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INTRODUCTION

Social Complexity and the Bow in the Prehistoric North American Record

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This Special Issue of *Evolutionary Anthropology* grew out of a symposium at the 2012 Society for American Archaeology (SAA) meeting in Memphis, Tennessee (April 18–22). The goal of the symposium was to explore what we will argue is one of the most important and promising opportunities in the global archeological enterprise. In late prehistoric North America, the initial rise of cultures of strikingly enhanced complexity and the local introduction of a novel weapon technology, the bow, apparently correlate intimately in a diverse set of independent cases across the continent, as originally pointed out by Blitz.[1] If this empirical relationship ultimately proves robust, it gives us an unprecedented opportunity to evaluate hypotheses for the causal processes producing social complexity and, by extension, to assess the possibility of a universal theory of history. The rise of comparably complex cultures was much more recent in North America than it was elsewhere and the resulting fresher archeological record is relatively well explored. These and other features make prehistoric North America a unique empirical environment. Together, the symposium and this issue have brought together outstanding investigators with both empirical and theoretical expertise. The strong cross-feeding and extended interactions between these investigators have given us all the opportunity to advance the promising exploration of what we call the North American Neolithic transitions. Our goal in this paper is to contextualize this issue.

It is well established that the human historical record includes dramatic, relatively abrupt changes in adaptive sophistication. For example, contemporary members of advanced market economies enjoy per capita wealth about 30–50-fold higher than did their ancestors for many millennia preceding the "modern economic miracle" of the last four centuries.[2–5] Similarly, the Mississippians of late prehistoric North America lived in settlements that were much larger and more long-lived than those of their ancestors of just a few centuries before, in settlements sustained by newly intensified subsistence economies.[6–10]

These and many other examples of adaptive revolutions confront us with a fundamental question: Why do human societies undergo relatively abrupt increases in their capabilities and scale? This question is one statement of the social complexity problem. In spite of the central importance of this problem, its investigation remains vexed and contentious. In this issue, a diverse group of authors explore features of various societies in prehistoric North America with the objective of improving our understanding of the origins of social complexity change.

We use the term North American Neolithic transitions to describe the various increases in social complexity that will concern us in this issue. Though we make this choice primarily for verbal convenience, we note that these societies arguably display significant similarities to the Neolithic cultures of Eurasia.[11] Thus, it may be of interest to reexplore the old idea that societies of comparable complexity and scale in the Eastern and Western Hemispheres may share similar causal antecedents, a future endeavor to which the papers in this volume may ultimately contribute.

PREHISTORIC NORTH AMERICAN SOCIAL COMPLEXITY AND ITS SOURCES

By the time of European colonial contact, many Native North Americans

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Box 1. Social Complexity and Arrival of the Bow: Criteria for Falisification of Two Major Theories

Social Coercion Theory

Primary prediction: When local subsistence capacity permits, local introduction of the bow will rapidly be followed by increases in social scale and economic intensification.

Secondary issues: Predicted effects result from the capacity of improved weaponry to allow expansion of the scale of individually self-interested intrapolity "law enforcement."

Increased military violence, a cooperative social endeavor, must *follow* other correlates of increasing complexity on this theory, with most extensive lag times in areas of greatest potential for raising Malthusian ceilings through social intensification of subsistence productivity.[10]

Warfare Theory

Primary prediction: Local introduction of elite bow will result in increased interpolity warfare, with increases in social complexity and economic intensification resulting from the demands or effects of increased warfare.

Secondary issues: Predicted effects result from selection for social units with properties that improve military performance, including increased social scale and economic intensification.

Increased military violence must *precede* correlates of increased social complexity on this theory.

already had more than 300–500 years of history of living in relatively complex societies.[6–10,12] Indeed, some of these complex North American cultures were successful in negotiating with European state-level societies from a position of strength and with political sophistication for nearly two centuries after initial contact.[12] Moreover, we have significant archeological insight into the context and chronology of the rise of these complex societies.

After millennia of less complex societies, by ca. AD 900–1100 various independent and complex societies were well established in diverse locations across North America, reflecting the North American Neolithic transitions. These included agricultural societies like the Mississippians of the mid-continental drainage and the Ancestral Pueblo (Anasazi) in the American southwest.[6–9] Both of these groups of societies made use of intensified field agriculture, including maize, in contrast to the family-scale horticultural use of these crops by their Woodland and Basketmaker antecedants.[8,9] These complex societies produced impressive architectural products like the enormous mounds at Moundville and Cahokia and the Great Houses in Chaco Canyon (Fig. 1). Moreover, the Mississippians built multi-generational settlements of formidable size (in some cases, apparently as large as 10,000 citizens), something never seen among their immediate ancestors. By ca. AD 900–1100, other nonagricultural societies also produced substantial economic intensification and large, permanent settlements. These include the Chumash of the Santa Barbara Channel[13] and the Calusa of southern Florida.[12] These societies fed themselves by intensifying the harvesting of wild resources, including fish and other aquatic animals.

Crucially, for our purposes here, the predecessors of the North American Neolithic societies were less complex in organization, smaller in population, and less productively intensified throughout the entire ca. 10,000 years of history up to ca. AD 400–800. In the cases of the Basketmaker and Woodland cultures, for example, these antecedents were characterized by residential settlements of one to a few families and were much more limited on an architectural scale. In contrast, the North American Neolithic societies emerged after a relatively brief period of rapid increase in local adaptive sophistication.

Our collective challenge as a discipline is to explain how and why a continent-wide series of Neolithic transitions occurred relatively synchronously across North America. These diverse societies shared little or nothing in the way of common cultures, languages, or religious or ritual practices. Moreover, the domesticated plants forming the basis of the agricultural cases among these societies were available for more than 1,000 years before local agricultural fluorescences in some locales, especially the Southwest.[14] Almost certainly, our theories of the Neolithic transitions of prehistoric North America must invoke some other continent-wide factors. Moreover, the rise of all these diverse societies during the same relatively brief interval strongly suggests the hypothesis that a single causal factor might have been ultimately decisive.

Two obvious candidates have been invoked previously for this possible continent-wide driver of Neolithic transitions: climate change and population increase. On one hand, these factors clearly are important at some level. A Neolithic agricultural society cannot be built on a polar ice cap nor can a single extended family construct Monk's Mound or Pueblo Bonito. The challenge, however, is to determine the relative contribution of these and perhaps other factors in the unfolding of the North American Neolithic.

Though the issue is still in doubt, we suggest that neither climate change nor population growth is a likely candidate for the continent-wide driver of the North American Neolithic, though each may have played an important secondary role in some localities. First, Holocene climate change was generally similar in its timing in both North America

Figure 1. Evidence of social complexity in the North American Neolithic. Top: Views of two different Mississippian mounds associated with large agricultural settlements at Moundville, Alabama, containing dozens of such mounds (J. Blitz). Notice the ca. 95-step ramp (left) and archeologists working an artificially leveled plaza area (right) as scaling objects. The Woodland precursor cultures of the Mississippians built only small residential settlements, containing one to a few family dwellings. Bottom: Two views of the Ancestral Pueblo structure Pueblo Bonito in Chaco Canyon, New Mexico (Z. Zachar and P. Bingham). Note the individual in the right hand image as a scaling object (arrow marks the same timber prop in each image). The Basketmaker precursor cultures of the Ancestral Pueblo built only small wood pithouses designed for individual families in small settlements. (Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.)

and Eurasia. Yet the North American Neolithic was delayed by roughly 10,000 years relative to the first Eurasian Neolithic cultures.[11] Second, population densities in North America obviously increased substantially from the arrival of the first people perhaps 12,000–14,000 years ago. However, there is little evidence of large inflections in population growth rates as a universal precursor for North American Neolithic cultures. Indeed, in a number of cases, increases in population density appear to be better interpreted empirically as *effects* of local Neolithic transitions rather than as their causes (see Bandy and Fox[15] for recent discussions and reviews of the Neolithic demographic transitions in North America).

If we are to look elsewhere than climate change and population increase for the causes of North American Neolithic transitions, the archeological record is where we must begin. We will return below to the relationship between this record and the possibility of complete theory. For the moment, we emphasize that all the highly diverse beliefs, practices, and technologies, the details and sophistication of which change in association with increases in social complexity, become sources of both spurious and potentially credible hypotheses for causation.

For example, among such potential sources of causation are developments in religious or ritual belief and in adaptive know-how, such as foraging and nonweapon-related manufacturing techniques. There are sound theoretical reasons for rejecting these developments as causes rather than effects of the North American Neolithic transition.[10,16] Moreover, there are also compelling empirical reasons for skepticism. For example, there is no evidence of newly arising, shared ritual or religious beliefs or subsistence practices between North American Neolithic societies as different and widely separated as the Chumash and the Mississippians or the Ancestral Pueblo and the Calusa.

Further, innovative productive technologies are very unlikely to represent continent-wide drivers of the North American Neolithic. For example, the Chumash tomol high-seas fishing technology[17] is unrelated not only to the farming technologies of the Mississippians[8] and the Ancestral Pueblo,[18] but also to the shallow-water estuarine fishing technologies of the Calusa.[12] Of course, this argument is equally persuasive against the claim that the acquisition of specific domesticates or the technology for maximizing their productivity was a continent-wide driver.

If we accept this logical chain for purposes of argument (and we note that some authors of the papers in this volume will not necessarily agree with some of our arguments here), we arrive at an important

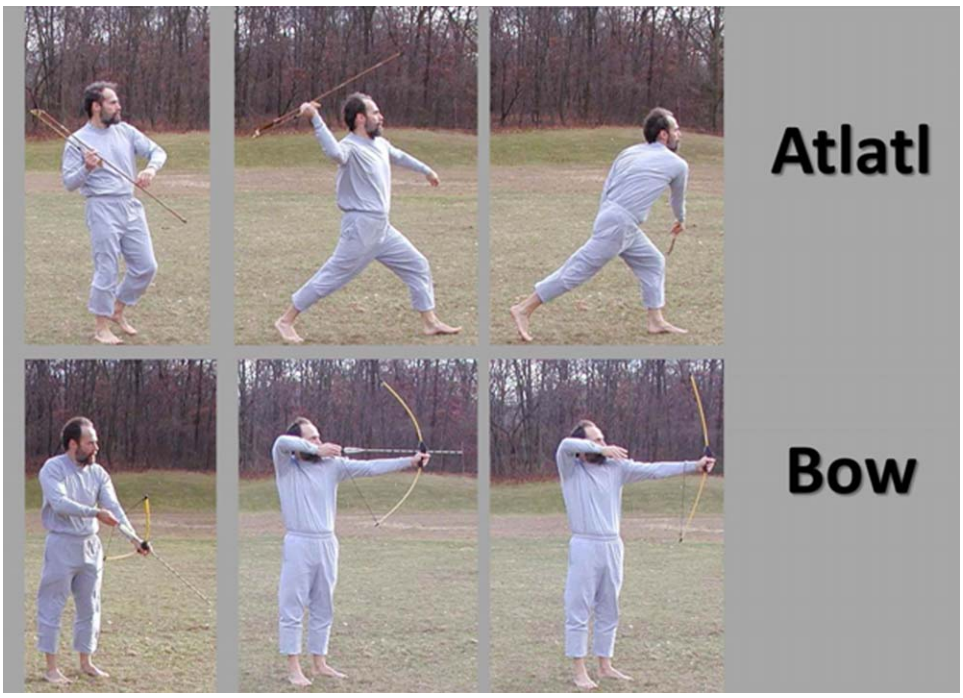

Figure 2. The bow and atlatl are very different weapons. Top: The use of the atlatl is illustrated. Notice that the weapon extends the arm, amplifying the normal human throwing motion. Notice also the extensive gross motor movements required by the weapon. These features complicate accurate delivery of the atlatl bolt, making mastery of the weapon challenging and time consuming. Bottom: The use of the bow is illustrated. Notice the use of only fine motor movements at the crucial moment of release of the arrow. This feature makes accuracy and consistency with the bow much easier to attain and sustain than with the atlatl. (Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.)

juncture. Having provisionally eliminated many potential sources of causation, we are arguably left with only one. While there is evidence of some apparently primitive forms of the bow at earlier intervals (see, especially, Maschner and Mason,[19] Walde,[20] and references therein) we argue that there is strong evidence of a relatively synchronous, continent-wide adoption of an advanced form of the elite bow at or near the appropriate time for this weapon to act as a driver of local North American Neolithic transitions.[1,10]

If this simple empirical picture were ultimately confirmed, its implications with regard to our understanding of the North American Neolithic transitions and human history more generally could be profound and pervasive. Legions of theories invoking other crucial causal factors to explain increases in social complexity become much less likely and our theoretical challenge would be drastically simplified.

HOW CAN THE BOW BE A CAUSE OF SOCIAL COMPLEXITY INCREASE?

All models explaining social change driven by the bow derive from the status of this weapon as superior in performance to its predecessors. The predecessor in the North American case is the atlatl, or spear-thrower. The atlatl consists of an extended stick on which a small spear (bolt) is mounted. The atlatl, held in the throwing hand, then amplifies the normal human throwing motion, allowing the bolt to be projected much farther than with the unaided arm (Fig. 2).[10,19,21] The atlatl was apparently brought to North America by the first human settlers millennia before the Neolithic. The local arrival of the bow was substantially later.

In contrast to the atlatl, the bow uses the recoil of deformed wood and/or bone or sinew to propel the bowstring forward at high velocity, driving the projectile (arrow) out of the weapon (Fig. 2). The bow's arrow typically is substantially smaller than the atlatl's bolt, making up for this lower mass with a higher velocity. The bow has long been regarded as a superior weapon in both rate of fire and accuracy. In this issue, Bettinger[21] contributes important new documentation further demonstrating the superior potential accuracy of the bow. These data indicate that the accuracy of the bow can be two to three times greater than that of the atlatl at short ranges. Moreover, the maximal projectile range achievable by a sophisticated self bow is of the order of threefold greater than with the atlatl.

These properties have crucial implications regarding use of the bow and atlatl in massed attack of the sort associated with human conflict. An effective hail of arrows can be launched from substantially farther away than can a hail of atlatl bolts. Moreover, this hail will be much denser due to the bow's higher rate of fire. This greater radius of

effective fire of the bow means that a much larger number of individuals can fire on a minority target (one or a few individuals, for example) than with the atlatl.

This increase in attacker numbers allowed by the bow has especially powerful effects in numerically asymmetric conflicts within or between human coalitions.[10,16,22,23] Specifically, the generalized square law for conflict with projectile weapons (derived from Lanchester's Law, developed to predict outcomes of World War I artillery duels) means that a larger force reduces the risks to each of its individual members by the square of their numerical superiority over their targets. Thus, each of 100 individuals attacking 10 experience a 100-fold lower individual risk ($100/10 = 10$; $10^2 = 100$) than each would have in a one-on-one duel with the bow or the atlatl. Similarly, 100 individuals attacking a single target would enjoy a 10,000-fold lower risk to each attacker.

This square law effect is extremely large and dramatically amplifies the potential impact of increased effective weapon range, implying that the larger numerical superiority potentially permitted by the bow would have substantial effects on the cost-benefit logic of human conflict and social coercion.[16] Moreover, the atlatl is more difficult to master and to sustain reliable mastery of than is the bow, giving the bow a substantial additional opportunity-cost advantage (Fig. 2).

In view of these features of the bow, there are at least three distinct models for the potential impact of advanced bow technology on human social complexity. To understand these theories, it is vital to recognize that each shares the common feature that the bow's effects drive an increase in the scale of human social cooperation. Scale-sensitive improvements in aggregate capability, such as more extensive individual specialization and economies of scale, then produce the improved adaptive sophistication and economic intensification associated with increases in social complexity. (The scope and scale of this increase in complexity is limited by the availability of local subsistence resources amenable to social intensification.[10])

Social Coercion Hypothesis

The social coercion hypothesis starts from the well-founded assumption that the conflicts of interest between nonkin members of the same species (conspecifics) in crowded (Malthusian) environments limit social cooperation, preventing the formation of large, sustainable cooperative social units unless these conflicts are somehow controlled or managed. The primary solution to this problem is proposed to be coercive suppression, supported by armed threat (what we think of as "law enforcement"), of free-riding or social parasitism. ("Law" is used metaphorically here, to include consensual norms of behavior, not merely the formal legalisms of recent state-level entities.) Coercive threat is used to ostracize or kill socially parasitic individuals, stabilizing and sustaining social cooperation with nonkin as the best individually adaptive choice within local coalitions.

Coercive suppression of conflicts of interest can arise and persist only to the extent that this behavior is individually self-interested. It follows that the scale of human social cooperation will always be limited by the scale on which available coercive weaponry permits relatively inexpensive (cost-effective) projection of coercive threat. Moreover, social parasitism is defined by majority consensus when access to coercive threat is broadly distributed, as it is generally expected to be with the bow. Thus, coercive threat directed at minority free-riders inherently involves numerically asymmetric conflict as a plausible potential behavior (a credible threat). Under these asymmetric conditions, the square-law properties allowed by projectile weapons loom large.

According to this view, we expect that the coming of an advanced bow technology, with its superior range and potency, substantially increased the potential local scale and effectiveness of coercive law enforcement. In turn, we expect that the outcome of this effect would have been an increase in the scale of socially cooperative coalitions (when other local variables permitted such an increase[10]), in turn engendering an increase in adaptive sophistication or economic intensification.

Warfare Hypothesis

There is abundant evidence of increases in the scale of warfare during and/or after various individual North American Neolithic transitions, as assessed by injuries in skeletal remains and the building of substantial fortifications.[7,13,19] Episodically intense warfare associated with the North American Neolithic is generally well-documented.[24–27]

According to the warfare hypothesis, this increased intensity of conflict creates strong selection among social coalitions for improved defensive and offensive capabilities. In view of the square-law properties of projectile weapons, one of the most effective ways to improve military effectiveness is to increase the size of attacking or defending coalitions. This requirement for increased military performance selects, in turn, for larger scales in enabling technologies, including intensification of food production and general economic performance. Thus, social complexity is presumed to increase. In the simplest versions of the warfare hypothesis, the novel scale of conflicts of interest inherent in the consequently larger social units is generally ignored.

Foraging Hypotheses

This view focuses on the fact that a new weapon such as advanced bow technology is an improved hunting tool. Thus, it is conceivable that increased social complexity might be driven by improved hunting success. For example, improved yield and reliability of hunting return might make larger, more permanent settlements possible, in turn sustaining the adaptive returns from cooperation by larger numbers of individuals.

There are various reasons not to favor foraging models for bow-driven increases in social complexity. For example, many of the increases in

social complexity in the North American Neolithic concern local agricultural revolutions, creating societies in which farming rather than hunting is the central food-related adaptive strategy.[6–8,28,29] New efficiency in hunting is an unlikely cause of such change. Similarly, the bow is unlikely to drive increases in marine foraging, as in the Chumash or Calusa cases. And if we accept the argument that the cases discussed in this issue should generalize to a broader theory of history, other dramatic changes in social complexity should also play by analogous rules. For example, there is extensive evidence of an intimate association between the invention of advanced gunpowder weapons and the rise of the modern state.[16,30,31] Yet game hunting with gunpowder weapons played a negligible role in the food-production of early states wherein domesticates made up virtually all calories consumed. Again, the novel scale of conflicts of interest inherent in larger social units is generally ignored by the simplest versions of foraging hypothesis.

Thus, we argue that only the social coercion and warfare hypotheses have significant credibility as potential explanations for the role of the bow in the North American Neolithic. Before turning to the vital challenge of subjecting these hypotheses to potential empirical falsification, we will define and clarify several crucial issues of context.

CONFLICTS OF INTEREST ARE UBIQUITOUS: SOCIAL COERCION THEORY AND THE SCALE OF HUMAN SOCIAL COOPERATION

Social coercion theory is newer and less widely understood than warfare and foraging theory. Thus, we briefly expand on its central details and implications. Social coercion theory is based on fundamental evolutionary biology, especially on how natural selection shapes social behavior. It is well understood that all organisms are under powerful selection for successful reproduction, almost always in a limiting environment. Usually, a key constraining feature of biological environments is competition with conspecifics, since they require all the same assets and resources. Biological environments are limiting, in large part, because they are almost always Malthusian. In this context, for straightforward biological reasons,[16] natural selection on head-to-head, in-the-moment strategies produces animals that behave as if they have confluent interests only with a small set of very close kin. Most conspecific individuals (nonkin), therefore, behave as if they have pervasive conflicts of interest.[16] Recent claims to the contrary[32] notwithstanding, there is abundant evidence that a large portion of nonhuman animal social behavior is well predicted by this picture (see commentaries by diverse authors in the March 24, 2011 issue of *Nature*).

Only one animal, humans, appears to violate the predictions of this picture in numerous ways and on very large scales. Though humans show strong kin preference, as do nonhuman animals, we also display pervasive cooperation with nonkin across a wide domain of behaviors, creating what we subjectively experience as our "public" lives, a pattern of social cooperation that nonhuman animals display on only a very small-scale, rare, and episodic basis. This uniquely human social adaptation has long been recognized.[16,22,33] The challenge has been to understand its evolutionary origin.

Social coercion theory[16] proposes that the nonhuman pattern of social behavior is endemic for a single reason. It is too expensive for individuals to forestall free-riding (social cheating) on any nonkin cooperative enterprise; "law enforcement" is not adaptive. The uniquely human solution to the nonkin conflict-of-interest problem arises from unprecedented access to inexpensive coercive management of conflicts of interest. More specifically, humans apparently evolved unprecedented access to individually inexpensive conjoint coercive threat; that is, the capacity to project threat against other conspecifics from a substantial distance (many body diameters) and, thus, simultaneously with other individuals sharing common interests.[16,22,23] Humans originally evolved this unprecedented capability as a consequence of the evolution of elite aimed throwing around 2 million years ago.[16,22,23] Under these specific, novel conditions, the very large reduction in the costs of coercion resulting from the square-law effects inherent in projectile weapon deployment was achieved.

Thus, humans are unique in being able systematically to afford to ostracize those engaging in the subset of individually self-interested behaviors that we perceive as "selfish." Each individual usually contributes to the necessary coercive threat toward others and is, simultaneously, a target of such threat from others. Under these species-typical conditions, selective pursuit of self-interest in only those ways that are also congruent with the self-interests of surrounding nonkin commonly becomes the best individually adaptive option in the public domain.

Moreover, the tactical details of coercion supported by projectile weapons evades the higher-order free-rider problem,[23] making enforcement of nonkin cooperative behavior directly, individually adaptive. As a result of these properties, social coercion theory does not require doubtful assumptions about either group selection or individually altruistic "punishment" behaviors invoked by alternative approaches.[34]

Our concern here is the substantial increases in human social complexity and adaptive sophistication during the late prehistoric era. Social coercion theory's prediction of these adaptive revolutions is straightforward. New weapons, in the hands of an animal with 2 million years of adaptation to social coercion, will be rapidly deployed in pursuit of self-interest. This will result in a corresponding increase in the scale of coercive management of conflicts of interest, engendering increased social scale and the ensuing improvements in adaptive sophistication.

In the specific case of North America, the pre-Neolithic atlatl has a maximum effective anti-personnel range of two- to threefold less than the later, superior bow technology.[16,21] It follows that we expect the

coming of the bow to increase the maximal effective scale of local social cooperation by roughly threefold. Moreover, more subtle issues, especially higher individual opportunity costs for effective employment of the difficult-to-master atlatl (Fig. 2), predict that the bow will be an inherently more effective weapon for everyday law enforcement (including in large, sedentary settlements) than will the atlatl.[16] (Note that the atlatl was a significant improvement over even earlier coercive technologies, including hand-thrown projectiles. As predicted by social coercion theory, there is evidence that the initial deployment of the atlatl is associated with an earlier increase in social complexity sometimes referred to as the "behaviorally modern" transition.[16,35])

In summary, the conflict of interest problem is ubiquitous and forever. No social entity, including a human culture, is sustainable beyond the scale at which this universal problem can be adaptively managed. Humans have a 2-million-year history of engaging in social coercion. Thus, when we are presented with a new coercive technology, we rapidly deploy it in a species-typical, self-interested fashion, ultimately resulting in increasing adaptive sophistication wherever local ecological circumstances permit.

WARFARE: EFFECT OR CAUSE OF COMPLEXITY?

Increased warfare is manifestly associated with some local North American Neolithic cultures.[7,36–39] Warfare theory predicts at least some features of this observation, invoking warfare as the primary cause of complexity. Social coercion theory also predicts increased warfare, but interprets this observation as an effect, not a primary cause, of increased social complexity. More specifically, according to social coercion theory, warfare is ultimately a cooperative response to Malthusian competition with other social coalitions. Moreover, warfare is susceptible to social intensification, but also replete with internal conflicts of interest. For example, each individual's immediate self-interest is best served by hanging back in battle and allowing nonkin others to assume more of the risks. Only some form of military discipline can manage this problem in a sustainable way. The scale on which this management of conflicts of interest can be individually adaptive will be limited by the properties of the weapons available to forestall free-riding. Thus, for both theories we expect that the arrival of the bow produced an increased scale of warfare, especially when local ecology permitted ensuing increases in population size or density.[10] This increased scale of warfare would have left obvious archeological correlates, including potentially massive fortifications.

Social coercion theory also makes predictions about the frequency, rather than the scale, of warfare over time; these are important in distinguishing this theory's account of the archeological record of military violence from that of warfare theory. Specifically, the initial social-scale-dependent intensification of resource production ensuing from the arrival of the bow can increase carrying capacity where other variables permit, raising the local Malthusian ceiling. Under such local conditions, population will increase and fissioning of settlements can be accommodated by the establishment of new ones without severe conflicts of interest, relying on improved productivity. (Maximal sustainable settlement size is predicted to be limited by the performance of coercive weaponry. Once a settlement exceeds the size at which social coercion is individually adaptive with currently available weaponry, settlements are expected to divide. Two settlements of this maximal sustainable size will then have unmanageable conflicts of interest analogously to nonkin nonhuman individuals.[16]) However, as this fissioning of settlements ultimately saturates the landscape at the new carrying capacity, other effects ensue.

As increase in population size overwhelms the capacity for management of conflicts of interest using available weaponry, fissioning into underused territory is no longer an option. Thus, cooperation within existing settlements becomes more problematic. As well, subgroups within existing settlements have increased incentive to engage in raiding rather than futile efforts to enhance saturated productive activities. In general, such subgroups can function most conveniently by refraining from raiding a home-base settlement while attacking nearby settlements. The initial response to these conditions is expected to be increased frequency of large-scale raiding and corresponding construction of improved defensive architecture.

According to social coercion theory, initial increases in social complexity will sometimes feature relatively less warfare, depending on local ecology,[10] with conflict frequency increasing substantially only later, after social complexity and settlement density reach sustainable maxima. There is considerable support for these specific chronological predictions of social coercion theory in the archeological records of portions of the Ancestral Pueblo and Mississippian domains.[6–10,13,24,25]

WARFARE AND SOCIAL COERCION THEORIES: APPROACHES TO EMPIRICAL FALSIFICATION

Scientific theories are valuable only to the extent that they make sufficiently numerous and precise predictions to be useful, on one hand, and empirically falsifiable, on the other. Both warfare and social coercion theories predict that significant local changes in social complexity should follow arrival of the bow. However, social coercion theory predicts that sustainable increases in social complexity (not attributable to novel exogenous increase in ecological carrying capacity through environmental change or growth of local populations up to this carrying capacity) can only occur through increases in social scale, and are dependent, in turn, on new weapons. (Weaker forms of warfare theory can be agnostic about whether there might sometimes be another cause

of increased social complexity in some local cases.)

Thus, confirmation that most or all increases in prehistoric North American Neolithic social complexity correlate in time with local arrival of an elite bow technology would argue that both warfare and social coercion theory survive a strong opportunity for falsification, dramatically focusing future analysis of the causes of social complexity. Though this question invites further investigation, we argue that earlier work and several of the papers in this issue strongly support this first, common prediction of both warfare and social coercion theory.[10]

The next challenge is to attempt to define predictions that distinguish between warfare and social coercion theories. We argue that this is comparatively straightforward (Box 1). Most importantly, warfare theory sees increased warfare resulting from new weapon technologies as the cause of ensuing increases in social scale or complexity. Thus, warfare must increase with or shortly before other symptoms of increased social complexity. In sharp contrast, social coercion theory sees warfare as an effect of increased social scale or complexity. Moreover, according to social coercion theory, increases in warfare will follow potentially predictable local chronologies, sometimes lagging substantially, perhaps for as much as several generations, behind other symptoms of increasing social complexity.

More specifically, in local ecosystems where resources are available that allow substantial increases in productivity through social intensification, Malthusian constraints, which engender active conflicts of interest, will be minimal in the early aftermath of increased social scale.[10] When this happens, local populations will grow in complexity with little or no increase in warfare in response to local arrival of the bow. However, once populations hit the new Malthusian ceiling, warfare will increase dramatically, having the new scale inherent in the new local social complexity.

Thus, chronology of increased warfare and enhanced social scale/complexity throughout the aggregate North American Neolithic record should provide clear opportunities for evaluating the relative merits of warfare and social coercion theories. If an increase in social complexity substantially precedes increased military violence in some localities, warfare theory is falsified. Moreover, if such cases of substantial lags in the inception of increased warfare occur after enhancements in social scale or complexity, social coercion theory survives a strong opportunity for falsification and is more likely to be correct. Moreover, social coercion theory can make potentially falsifiable predictions about the details of local subsistence economies and the magnitude of these lag periods.[10]

The papers in this issue provide rich empirical material and thoughtful discussions of this extremely important theory-testing project. In the Synopsis paper at the end of this issue we will discuss views of the current status of this effort.

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