracking the performance and levels of participation of multiple individuals over time and through ambiguous situations with limited information—not to mention orchestrating one's behavior so that it meshes simultaneously with that of several others—requires extremely sophisticated cognitive mechanisms. As will be discussed below, preliminary analysis indicates that cognitive programs designed to regulate adaptive behavior in coalitions must have additional specialized design features different from those required for engaging in dyadic social exchange (Tooby, 1987).

It may be that the distribution of war in the animal kingdom is limited by the same factor that limits the emergence of the multi-individual cooperation on which war depends: the cognitive prerequisites necessary to exclude cheaters from benefiting from joint action as much as, or more than, genuine cooperators. Returning to our prior examples: by teaming up to oust the resident male, male elephant seals and langurs could change their reproductive success from zero to positive. They would need to coordinate their attack and share the reproductive opportunities that result when they win. Yet they do not. We suggest that the barrier to the evolution of such coalitions was cognitive: these species did not have the cognitive pre-adaptations

necessary for the emergence even of enduring dyadic coalitions, of the kind that baboons can orchestrate (Packer, 1977). It seems plausible that such cognitive or evolutionary psychological factors may help to explain the disappointing discrepancies between theory and observation in socioecology (Tooby, 1987; Tooby & DeVore, 1987).

Chimpanzees and humans appear to have the cognitive mechanisms it takes to observe, assess, and regulate the appropriate pattern of response toward several different males structured into a coalition (see, e.g., de Waal, 1982; Cosmides, 1985).² We propose that humans and a few other cognitively pre-adapted species have evolved specialized Darwinian algorithms (cognitive programs) that govern coalitional behavior, which constitute a distinctive *coalitional psychology*. Our belief is that innumerable instances of coalitional conflict in the Pleistocene among hunter-gatherer bands (living more densely than do modern relict populations of hunter-gatherers [see Alexander, 1979]) selected for psychological mechanisms regulating thought, emotion, and behavior within and between coalitions, independently from any cultural process. We have inherited these psychological mechanisms, which are now functioning (or more commonly, malfunctioning) in vastly changed contexts. By exploring the selective pressures and consequent cognitive mechanisms that would have operated under conditions of primitive war, one can derive a preliminary map of the psychological characteristics modern humans bring to situations of modern conflict. Traces of Pleistocene design determine how humans think about, and how they feel about coalitions, intergroup competition, and war.

4. The evolution of specialized cognitive mechanisms to regulate coalition participation

Evolutionary considerations indicate that for recurrent, evolutionarily important situations, the psyche will evolve specialized information processing procedures, Darwinian algorithms, which can handle these situations with special efficiency (Cosmides, 1985; Cosmides & Tooby, 1987; Symons, 1987). These programs, or algorithms, should organize information into adaptively meaningful units, focus attention on adaptively important environmental circumstances, call up specialized inference networks, and so on, allowing the animal to solve such recurrent problems using procedural knowledge built up over thousands of generations. The question is, what kind of Darwinian algorithms regulate coalitional aggression in humans?

Cooperation in aggressive coalitions involves strategic social behavior: the best response depends on what other social actors can be expected to do. It cannot evolve unless the psychological mechanisms that cause it satisfy certain requirements, and these requirements can only be realized by the psychological mechanisms of the participants. Detecting cheaters is one example: this ability is necessary for cooperation to evolve, but mechanisms that solve this problem are properties of an organism's psychology, not its ecology.

Coalition formation, maintenance, and war are behaviors; these behaviors are produced by psychological mechanisms. To be maintained by natural selection, these mechanisms need to embody decision rules (strategies) for engaging in coalitional aggression that are evolutionarily stable. And which rules are evolutionarily stable will depend crucially on the psychology of other individuals in one's social world. So, to understand the cooperative basis of war, one must understand more than the evolutionary game-theoretic structure of multi-individual cooperation, as it would have applied to tens of thousands of generations of our ancestors. One must also understand the cognitive mechanisms that

¹ This research continued; for reviews see Cosmides, Barrett, & Tooby, 2010; Cosmides & Tooby, 2008, 2015 in Further Reading (section 8.4).

² Later work by Richard Wrangham and his colleagues showed that the main fitness-promoting resource male chimps gain through coalitional aggression is a larger foraging territory for the females in their troop, resulting in shorter interbirth intervals. Note that the more complicated problem of how to distribute and share the fruits of success is solved by males having sexual access to the troop's females, who mate promiscuously.

incarnated the solutions to these game-theoretic preconditions, which made these aggressive coalitions function adaptively in the distant past. Examining the problem at both of these levels simultaneously is necessary for the coherent exploration of the cooperative side of war.

The *risk contract of war* is a task analysis: a theory of the computations that need to be performed when deciding whether to form a coalition, join one, and initiate coalitional aggression. It also includes how the costs and benefits that coalitional aggression produces need to be allocated for selection to favor decisions to participate. To paraphrase Marr and Nishihara (1978, p. 30), who were trying to understand perception, we do this “because the nature of the computations that underlie [coalitional aggression] depend more on the computational problems that have to be solved than upon the particular hardware in which their solutions are implemented. To phrase the matter differently, an algorithm is likely to be understood more readily by understanding the nature of the problem it deals with.”

Considering the relevant selection pressures exposes information-processing problems that algorithms causing coalitional aggression had to be good at solving to produce behavior that promoted reproduction ancestrally. This task analysis reveals that our coalitional psychology should have some surprising characteristics. Perhaps the most surprising: under certain conditions, mortality rates do not negatively impact the fitness of males in the coalition. This analysis suggests why warfare is so favored an activity among males, despite its risks to the participating individuals’ welfare.

5. Cooperation and the risk contract of war

Not only is the problem of multi-individual cooperation difficult for an animal to solve, it is also more difficult for the evolutionary biologist to solve. Although considerable progress has been made in modeling and conceptualizing two-individual cooperative interactions, the theory of multi-individual cooperation in the context of aggression remains largely undeveloped, not least because it has not been much addressed (Axelrod, 1984). Evolutionary theories of cooperation need to be modified to address the somewhat differing case of multi-individual coalitions, especially in the context of competition between two competing coalitions. The differences between dyadic cooperation and coalitional cooperation have significant implications for the study of war. Once the features of multi-individual cooperation are analyzed, then a more precise model can be made of exactly what cognitive programs must be present to regulate socially interdependent behavior among members of an aggressive coalition.

The *risk contract of war* specifies the circumstances under which selection would favor motivations to cooperate with others by initiating or joining a coalitional attack. Certain features are readily grasped, and parallel two-person cooperation: cheaters or non-participants must be identified and excluded (or punished). More generally, the coalition is not stable unless the participants are rewarded or punished in proportion to the risks they have run, and in proportion to how important their contribution was to success. The elements that must be integrated into a model of coalitional aggression (and into psychological mechanisms regulating participation) include:

- the risk and/or cost to each participant,
- the relative value of the actions of each participant to achieving the common goal,
- the probability of achieving success given a certain set of performances by the members of the coalition,
- the aggregate value of achieving the common goal, and
- how the aggregate benefits of victory are allocated to each participant.

Each coalition member has an impact on the coalition by (1) regulating the level of his own direct participation in the joint action, and (2) undertaking actions to enforce the risk contract on the other coalition

members. These two dimensions of *regulating direct participation* and *enforcement* have important and sometimes surprising properties, which deserve independent exploration.

For example, the optimum level of direct participation is extremely sensitive to the probability of success. The relationship between these two variables may help explain why men will engage so readily in warfare when they are confident of success. Selection will favor decisions to participate in a coalitional attack regardless of the possibility or even level of mortality (within broad limits), when the following conditions are met:

1. Victory is certain,
2. The risk of death among participants is randomly distributed,
3. The benefits of victory are allocated in a relatively “fair” manner, and
4. Reproductive resources are efficiently utilized on zero-sum basis.

“Reproductive resources” includes access to mates and/or resources that can increase one’s own reproduction or the reproduction of kin (such as a larger foraging territory). This analysis does not assume that men will be more motivated to initiate coalitional aggression than women; that is an outcome of the model.

To see why, let’s consider a simple case: a polygynous mating system in which access to females is the limiting resource for male reproduction (Trivers, 1972) and male labor is comparatively unimportant to female reproduction. When this is true, the deaths of some members of a coalition will not decrease the *average* reproduction of the members of the coalition because reproductive resources that already exist within the coalition and those gained as the result of victory will be reallocated among the survivors. So long as the members of the coalition do not *lose* reproductive resources, the level of deaths among the males will not influence the average success of the coalition members. Each individual who dies loses, but the survivors gain to the same extent.³ Provided the participants do not know *in advance* who will live and who will die (i.e., risk is distributed randomly), and provided they are assured of success (as, for example, when a much larger group attacks a much smaller one), the collective decision of the coalition to go to war will benefit its members (in the currency of fitness). This is because natural selection weighs decisions on the basis of their *average* consequences to the genes underpinning the decision-making machinery, summed over evolutionary time.

These factors explain why males can so easily be induced to go to war, despite its lethal effects on many of them. To put it starkly: (1) if males do not invest, and (2) if the model evolutionary world is divided into just two coalitions, with no possible aggressive threats from elsewhere, then (3) theoretically, it would not matter if all but one of the winning coalition of males were killed, provided all of the males in the losing coalition were killed. It would not even matter if this war gained the winners no additional females.

This zero-sum nature of within coalition reproductive reallocation cushions successful coalitions from most of the negative fitness consequences that would seem to necessarily follow from the decision to initiate warfare. Because evolved psychological mechanisms will be shaped by the average result of a decision, the finding that average fitness is enhanced by the decision to embark on a successful war provides a powerful explanation for the existence of strong pro-war emotions (given the necessary conditions). Coalitions of males, when they assess the relevant variables indicating that they are larger or more formidable than any local competing coalitions, should appear to manifest an eagerness and satisfaction in initiating warfare and an

³ Imagine a coalition of six men conduct a raid and gain six notional units of reproductive resources. If they all live, each gets one unit: an average payoff of one unit per coalition member. If three die, those three get zero units, but the other three each get two units. The gain *on average* is still one unit / coalition member: $(3*0 + 3*2)/6$ men.

obliviousness or insensitivity to the risk they run as individuals, in terms of their individual somatic welfare.

This approach also predicts the striking asymmetry that exists between males and females in coalitional aggression. Because the reproductive success of females is rarely limited by sexual access to males, the net reproduction of a coalition of females would drop in direct proportion to the number of females killed. In a curious fashion, males may be so ready to engage in coalitional aggression because, reproductively, it is safer for them to do so. Females have more to lose, and less to gain, by initiating a coalitional attack.⁴ Such differences in consequences should be reflected in psychological sex differences in attitudes toward coalition formation and coalition-based aggression.

However, it is important to bear in mind that this willingness to participate is directly dependent on the probability of success, and on the fact that the coalition members do not know which of them is going to suffer the costs of death or disability. In mirror image to the case of success, if failure is guaranteed, any risk or participation is a direct loss to a male. Moreover, (leaving aside kin selection) an important aspect of the risk contract of war is that risk be randomly distributed: if males find themselves in situations where death is certain for them if they continue, there is no inducement that is sufficient to make continued participation worthwhile to them, in the currency of fitness. Many important aspects of warfare are derived from this: if one side can create circumstances where death seems certain to some part of the opposing coalition, panic and rout—an expected psychological adaptation to this circumstance—should result.

More globally, perception and belief in success play a crucial role in encouraging coalitions to initiate war. Exploring the psychological mechanisms for assessing the probability of success, and what cues—reliable in the Pleistocene—are used in making such determinations, will prove important to understanding coalitional behavior even in modern contexts. Mob and crowd behavior, civilian and military morale, eagerness or reluctance to go to war, and group panic can all be at least partly illuminated by this kind of analysis and its accompanying empirical investigations. A social psychology that evolved in the Pleistocene to assess and predict success on the basis of the behavior of dozens or, rarely, hundreds of individuals, might well derive “supernormal” confidence in a crowd of hundreds or thousands: in the Pleistocene, having so many on your side would have nearly always guaranteed invincibility. There is no evolutionary precedent for imagining or assessing the existence of thousands or millions of opponents who cannot be directly perceived. It seems likely that one of the mechanisms regulating the perception of the probability of success is *direct observation of relative numbers*. Public demonstrations by populations crowding the streets can create panic even among militarily well-entrenched rulers.

Approximations of the prerequisite conditions, while not always present, should have been frequently approached in the Pleistocene. In primate groups and hunter-gatherer bands, female reproductive capacity does not appear to go unused due to the mortality of males associated with those females. It is reallocated among the living local males: a woman whose mate dies in war becomes the mate of another man. Secondly, while male labor and male parental investment appear likely to have been a factor in human evolution, variation in ecological circumstances would have often made men’s contributions relatively unnecessary. *In short, war is not simply a response to resource scarcity: when*

times are good and male productivity irrelevant, war may be very advantageous to men.

The same reasoning suggests which men will be more motivated to initiate coalitional aggression in ecologies where the fitness of children does depend on male labor. All else equal, initiating warfare will be more attractive to men without mates, men without children, and men whose mates and children will be provisioned even if he dies (men in many hunter-gatherer groups engage in risk-pool sharing: hunted meat is shared widely in the band).

The requirement that “victory be assured” or at least very likely is not as stringent as it may seem. While modern history is full of surprises, primitive war between small coalitions may be more predictably related to relative size. Barring very large differentials in individual aggressive formidability, assembling a significantly larger coalition will virtually guarantee victory. Such a consistent relationship between size and probability of victory leads to the “balance of power” races discussed by Alexander (1979) as being a prime mover in social evolution. Being a member of an identifiably small coalition—a “minority”—is a dangerous proposition: the persecution and expropriation of local minorities is a relatively safe fitness-enhancing activity for males doing the expropriation. Correspondingly, the most significant cost of mortality to males may be a Pyrrhic victory: if your coalition wins but too many men die, your coalition may become smaller and weaker than neighboring coalitions, and itself subject to victimization.

6. Quis custodiet ipsos custodes? Guarding the guardians, and the problem of enforcement

A second dimension of coalitional aggression involves the enforcement of the risk contract. It is not sufficient for members simply to regulate the level of their own direct participation: for coalitions to stably evolve and function, the risk contract must be enforced by some or all of its members on any cheaters, defectors, or non-participants. Are others running their share of the risk and contributing their share to the joint effort? If not, at least some members of the coalition must exclude them from sharing in the benefits, or otherwise eliminate the benefits free riders would accrue by parasitizing coalitional gains. In situations where numbers are a key to success, exclusion as a punishment has direct costs to the coalition. Instead, enforced inclusion, coupled with punishment or retaliation for non-participation, is an alternative strategy that would be favored in conditions of intense coalitional competition. Active recruitment and enforcement of coalitional participation are repeated features of human social life: even under complex modern political situations, the persecution of pacifists and those who avoid conscription is widespread, and there are indications that much mob activity seems motivated by fear of non-participation as well as by attraction to the coalitional goal.

Exploring the specific adaptive design criteria for the psychological mechanisms involved in enforcement is beyond the scope of this paper. However, it bears pointing out that the problem of coalitional enforcement is itself a problem in cooperation: rewarding positive contributions or punishing defection itself requires effort, cost, and risk. The problem of multi-individual cooperation is recursive. Are others running their share of the risk and contributing their share to the joint effort of enforcing equal participation? Who bears the costs of enforcing the reciprocal distribution of the duties of enforcement? If some individuals are bearing the costs of enforcing coalitional participation, and others are garnering equal benefits without paying the costs, then enforcers will be selected against. The structure of the problem is similar to models of hypothetical group-selected reproductive restraint, in which the benefits of reproductive restraint are distributed throughout the group or local population, while the costs are born by the individual practicing restraint. While group selected reproductive restraint proved to be mythical, large coalitions are very much a part of human social life. Does this imply group selection? This problem with coalition maintenance is so severe that Boyd and Richerson (1985) consider it a fundamental

⁴ Because women’s reproductive success is not generally limited by sexual access to men, women would gain little by capturing additional mates. If a larger foraging territory were the resource a coalition of women would gain, men in their group would also benefit from the ensuing increase in women’s reproductive success, but each woman who died in combat would decrease the average reproduction of the men. In this case, women would have a higher payoff by encouraging men in their group to attack than by taking the risk themselves (and men would too).

objection to the idea that coalitional behavior (involving more than a very small number of individuals) can evolve by natural selection at all. They prefer attributing such coalitional behavior to cultural processes or dual inheritance processes.

We feel that evolutionary processes creating specialized cognitive adaptations in the context of coalitional aggression can be straightforwardly explained using standard genic selection, without recourse to either group selection or gene-culture coevolution theories. That said, if individual (i.e., genic) selection operating in complex social groups designed adaptations that fulfill the requirements of the risk contract of war, it is easy to see how cultural processes or group selection (or both) may magnify or slightly modify the process (see, for example, Durham, 1976; Alexander, 1979). Although a full analysis of the selective dynamics relevant to the problem of enforcement must be dealt with elsewhere,⁵ there are several families of possible solutions to the question of how enforcement can evolve. The most straightforward are as follows.

1. In the real world of Pleistocene hunter-gatherer bands, or even modern horizontal societies, the benefits of coalitional action are not necessarily a public good, shared equally, but vary depending on life history variables, kinship, and many other social variables. Some individuals will have a far greater stake in successful coalitional action than others, and their cost of enforcement will be offset by greater individual benefit. For example, because individuals with many kin in the coalition will benefit far more from successful coalitional behavior, they should be disproportionately involved in enforcement. This is not simply a theoretical possibility: Chagnon's (1988) striking work describes just this phenomenon: "the leader of the largest descent group is invariably the headman of the village", and "the leaders are the very individuals who decide whether killings are revenged" through coalitional action against members of the offending village. Similarly, more formidable individuals can enforce with less cost and personal risk than less formidable individuals.
2. The effect of incentive asymmetries toward solving the enforcement problem can be strongly magnified by the unique properties of contingent threat: unchallenged, threats are low cost and reusable. If particular individuals in the group have a greater than average interest in certain coalitional behavior, they will have an incentive to enforce that behavior. If that enforcement is in the form of a threat, it need not be costly to the threatener provided no one calls his bluff or takes up his challenge. If the threatener has a stronger interest in the coalitional action than threatened individuals have in avoiding cooperation, then it will not make sense to resist, and the enforcer costs himself nothing in making the threat. A person with one bullet in his gun can order around many unarmed people, and a strong asymmetric incentive parallels a one-bullet gun. Such an enforcer can do this indefinitely, never having to "fire the gun", provided that he does not order others to do things that are too objectionable. Again, Chagnon's work is illuminating: in his studies, no one attempts to coerce local village members into attacking other villages where they have close kin (Chagnon, 1988). The cost of enforcement is prohibitive in such cases. One expects to see separate psychologies of offense and defense: differences between when the coalition is attacking, and when it is defending itself. For one thing, successful defense is more of a public good, and insufficient participation in defense, as expected, does appear to be considered more reprehensible than insufficient enthusiasm for initiating a war.
3. Such effects can be still further magnified if the individuals or core group with the strongest incentive to enforce coalitional behavior

⁵ See Further Reading (section 8.1) for later analyses and a model illustrating how punishing free riders on the group can evolve without creating a second-order problem; Krasnow, Delton, Cosmides and Tooby (2015) and Tooby, Cosmides, and Price (2006).

direct their efforts not only at enforcement, but at involving other coalition members in the process of enforcement. The threat is made or pressure is exerted on selected individuals in order to induce them to go out and actively enforce coalitional norms. *By this process, those who direct the enforcement of coalitional behavior may effectively divorce their own self-interested management or regulation of enforcement from the actual costs of the enforcement: sergeants work harder than generals.* As modern political life shows, such geometric structures of coercion can be indefinitely extended, from generals and party chairmen on down to individuals in charge of neighborhood block surveillance. Getting someone else to do the dirty work seems quite widespread: a classmate doing fieldwork in Afghanistan was induced by the members of the group he was studying to go to evict, single-handedly, heavily armed trespassers and their livestock from a nearby pasture (Barfield, pers. comm.).

These and other potential solutions to the problem of enforcement, when combined with plausible assumptions about Pleistocene conditions (at the group sizes and demographic factors likely to be involved), indicate that strong selection would have existed for the growth of an adaptively designed coalitional psychology in a manner not requiring recourse to either group selection, cultural processes, or gene-culture coevolution.

7. The importance of exploring the evolutionary dynamics and cognitive foundations of coalitional aggression

The political complexity of post-Neolithic state systems cannot be directly reduced to models based on inter-band conflict in the distant past. In the modern world, wars may occur that few, if any, want, fueled by political systems based on coercion of the unwilling. However, to understand these more complex manifestations, it is nevertheless necessary to explore the evolutionary and psychological basis of coalitional aggression. This evolved psychology underlies the human history of warfare, and still interpenetrates modern group, political, religious, and mob phenomena.⁶

Although humans now nearly universally live in state systems, our minds were formed during tens or hundreds of thousands of generations in small, horizontally organized hunter-gatherer bands. The special psychological mechanisms to deal with coalitional aggression that evolved then are with us now, and influence modern human behavior in a wide variety of contexts. Phenomena that might be partially illuminated by the approach we have outlined include the appearance and distribution of pro-war attitudes; attitudes toward dissidents, draft evaders, and pacifists; the formation of attitudes among elite male organizations and coalitions; gang behavior; attitudes toward accusations of cowardice; exclusivity and bandwagon effects with winning coalitions; mob behavior; psychological sex differences in male-female sociality; military and civilian morale preceding and during wartime; the political consequences of mass public demonstrations; the effects of real or falsely depicted external threats on public attitudes; the militarization of society as a means of stifling dissidents; and the distinctive ethos of warrior groups.

8. Further reading

8.1. The evolution of coalitional cooperation

Many of the points made in "The evolution of war and its cognitive

⁶ For subsequent empirical examples of this phenomenon, see Sell et al. (2009, 2017) in Further Reading (section 8.3). In the smaller coalitions common ancestrally, a man's physical strength was an important component of his coalition's formidable strength. Sell et al. found that a man's upper body strength predicts his attitudes about the efficacy of his nation's military now.

foundations” were worked out further in later papers. Preprints can be found at www.cep.ucsb.edu, the Center for Evolutionary Psychology website. A short, annotated guide follows.

Tooby, J., Cosmides, L., & Price, M. E. (2006). Cognitive adaptations for n-person exchange: the evolutionary roots of organizational behavior. *Managerial and Decision Economics*, 27(2-3), 103-129.

On how adaptations for coalitional action can be built from cognitive foundations for dyadic cooperation. Solving problems of coordination; amplification coalitions (more stable groups) as a way of solving coordination problems; alliance detection; the status of coalitions as public goods, making preserving their status collective actions; repurposing theory of mind systems by representing groups as individual agents with interests; the role of outrages as public coordinative signals for negotiating welfare tradeoffs between groups/coalitions.

Tooby, J., & Cosmides, L. (2010). Groups in mind: The coalitional roots of war and morality. Høgh-Olesen, Henrik (Ed.): *Human morality and sociality: Evolutionary and comparative perspectives* (pp. 91–234), Palgrave Macmillan.

On the logic of conflict as applied to coalitions and war. The emergence of morality as a solution to problems of coordination in group cooperation; moral communications (“what they did to me shows what they are willing to do to you/ any of us); the role of moral outrages and common knowledge/ public co-registration of events in creating and stabilizing coalitions that can amplify one’s ability to achieve goals—especially for negotiating the relative ranks of competing coalitions.

Tooby, J. (2020) Evolutionary psychology as the crystallizing core of a unified modern social science. *Evolutionary Behavioral Sciences*, 14(4), 390-403.

Coalitions and evolutionary mismatch. Systems for representing situations designed for the ancestral world of foraging bands involving hundreds are “informed by cues that no longer reliably mean what they once signaled, effectively causing hallucinations”. This causes societal conflicts fueled by “hallucinated misinterpretations that no longer correspond to the actual world.”

Tooby, J. & Cosmides, L. (2020). Natural selection and the nature of communication. In: Floyd, Kory & Weber, Rene (Eds.): *The handbook of communication science and biology* (pp. 21–49), Routledge.

On entropy and evolution giving rise to a new kind of order in the universe: replicative order. Communication at all levels, from cells to coalitions. See especially the section on “Communication and human coalitions”, for an analysis of what kind of events should be effective as moral outrages for negotiating group WTRs and group social ranks.

Krasnow, M. M., Delton, A. W., Cosmides, L., & Tooby, J. (2015). Group cooperation without group selection: Modest punishment can recruit much cooperation. *PLoS one*, 10(4), e0124561.

Presents an agent-based model showing that, in group cooperation, punishment of free riders can evolve easily without triggering a second-order free rider problem.

8.2. On alliance detection

Pietraszewski, D., Cosmides, L., & Tooby, J. (2014). The content of our cooperation, not the color of our skin: An alliance detection system regulates categorization by coalition and race, but not sex. *PLoS one*, 9(2), e88534.

One in a series of empirical papers on the cognitive foundations of alliance detection. The 16 studies in this one establish many design

features of an alliance detection system and eliminate a number of alternative hypotheses.

8.3. On formidability regulating attitudes toward international conflict in the modern world

Sell, A., Tooby, J., & Cosmides, L. (2009). Formidability and the logic of human anger. *Proceedings of the National Academy of Sciences*, 106(35), 15,073–15,078.

Sell, A., Sznycer, D., Cosmides, L., Tooby, J., Krauss, A., Nisu, S., Ceapa, C., Petersen, M. B. (2017). Physically strong men are more militant: A test across four countries. *Evolution and Human Behavior*, 38(3), 334–340.

8.4. On later evidence for cognitive adaptations specialized for social exchange

Cosmides, L., Barrett, H. C., & Tooby, J. (2010). Adaptive specializations, social exchange, and the evolution of human intelligence. *Proceedings of the National Academy of Sciences USA*, 107, 9007–9014.

Presents data demonstrating key design features of a cheater detection mechanism and ruling out alternative explanations. A deontic rule must regulate access to benefits; the mechanism detects cheaters, not innocent mistakes (demonstrated with studies using the same [deontic] social contract, which holds the interpretation of the rule constant).

Cosmides, L. & Tooby, J. (2008). Can a general deontic logic capture the facts of human moral reasoning? How the mind interprets social exchange rules and detects cheaters. In W. Sinnott-Armstrong (Ed.), *Moral psychology, Volume 1* (pp. 53–119) Cambridge, MA: MIT Press.

Reviews years of evidence; focus is alternative explanations invoking deontic or logical reasoning. Includes discussion of neural dissociations between social exchange and precautionary reasoning.

Cosmides, L. & Tooby, J. (2015). Adaptations for reasoning about social exchange. In Buss, D. M. (Ed.), *The Handbook of Evolutionary Psychology, Second edition. Volume 2: Integrations*. (pp. 625–668). Hoboken, NJ: John Wiley & Sons.

Reviews 25 years of evidence, with a focus on testing adaptationist predictions. Includes discussion of developmental and cross-cultural evidence as well as neural and functional dissociations between social exchange and precautionary reasoning.

CRedit authorship contribution statement

John Tooby: Conceptualization, Writing – original draft. **Leda Cosmides:** Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

Acknowledgments

Thank you to Debra Lieberman and Daniel Sznycer for their encouragement and helpful comments on the original, 1988 manuscript. Perplexity’s AI Assistant was used for advice on simplifying sentences; all suggestions were reviewed and edited by the author.

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