

# UCLA

## UCLA Previously Published Works

### Title

Change in the Form of Evolution: Transition from Primate to Hominid Forms of Social Organization

### Permalink

<https://escholarship.org/uc/item/3dj013mf>

### Journal

Journal of Mathematical Sociology, 29(2)

### ISSN

0022-250X

### Author

Read, Dwight W

### Publication Date

2005-04-01

### DOI

10.1080/00222500590920842

Peer reviewed

# Change in the Form of Evolution: Transition from Primate to Hominid Forms of Social Organization

Dwight W. Read

Department of Anthropology, UCLA, Los Angeles, CA 90035, USA

Author Final Version. Published in the Journal of Mathematical Sociology 29: 1-24, 2005

## Introduction

Whether the evolution of the forms of social and cultural organization that characterize modern *Homo sapiens* is one of degree rather than kind in comparison other animal species is still contentious (cf. Rendell and Whitehead 2001). Favoring degree rather than kind are observations that expand our understanding of the range of capacities likely to be already present in an ancestral primate common to both the lineage leading to *Homo sapiens* and our nearest ape relatives, the African pongids (gorilla and chimpanzee). Chimpanzees have been shown to have linguistic capabilities once thought to be unique to ourselves. Observations on primate behavior in the wild have documented, as Yerkes (1927) foresaw, the role of social, as well as genetic, transmission of behavior. An expanded view of Darwin evolution based on inclusive fitness and models for direct phenotypic transmission of behavioral traits have all provided, some have argued (e.g., Cavalli-Sforza 1982; Boyd and Richerson 1985; Durham 1992), a Darwinian framework for models of cultural evolution.

Not yet answered is whether this expanded view of evolutionary processes and the capacities of an ancestral primate species provides a sufficient basis for modeling the emergence of the culturally framed forms of social organization that characterizes modern *Homo sapiens*. The answer to be sketched in this paper is: No. Instead, it will be argued, the transition to the forms of social organization that characterize human societies also involved a fundamental shift to evolution driven by the transmission of conceptual systems underlying social organization rather than transmittal of individual traits, per se. The shift, I argue, made it possible to transcend a “barrier” that limited the complexity of social organization that was possible under the biologically driven evolutionary pathway leading to modern pongids. The barrier represents the difficulty in maintaining a coherent form of social organization in the face of an evolutionary trend towards increased individuation of behavior as exemplified in the transition from the cercopithecines (Old World monkeys) to the apes. This increased individuation led to potential reduction in the coherency of social organization that was resolved among the pongids either through reduction of the size of social units or through partial solutions to the problem of maintaining social coherency in the face of extensive individualization. A more complete resolution of the conflict between individuation and social coherency depended upon a shift away from social organization arising from a genetic/individual-learning/individual-interaction foundation to social organization constructed around a conceptual system for interaction that transcended individual fitness as the primary basis for evolutionary change. As noted a half-century ago by the structural anthropologist Claude Lévi-Strauss: “It seems as if the great apes, having broken away from a specific pattern of behavior, were unable to re-establish a norm on any new plane. The clear and precise instinctive behavior of most mammals is lost to them, but the difference is purely negative and the field that nature has abandoned remains unoccupied” (1969[1949]:8).

The “field that nature has abandoned” became filled only during the evolution of the hominids. A new form of social organization based on conceptually constructed relations among individuals arose that overcame the combinatorial complexity introduced by the advent of increased individuality for social organization based on face-to-face interaction. Evolution of biologically based cooperative patterns of behavior driven by inclusive fitness as a way to overcome the problems introduced by individuality are

limited by the shallow depth of biological kin relations that can be activated among the non-human primates. Accommodation of individualized behavior had to shift from a biological kin basis to a conceptual basis for constructing relations among group members that transcended the limitation posed by means for identification of biological kin. This shift enabled patterns of behavior conducive to social cohesiveness in the face of extensive individualization of behavior to arise and thereby restructure the mode of evolution as it applies to hominid social organization and cultural systems.

## Individualization and Social Complexity

Individualization of behavior runs contrary to the coherence of a social group, where we can characterize a social group,  $G$ , as a set of individuals for which the probability,  $p_b$ , of a behavior,  $b$ , of an individual over some appropriate time frame  $\Delta t = [t_0, t_1]$  is dependent on current behaviors of other individuals in  $G$ . We will say that  $G$  is a coherent group when the probabilities  $p_b$  are stable over time. Implicit in the notion of coherency is the assumption that the time scale for change in membership of the individuals of group  $G$  whose behaviors are relevant to the probabilities,  $p_b$ , is long in comparison to the time scale required for observing instances of the behavior  $b$  and inferring values for the probabilities  $p_b$ . Coherency of a group in this sense refers to the ability of one individual to take into account, or “model,” the behavior of other individuals in the group, thus making the probabilities  $p_b$  part of the information repertoire of the members of the social group (Read 2004).

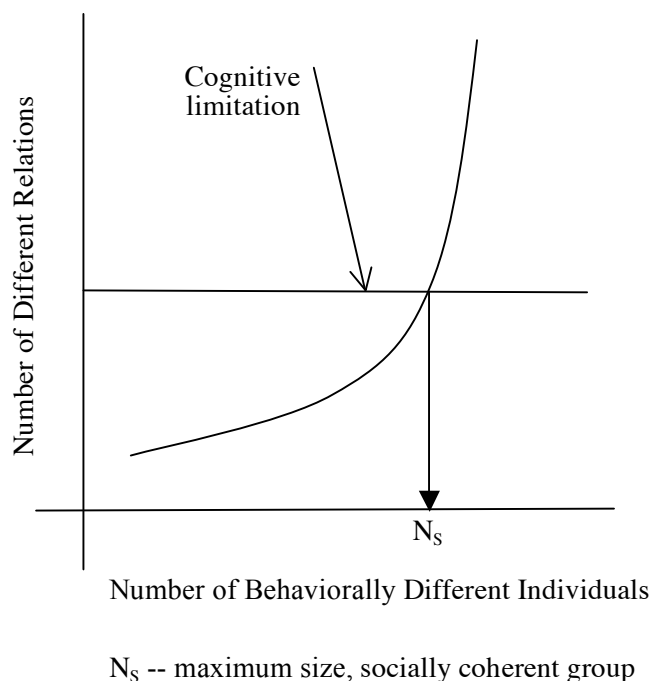
By individualization of behavior I mean expansion of the behavioral repertoire of group members relevant to the fitness of individuals to the point where the behavior of one individual cannot be predicted simply from knowing the behaviors of another individual in the group. More formally, assume we have a group  $G$  of  $n$  individuals and let  $B_i = \{b_{i1}, b_{i2}, \dots, b_{imi}\}$  be the repertoire of behaviors that can be engaged in by individual  $g_i$  in  $G$  and whose occurrence may have an impact on the fitness values associated with behaviors by other group members. Lack of individualization will correspond to low diversity across the sets  $B_i$  and extensive individualization will correspond to high diversity across the sets  $B_i$ .

Next we can define a simple society as one in which the sets  $B_i$  have low diversity, hence different individuals exhibit essentially the same range of behaviors, thereby facilitating transference of knowledge and predictability about one individual's behavior to the behavior of other individuals (Read 2004). Simple societies (such as a school of fish or a herd of ungulates) will thus tend to be scale free with respect to group size due to low diversity of behaviors across individuals.

Define a complex society to be one with high diversity of behaviors; that is, where little transference can take place and so the experience one individual has with another individual may only have limited applicability towards predicting the behavior of other individuals. Under these circumstances social coherence will depend upon the number of individuals for whom behavior is predictable, which will be related to the total number of individuals, hence social coherence in complex societies will not be scale free and social coherence will decrease with group size, all other things being equal.

## Social Complexity and Group Size

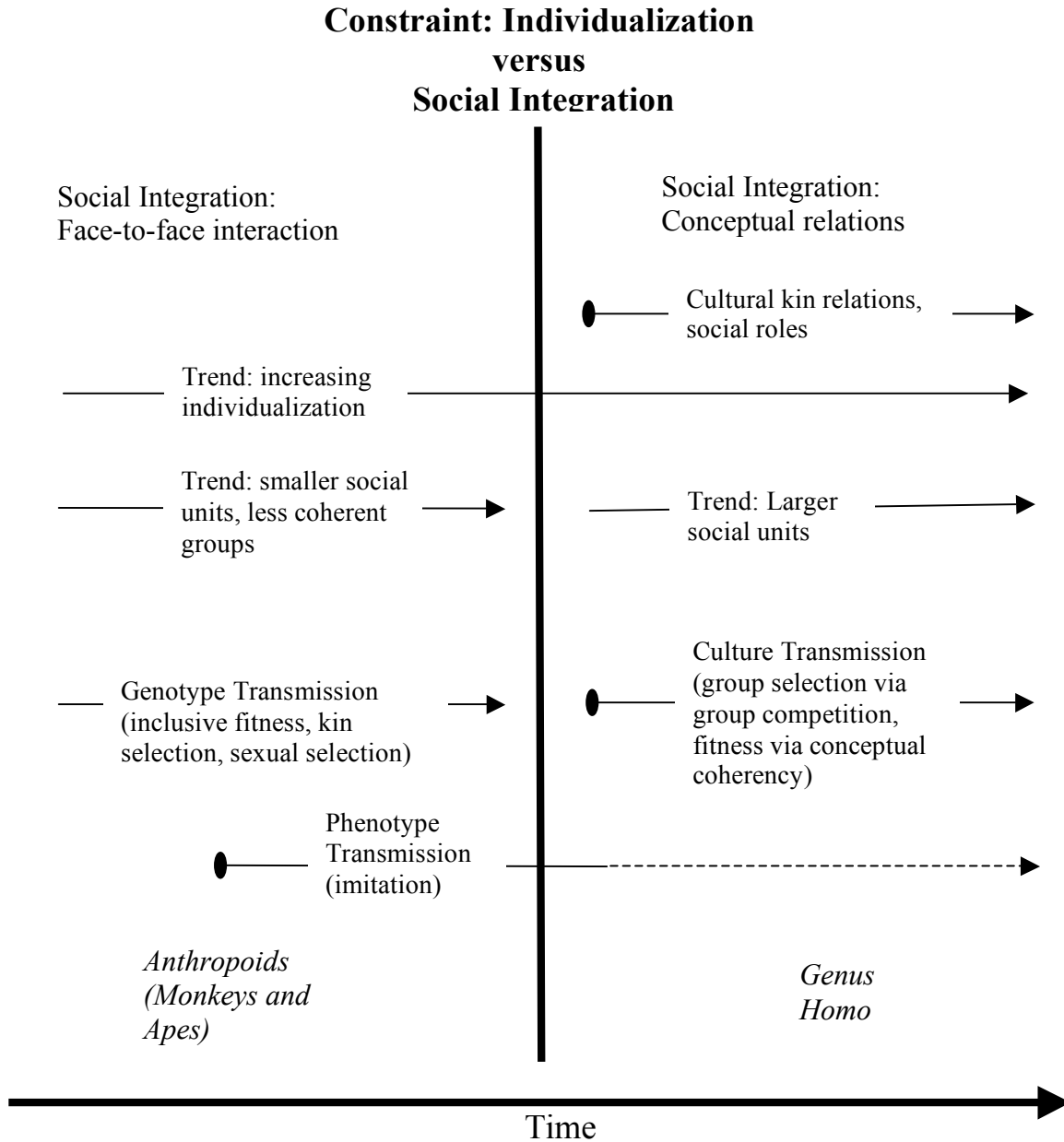
A problem faced by any social group is coordination of behavior among group members so as to reduce within group and between individual conflict. With the advent of the primates and their evolution from the prosimians to the pongids, ability to make predictions about possible behaviors of other group members has become a regular part of their cognitive repertoire (Tomasillo 1999). As the ability to predict has increased, more complex forms of social organization that may have a fitness payoff for individual group members have become possible. This interdependence between mental capacity and complexity of social organization has been discussed, following seminal papers by Chance and Mead (1953), Kummer (1967) and Humphrey (1976), by a number of researchers under the rubric “Machiavellian Intelligence” (Whiten and Byrne 1988, Byrne and Whiten 1997), with social complexity seen as a driving force for increased mental capacities among the pongids and hominids (and



**FIGURE 1 Relationship between individuation (behaviorally different individuals) and social complexity (number of different possible relations based on behavioral differences. Cognitive limitation places an upper bound on the maximum size of a socially coherent group.**

possibly for other social mammals). Increased mental capacity for varied behaviors and the capacity to modify one's own behavior in expectation of the likely behavior of other group members was also an impetus for increased individualization of behavior. Consider next the consequence of increased individualization for the complexity of the social field in which individual group members interact.

In a simple society the social field for an individual will tend to be determined by the variety of behaviors within a single behavior set,  $B$ , due to similarity of behavior sets across individuals, and not by the number of individuals. As a first approximation, if we assume that individuals can cope with all the behaviors in the behavior set, the complexity of the social field will tend to be independent of the size of the group. In a complex society, however, the complexity of the social field will scale with the number of individuals in the group plus the number of dyads (since a dyad can form a temporary alliance vis-à-vis a third individual), the number of triads and so on. As noted by Byrne and Whiten (1997 "a monkey, taking the probable actions of a third party into account, is facing a more challenging world than an animal that only interacts dyadically . . ." (p. 11). Even if we only take dyads into consideration the complexity of the social field in a complex society will scale with  $n^2$ ,  $n$  the size of the group.



**FIGURE 2 Vertical line: Evolutionary barrier for genetically based behavior.**

Ability to cope with behavior diversity depends in part on the mental capacities of the members of a species and is reflected in a positive correlation between innovative behavior and executive (neocortex) brain size (Reader and Laland 2002). For any species an upper bound exists with regard to mental capacities, hence the size of a complex society that can remain coherent through coordination of behaviors is bounded by a limit on mental capacity for dealing with a varied pattern of social interactions (see Figure 1; cf. Dunbar 2003). As a consequence, increased individuality should eventually lead to a decrease in the group size of coherent social units. It appears, then, that increased individualization may bring a species up against an evolutionary “barrier” of social complexity caused by increased individualization.

We may summarize the argument in the manner displayed in Figure 2. The solid vertical line represents the constraint that separates the non-human primates from the kind of social organization eventually developed in the hominids with the appearance of *Homo sapiens*. For the non-human primates to the left of the vertical line, social integration centers around face-to-face interaction. But the effectiveness of face-to-face interaction as a means to accommodate individualization rapidly diminishes with increased individualization. One way to accommodate both increased individualization and social cohesion is to reduce the size of social units in which individuals are embedded for day-to-day activities. Data on the pongids (orangutans, gorillas and chimpanzees), in comparison to Ceboids (New World monkeys) and the Cercopithecoids (Old World monkeys) suggest that there was a shift towards increased individualization with the pongids and consequently a reduction in the size of their social units and a shift to less cohesive social units.

On the hominid (right) side of the vertical line is posited the advent of an ideational system comprising conceptually formulated social roles such as kin relations whose implementation does not depend upon prior identification of biological kin relations. To the extent that expected patterns of social behavior can be associated with these social roles, social integration and group coherency no longer depends on prior face-to-face interaction before social interaction can take place (Rodseth et al. 1991). The key, conceptual abilities that were needed to make this shift to a different basis for social integration (to be discussed below) do not appear to be present in the non-human primates, hence the transition was not a simple elaboration upon already present capacities but depended upon the introduction of new conceptual abilities (to be discussed below). The transition also had the consequence of shifting the unit of evolution from the individual to the group through fitness arising from the coherence of a conceptual system in the face of recruitment of new individuals into a social group and across generations. This shift from individual to group selection may have had as a precursor direct transmission of behavioral phenotypes through imitative behavior and social learning, but neither direct phenotypic transmittal nor genetic transmission, nor a combination of these, suffices to account for the form of social organization and cultural systems that eventually arose with the hominids.

## Baseline: Social Cohesion among the Ceboids and Cercopithecoids.

Though no single model of social integration adequately accounts for the full wide range of patterns of social organization that occur among the Ceboids and Cercopithecoids, a general pattern of relatively cohesive social units does appear to be common, regardless of the modality (individual interactions, social organization of a group, between group interactions, determinants of group size) considered (see Table 1). Even when social organization takes on a fusion-fission pattern social cohesiveness still applies as indicated by Chapman's (1987) observation for the howling monkeys that "when subgroups united, agonistic behaviours were rarely seen" (p. 102). Even for the highly territorial vervet monkeys, encounters between groups "seldom results in physical contact" (Cheney 1987: 279). The overall pattern for monkey species, despite the wide variation in the mode and scale of social organization, appears to be one of socially coherent, stable social groups that are internally integrated through "short-term contingent decision-making" (Barrett and Henzi 2001: 263) and externally able to respond in a flexible manner to conditions the group may encounter. As noted by Strier (2000) "some of the strongest evidence of kin selection in action has been found among female Old World cercopithecine monkeys, such as baboons, macaques, and vervet monkeys" (p. xx).

**TABLE 1** Social Cohesion Among Ceboids and Cercopithecoids (Old and New World Monkeys)

Grooming	Occurs primarily between biologically related individuals, especially mothers and offspring (Gouzoules and Gouzoules 1987)
Social Organization	Stable groups around 30 – 50 individuals with aggregates of up to 200 (Kummer 1968; Crook 1966; Dunbar and Dunbar 1975; Sharman 1981) most males transfer from natal group to neighboring groups (Pusey and Packer 1987); stable female dominance hierarchy (Melnick and Pearl 1987)
Territoriality	Variable pattern by species: Not territorial – e.g. baboons (Hamilton, Buskirk and Buskirk 1976) Territorial – e.g. vervet monkeys (Cheney 1987)
Size of Social Units	" Ecological factors are sufficient to explain variation on group size, female dispersal, and establishment of hierarchical dominance relationships" (Izar 2004, p. 95; see also Jenson 1988, Symington 1988, Chapman 1990)

## Loss of Coherence: Pongids and Individuality

The pongids have long been noted for individualization of behavior. As noted by Yerkes (1927), "The orang-utan, gorilla and chimpanzee especially resemble man in this individualization of behavior" (p. 192). More recently Maryanski and Turner (1992) have commented: "And perhaps the most intriguing finding is the selection for high individuality, since apes are rather self-contained individuals with few strong tie networks" (p. 30). McGrew (2003) has observed: "In chimpanzees, each alpha male has his own style" (p. 425). Correspondingly, the pongids differ markedly from the monkeys on all of the social dimensions considered in Table 1. As shown in Table 2, we see a pattern for *Pan troglodytes* in which social cohesion seems to be highly problematic at every level. Groups within a community are unstable, do not have a consistent set of members, only involve males and the size of foraging groups is not determined by considerations of foraging efficiency as is true for monkeys. Thus they are not a social unit that encompasses the full range of relations that are part of the social groups one finds among the ceboids and cercopithecoids. Nor is the community a coherent, stable unit nor is it an integrated unit of females and males as each sex has markedly different patterns of interaction within a community (Wrangham 1987).

Also striking is the variety of forms of social organization among the pongids. In addition to the pattern displayed in Table 2 for *Pan troglodytes*, *Pongo pygmaeus* (orangutan) has a solitary form of social organization, gibbons and siamangs are pair-bonded, gorillas have a single male + several female “harem” type of social organization and the social organization for *Pan paniscus* appears to be based on female relations built around genital rubbing and other means for forming coalitions among females. Yet

**TABLE 2** Lack of Social Cohesion Among *Pan troglodytes*

Grooming	Mainly male-male adult grooming: 59% male-male versus 13% female-female adult grooming (Table 7, Nishida 1979); grooming occurs in reunions of male groups, with grooming directed towards newcomers to the group (Bauer 1979)
Social Structure	Community – shares single home range, consists of 20 – 100 individuals but made up of small, unstable male groups (< 6 for Pan); community fissioning occurs when there are around 19-20 males; females transfer from natal group; unstable male dominance hierarchies (Nishida and Hiraiwa-Hasegawa 1987)
Territoriality	“...chimpanzees have aggressive and dangerous inter-community relationships.... Encounters between different communities carry a risk of severe aggression.... Adult males of the main community repeatedly invaded the territory of the branch community and deliberately killed at least three adult males and one adult female. They were suspected of killing two additional adult males...” (Nishida and Hiraiwa-Hasegawa 1987).
Size of Social Units	“Foraging efficiency ... was poorly correlated with foraging party size” (Isabirye-Basuta 1988: 140); “... <i>P. troglodytes</i> party size appears to vary little across habitats varying from forest to savannah” (White and Wrangham 1987:159).

common to all of them appears to be a pattern of formulating solutions (albeit different solutions) based on smaller group sizes as a way to resolve the problem of accommodating a degree of individuation. As a consequence, the pongids do not form coherent social groups on the same size scale as is the case for the cercopithecines and the ceboids. Still another change that occurs with the pongids – and possibly with some of the cercopithecines – is the introduction of socially based transmittal of behavior traits in the form of direct phenotypic transmission, as indicated in the bottom of Figure 2.

Direct phenotypic transmission of traits allows for a wider range and variety of traits to spread through a social group than is true with genetic transmission of traits and has been discussed extensively by Cavalli-Sforza and Feldman (1981) and Boyd and Richerson (1985). Since transmittal shifts from reproduction to interaction between group members with direct phenotypic transmission, selection shifts from reproductive success to conditions that favor transmittal of behavioral traits. Hence the association between Darwinian fitness and genetic transmittal is relaxed and a trait may spread even though it confers no fitness advantage, depending on the mechanism posited for direct transmittal of a trait, such as imitation of individuals that are perceived to be “successful.” Though the extent to which behavioral traits observed among the pongids are the consequence of imitation of the behavior of other group members has been disputed (see review by Tomasello 1999; see also Galef 1998), some examples such as the hand-clasping, grooming behavior among one group of *Pan troglodytes* appear to be instances of a

**TABLE 3** Food Sharing Among *Pan troglodytes*

37 Individuals	mother(mo)/offspring(o)	no biological connection	Total
Sharing Instances	360 (mo → o) 31 (o → mo)	47 (m → f) 17 (other)	455
Dyads	33	625	658
Sharing Rate	11.8 / dyad	0.1 / dyad	



behavioral trait being distributed through a group through social interaction and imitation as this behavior is “learned (rather than instinctive), social (rather than solitary), normative (rather than plastic), and collective (rather than idiosyncratic)” (McGrew 2003: 433). Nonetheless these are what Premack and Hauser (2001) refer to as “trivial behaviors” rather than “cultural practice.”

Though direct phenotypic transmission is an important mechanism for the inheritance of behavior traits -- and a mechanism that plays a wide role in human societies – data on cooperative behavior among the non-human primates, especially food sharing, illustrates the limited role that direct transmittal of behavior traits plays in social behaviors such as cooperative behavior and the qualitative difference between pongid food sharing versus food sharing as it occurs in extant hunter-gatherer societies. Table 3 shows the pattern of food sharing among *Pan troglodytes*. Sharing is clearly dominated by fitness values accruing from mother/offspring sharing and secondarily by male/female dyads, the latter being a pattern for which “it seems likely that both sexes were playing out long-term reproductive strategies” (McGrew 1992: 110) -- neither of which are examples of behavior distributed socially through imitation.

In sharp contrast to sharing along dyads directly reflecting reproductive success, Marshall (1976) in her ethnography on the !Kung san, a hunter-gatherer group in Botswana, discusses one instance of sharing of a kudu that 3 hunters had killed with a poison arrow. Just taking into account the individuals who eventually received meat from this kill, she reports data whose pattern is shown in Table 4. Striking is the dissimilarity with the pattern in Table 3, especially the preponderance of recipients without a genetic connection to the hunters, a pattern that cannot easily be accommodated within the framework of

**TABLE 4** Food Sharing in a Hunter-Gatherer Group

Genetic Kin		Non-genetic Kin	
parent	3	affines	20
Sibling	2	uncertain	6
Biological cousin	9	other	20
Other biological kin	2		
Total	16		46

kin selection and inclusive fitness. In addition, cooperative behavior occurs across residence/living groups and the 62 individuals who received meat from this kill were also from 6 different residence groups.

Perhaps more striking than the pattern of persons receiving meat from the animal killed by the numbers is the fact that cultural rules govern the sharing of meat, not imitative behavior. The !Kung san, like other hunter-gatherer groups, do not consider the animal that has been killed by the hunter as being owned by the hunter. Instead, cultural rules govern both ownership and how the meat will be distributed. The effect of the meat sharing rules, for the !Kung san, is to first define the killed animal as owned collectively and not individually by the hunters, and second to distribute the meat to those individuals who are the collective owners of the killed animal in accordance with cultural rules about meat sharing with culturally defined relatives. In the case of the !Kung san these rules shift the meat distribution from the hunters to the owner of the arrow that killed the animal and that owner need not be one of the hunters. While a hunter always receives meat from the animal he has killed, his skills as a hunter have, in effect, become skills that benefit the cultural kin of the owner of the arrow even when the owner of the arrow does not have a close biological relationship to the hunter.

The persons who receive the meat from the distributor do so on the basis of kin obligations between the owner of the arrow and his or her kin, where what constitutes kinship is culturally constructed by criteria that are not dictated by the biological relatedness of individuals (see Read 2003). Meat distribution is based on a conceptual system of obligations expressed in terms of culturally constructed kin relations that transcend the limitations of biologically based systems of cooperation and sharing. The transition from behaviors arising out of day-to-day interactions among group members to a system of obligations arising out of a shared conceptual system of inter-individual relations – cultural

kinship -- and expected behaviors based on those relations enabled, I suggest, the barrier of individualization and social coherency to be transcended.

## Constructed Kin Relations: Cultural Kinship

In human societies we refer to, and identify, those we consider our kin through two, complementary conceptual systems. One system underlies the tracing of genealogical linkages between a focal person (such as oneself) and another person, based on repeated use of relative products; e.g., a construction such as “he is my father’s brother’s son.” The other is the system of terms of reference that express and identify who are one’s kin. For American/British English speakers these are the terms mother, father, son, daughter, aunt, uncle, cousin, etc. that a child learns as part of one’s linguistic, social and cultural development. The two systems interrelate; e.g., the relation implied by the genealogical tracing “he is my father’s brother’s son” can be expressed, “he is my cousin,” by users of the American kinship terminology (AKT).

Of these two conceptual systems, the greater difference across societies occurs with kinship terminologies as kin terms reflect cultural differences in what constitutes the domain of kin. In addition, the latter often cannot be translated from one language into another. Whereas Americans have the pair of kin terms, aunt and uncle, for example, other societies may conceptually distinguish between relations through genealogical mother versus genealogical father and thus have four “aunt” and “uncle” terms, none of which have a direct counterpart in the AKT.

Extensive research on kinship terminologies (Read 1984, Read and Behrens 1990, Read 2001, Read 2003, Bennardo and Read n.d.,) has established that a kinship terminology is a culturally constructed conceptual system with an underlying logic, or “grammar” that enables the conceptual system to be generated, much like an abstract algebra, from a set of symbols (the kin terms), a binary product for those symbols (the computations users of a terminology make with kin terms) and a set of structural equations that determine both structural features of terminologies in general (e.g., reciprocity of kin terms such as occurs with the kin terms father and son in the AKT) and the particular structural features that distinguish each of the variety of kinship terminologies that occur in human societies. From a modeling viewpoint, the underlying structural form for a kinship terminological system matches that of a semigroup when the kin terms are viewed as a set of symbols (in the mathematical/linguistic sense) with a binary product over that set defined by the computations individuals make with the terms to determine kin relations.

Corresponding to each of genealogical tracing and the terminological system are two kinds of computations. One computation underlies the formation of genealogical pathways by tracing from a focal individual to another individual. Genealogical tracing, it should be noted, is not a “best attempt” to identify biological relations since the criterion for someone being a genealogical father need not be biological. In many societies the man recognized as genealogical father may simply be the man currently married to a woman regardless of his biological status vis-à-vis her offspring. In addition, a male’s biological role in procreation may be ignored under a “folk theory” of conception that focuses on social reproduction rather than biological reproduction (see, Goodale 1971, among other ethnographies).

A second kind of computation is done directly with kin terms and does not depend on genealogical tracing. As noted by the anthropologist Marshall Sahlins (1962) with regard to Moala kinship: “. . . [kin] terms permit comparative strangers to fix kinship rapidly without the necessity of elaborate genealogical reckoning—*reckoning that typically would be impossible*. With mutual relationship terms all that is required is the discovery of one common relative. Thus, if A is related to B as child to mother, *veitanani*, while C is related to B as *veitacini*, sibling of the same sex, then it follows that A is related to C as child to mother although they never before met or knew it. *Kin terms are predictable. If two people are each related to a third, then they are related to each other*” (p. 155, emphasis added). If we consider the kin terms to be a set of symbols,  $S$ , then the kin term computation discussed by Sahlins defines a binary product that may be extended into a binary product over  $S$  by adjoining the symbol, 0, (as is done with algebraic structures) with interpretation “not a kin term” (e.g., the product of father and

father-in-law is not a kin term in the AKT as there is no kin term “grandfather-in-law”). Extensive variation in the form of kin terminology structures, which relates to differences in generating terms and structural equations satisfied by the products of generating terms, makes evident the disjunction between a universal system of biological relations produced through procreation, on the one hand, and culturally specified systems of constructed kin relations, on the other hand.

Connection between the abstract, conceptual system and the terminology as it is used by culture bearers is made through cultural instantiation (see Read 2002), with genealogical constructs, of the abstract concepts of the conceptual system. For example, for the AKT the kin term concept, mother, is given content by the instantiation: mother  $\rightarrow$  {genealogical mother}; the kin term concept father  $\rightarrow$  {genealogical father}, and similarly for son and daughter, the reciprocal generating terms. Other instantiations are possible such as mother  $\rightarrow$  {adopting female}. The “algebraic logic” of the abstract terminology can then be used to extend the instantiation of the generative kin terms (e.g., mother, father, son and daughter in the case of the AKT) to the instantiation of all other kin terms with regard to genealogical tracing. This leads to a predicted set of genealogical definitions of the kin terms making up a terminology and for the wide variety terminologies considered to date (AKT, Shipibo – South American horticultural group, Trobriand islanders, Tongan), the predicted genealogical definitions of kin terms agree without exception with the definitions previously worked out by anthropologists in consultation with native informants.

The precise correspondence between the predicted kinship system and the kinship system as it is used by culture bearers is remarkable and has numerous implications for the ability of the human mind to learn inferentially (see review by Salamon 2002), conceptualize and work with abstract systems at a non-conscious level since individuals are not cognizant of the logic underlying the kinship systems they have learned as part of becoming culture bearers. For our purposes here it raises the question, from an evolutionary perspective, of why a conceptual system such as a kinship terminology should be highly logical despite all the vagaries that can occur in the transmission of behavioral and conceptual traits from one individual to another. The answer to that question also identifies the basis by which our hominid ancestors were able to transcend the barrier shown in Figure 2.

## Evolutionary Origins of Conceptual Systems

Space only permits sketching out a possible scenario for the evolution of culturally constructed conceptual systems such as a kinship terminology or genealogical tracing. Nonetheless it will be evident that a shift takes place from the individual as the primary unit of transmission (whether genetic or phenotypic) to a group as the unit of transmission; i.e., a shift to group selection. However, group selection in the form it has often been considered only shifts the fitness calculation to the group level without simultaneously taking into account that the traits in question must occur at the group, not the individual, level. For group selection to be viable three criteria need to be satisfied: (1) a trait is expressed at the level of a group – call it a group trait, (2) a fitness value associated with a group trait is defined at the level of the group and not at the level of individuals in the group and (3) there must be a means for transmittal of the group trait from one group to another. The trait we will consider here is the conceptual system of genealogical tracing as a means of establishing a relation between individuals.

As with imitative behavior, certain biologically based capacities must be present in individuals before genealogical tracing is cognitively viable. Minimally these are: (1) ability to conceptualize a relation, (2) a theory of mind (Premack and Woodruff 1978) and (3) the conceptual ability to do recursive reasoning. Lack of these three capacities, especially lack of ability to do recursive reasoning among non-human primates (Hauser 2001), implies a difference in kind between pongid and *Homo sapiens* conceptual abilities. Evolution of the capacity to do recursive reasoning as part of genealogical tracing is also a potential candidate for a pre-cursor to recursive reasoning in languages, which Hauser, Chomsky and Fitch (2002) suggest is the primary difference in linguistic capacity between *Homo sapiens* and non-human primates.

### **Concept of a Relation**

By the concept of a relation between individuals is meant generalization over concrete instances of behaviors, such as how females act with their offspring, and then categorizing -- not on the basis of shared behavioral features, per se, but on the basis of a more abstract notion of a kind of relation. Categorization based on shared features is widespread among organisms and in simple societies categorization of behaviors might occur in terms of behavior features that are expressed in a similar manner regardless of the individual. But with complex societies and with increased individualization, the basis for categorization using shared behavior features diminishes and categorization either does not occur or, if it occurs, it must be at a more abstract level than shared behavioral features. The cognitive capacity needed to form an abstract category such as a “mother relation” among the non-human primates is not common, though it apparently occurs among the macaques. Based on experimental observations regarding ability to discriminate mother-offspring pairs from female-infant pairs, Dasser (1988) comments: “Mother-offspring pairs were differentiated from any other pair [of females and infants]... *cues other than the relation between individuals* do not plausibly account for the result” (p. 91, emphasis added).

### **Theory of Mind**

By theory of mind is meant not only self-awareness, but the ability to imagine that another individual has awareness similar to one’s own sense of awareness. Included under theory of mind is the idea that if one individual is aware of why he or she acts in a certain way, then that individual, upon seeing another individual acting in a similar way, is able to imagine that the second individual may be acting in that manner for a similar reason. Theory of mind may possibly occur among the chimpanzees, but does not appear to be part of the cognitive repertoire of the Old or New World monkeys.

### **Recursive Reasoning**

Recursive reasoning is fundamental to genealogical tracing and enables the conceptual construction of new relations while requiring neither an experiential basis for the new relation nor that it reflect a criterion such as biological kinship. With recursion one can construct new, conceptually formulated relations on the basis of an already held experientially conceptualized relation such as the “mother” relation that the macaques appear to recognize. With recursion one can apply the relation to the output of the experientially conceptualized relation and thereby conceptualize a new relation (the relation of a relation) between the focal individual and a third individual. In brief, if individual  $a$  recognizes a mother relation (which we can represent in the form of a two-place predicate  $M( , )$ , or  $M$  for short) of her/himself to some adult female  $b$  (which we can denote by  $M(a,b)$ ) then we can use the  $M$  relation recursively to construct a new relation  $MM( , )$ . Namely, we form the relation  $MM( , )$  where  $MM(a, c)$  is valid when there is a  $b$  such that  $M(a, b)$  is valid and there is a  $c$  for which  $M(b, c)$  is valid. Evidence from language learning experiments among non-human primates suggests, however, that recursive reasoning like this is not part of their cognitive repertoire (Fitch and Hauser 2004).

## **Genealogical Tracing and Group Selection**

These three pieces, concept of a relation, theory of mind and recursive reasoning, provide the conceptual basis for genealogical tracing. In general, the concept of a relation,  $R( , )$ , allows an individual  $a$  to form an instance  $R(a, b)$  of the relation for some individual  $b$ . The theory of mind allows individual  $a$  to perceive that individual  $b$  can make a similar construction, hence individual  $a$  perceives that there must be an individual  $c$  for whom  $b$  can construct the instance  $R(b, c)$  of the relation  $R$ . By recursion, individual  $a$  can now construct the relation  $RR$  as outlined above since individual  $a$  forms the instance of the relation  $R(a, b)$  and individual  $a$  perceives that there is an individual  $c$  such that  $R(b, c)$  is also a valid instance of  $R$ , it follows that individual  $a$  can form the composite relation  $RR(a, c)$ , and so on. Observe that even though the initial relation,  $R$ , may be based on experience and may be grounded in biological relations, the theory of mind does not require that the same be true of  $b$  and  $c$ . From  $a$ ’s perspective,  $a$  only needs to believe that there is an individual  $c$  for whom  $R(b, c)$  is true and the actual biological relation of  $c$  to  $b$  is not critical. This is precisely one of the key aspects of genealogical tracing.

Genealogical tracing need not model actual biological relations as it is a conceptual means to construct relations among individuals based on accepting (or believing) that a claimed instance of the relation as valid (or believing that it is valid).

### **Group Trait**

The importance of genealogical tracing lies in constructing a consistent pattern of relations for group members for which expected patterns of behavior can be mapped to kinds of relations in a consistent manner consistent across individuals. Genealogical tracing by one individual, though, need not match genealogical tracing by another individual, hence relations constructed by one individual cannot simply be combined with relations constructed by other individuals to form a coherent and consistent overall pattern of relations among individuals. Thus the utility of genealogical tracing in forming kin relations upon which expected patterns of behavior might be based requires that the tracing be a group, rather than an individual, property; that is, the tracing must be coherent for the group as a whole.

### **Group Fitness**

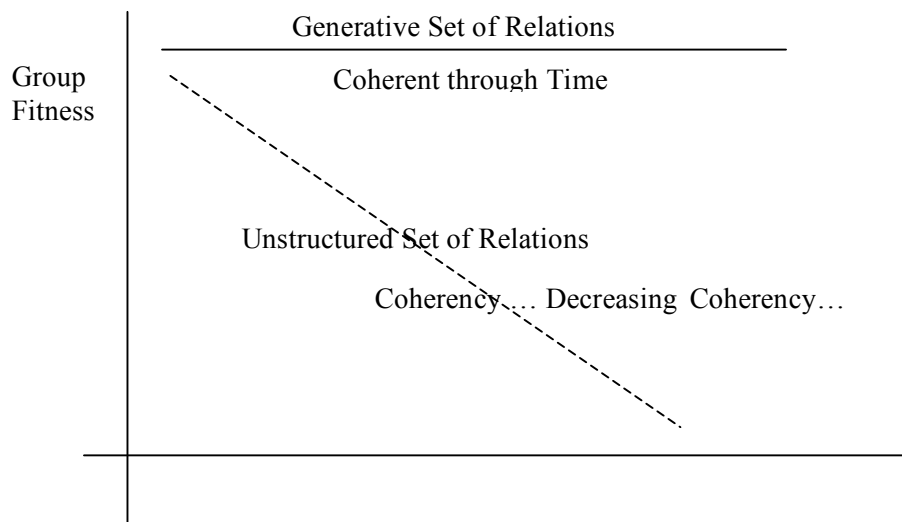
Group fitness arises out of group competition modeled using the Lotka-Volterra equations for competition between two species: (1)  $dP_1/dt = P_1(a_1 - b_{11}P_1 - b_{12}P_2)$  and (2)  $dP_2/dt = P_2(a_2 - b_{21}P_1 - b_{22}P_2)$ , where  $P_i$  is the population size of group  $i$ ,  $a_i$  is the intrinsic growth rate of group  $i$ , and  $b_{ij}$  measures the inhibitory effect of species  $j$  on the growth of species  $i$ ,  $1 \leq i, j \leq 2$ .

These equations apply to groups if we also allow for movement of individuals in or out of groups as part of the dynamics of growth. The outcome of competition is determined by the parameter values. For fixed parameter values, a stable relationship can occur between two groups when  $b_{ij} < b_{ii}$ ,  $i \neq j$ ,  $1 \leq i, j \leq 2$ ; that is, when the inhibitory effect of one group on its own growth is greater than the inhibitory effect of that group on the growth of a second group. If  $b_{ij} < b_{ii}$  and  $b_{ji} > b_{jj}$  then group  $i$  will drive group  $j$  to extinction. If  $b_{ij} > b_{ii}$ ,  $i \neq j$ ,  $1 \leq i, j \leq 2$  an unstable equilibrium is theoretically possible in the absence of stochastic effects. When parameter values can change – the situation of interest here -- a small change in parameter values need not change, for example, the condition for a stable equilibrium. Instead the effect of a small change in parameter values will be to change the relative sizes of the two groups. A shift from stable equilibrium to group  $i$  winning out in competition would arise when  $\Delta b_{ji} > b_{jj} - b_{ji}$ ; that is, it depends on one group substantially modifying its competitive position vis-à-vis the other group.

These observations suggest that we can use group competition and the consequences of change in parameter values as the basis for measuring group fitness. A change in parameter values by one group increases its fitness when the new equilibrium value leads to an increased population size for that group (assuming fixed areas) or an increase in population density (assuming variable areas).

### **Group Inheritance**

Inheritance of a trait – morphological, behavioral or conceptual – is directly from one individual to another. Group inheritance arises only when properties are transmitted by individuals that are not simply a summary of individual traits. The group trait identified above -- coherence of genealogical tracing across group members – satisfies this condition. Individuals transmit their understanding of genealogical tracing, not coherence of genealogical tracing across group members. Imagine that an ancestral group of hominids has worked out some pattern of genealogical relations and expected patterns of behavior for those relations that has fitness benefit for individuals in the group. Initially the set of genealogical relations may be little more than relations abstracted from experience and the expected behaviors may simply reflect the experiential basis for the relation that has been conceptualized. Coherence of even a simple set of relations and associated patterns of behavior for a group depends upon accurate transmittal of those concepts to other individuals. But transmission need not be faithful and the coherence of that suite of concepts and associated behaviors will diminish through time and across generations even for a small set of concepts (cf. Komarova and Nowak (2001) for maintenance of word-meaning associations in an evolving population), hence the fitness benefit accruing from the suite of genealogical relations and patterns of behavior will diminish through time (see dashed line in Figure 3). Inaccurate transmittal becomes exacerbated as the suite of relations and associated behaviors becomes



**FIGURE 3 Schematic diagram for change in group fitness with an unstructured set of relations versus a generative set of relations.**

larger in scope. In addition, as the suite of relations is extended through recursion, the space of possible relations grows exponentially in size and the conceptual space that needs to be transmitted increases exponentially in complexity as recursion becomes more extensive.

The barrier of complexity growing exponentially at the behavior level with the expansion of individualization and now again at the conceptual level with relations constructed through recursive reasoning is resolved when the domain being transmitted becomes simplified through having a logical/syntactical basis to its form. Both the generative property of kinship terminologies and the logic underlying recursion carried to its full extent give rise to conceptual domains where the domain itself does not need to be transmitted *in toto*; rather, only the properties and logic from which the domain can be generated need be transmitted. For genealogical tracing, it is far simpler to transmit consistently and in a coherent manner, as indicated by the solid line in Figure 3, the logic by which the full space of genealogical relations is generated rather than some unstructured set of genealogical relations (see D'Andrade 1970, Read 2000 for a discussion of the logic the space of genealogical relations).

Transmittal of the underlying logic has two critical implications. First, any errors or omissions in direct transmission of the genealogical space can be self-corrected by inconsistency with the logic of how the genealogical space is generated. Second, coherency across individuals arises from the logic of genealogical tracing carried out individually; e.g. if persons *a* and *c* currently do not know their genealogical connection but person *a* traces back to person *b* and person *c* also traces back to person *b*, then *a* and *c* can now compute their genealogical connection.

Under these conditions group selection in the form of group competition will favor groups that begin to utilize the logic of genealogical tracing and shift towards transmittal of the underlying logic and not simply some set of genealogical tracings. In addition, for the competition argument to apply, appropriate environmental conditions must exist under which more extensive sharing or cooperation among individuals who perceive themselves to be related has an impact on the parameters of group competition. Conditions favoring such sharing include environments in which the spatial scale for temporal and spatial variability in resource abundance is comparable to the spatial scale for the resource base of a group in isolation; that is, environmental conditions wherein one group may have shortage of resources while another group has abundance of resources, hence sharing of resources will lead to an increase in population size/density (see Read and Leblanc 2003). If the increase is large enough, competition will ensure that the groups able to share resources – along kin lines constructed through

genealogical tracing in conjunction with patterns of behavior associated with these relations – will win out in competition with other groups.

## Conclusion

Under the scenario proposed here, evolution of forms of social organization has shifted from change in frequency of individual traits driven by individual fitness to evolution driven by coherency of conceptual systems for the social organization of a society. As a consequence the “[cultural] system has become independent from biology in such a way that the constraints acting for stabilization or for changes in a given culture are internal” (Ripoll and Vauclair 2001: 355) and fitness arises from the impact the conceptual system has on the parameters for group competition. Group fitness in this scenario is related to the cognitive ability to formulate a conceptual system of relations with an underlying structure that enables transmittal of a complex system of organization at the behavioral level by shifting transmission from individual phenotypic transmission to transmission of group properties via a coherent system of relations. The conflict between individualization and social coherency is resolved by associating expected patterns of behavior with the constructed relations and by individuals acting in accordance with those expected patterns of behavior. In sociological terms, individuation becomes subsumed under roles and roles become the equivalent of genotypes in a genetic system. Change in roles thus becomes central to change in human societies as noted in Klüver’s (2002) comment that “*sociocultural evolution is the changing and creating of social roles by means of changing and ... enlarging components of culture; i.e., knowledge, and by ... changing and enlarging sets of social rules, i.e., social structure...*” (p. 48, italics in the original).

## References

- Bauer, H.R. 1979. Agonistic and grooming behavior in the reunion contexts of Gombe Stream chimpanzees, in D.A. Hamburg and E.R. McCown (Eds.) *The Great Apes*, Menlo Park: The Benjamin/Cummings Publishing Co.
- Barrett, Louise and S. Peter Henzi 2001. Constraints on relationship formation among female primates. *Behaviour* 139:263-289.
- Bennardo, Giovanni and Dwight Read. n.d. The Tongan kinship terminology and culture: Insights from an algebraic analysis. Manuscript.
- Boyd, R. and P.J. Richerson 1985. *Culture and the Evolutionary Process*. University of Chicago Press, Chicago.
- Byrne, R.W. and A. Whiten 1997. “Machiavellian Intelligence,” in A. Whiten and R.W. Byrne (Eds.) *Machiavellian Intelligence II: Extensions and Evaluations*, Cambridge: Cambridge University Press.
- Cavalli-Sforza, L.L. and M.W. Feldman 1981. *Cultural Transmission and Evolution*. Princeton University Press, Princeton.
- Chance, M.R.A. and A.P. Mead 1953. Social behaviour and primate evolution, *Symposia of the Society for Experimental Biology*, VII, 395–439. Reprinted in (1988), R.W. Byrne and A. Whiten (Eds.) *Machiavellian Intelligence*, Oxford: Clarendon Press.
- Chapman, Colin 1988. Patch use and patch depletion by the spider and howling monkeys of Santa Rosa National Park, Costa Rica. *Behaviour* 105:99-116.
- Chapman, Colin 1990. Ecological constraints on group size in three species of neotropical primates. *Folia Primatologica* 55:1-9
- Cheney, D.L. 1987. Interactions and relationships between groups, in B.B. Smuts, D.L. Cheney, R.M. Seyfarth and T.T. Struhsaker (Eds.) *Primate Societies*, Chicago: University of Chicago Press.
- Crook, J.H. (1966), Gelada baboon herd structure and movement: A comparative report, *Symposium Zoological Society London*, 18, 237–258.
- D’Andrade, Roy 1970. Structure and syntax in the semantic analysis of kinship terminologies, in *Cognition: A Multiple View*, ed. P. L. Garvin. New York: Spartan Books. pp. 87-143.
- Dasser, V. 1988. Mapping social concepts in monkeys. In *Machiavellian Intelligence and the Evolution*

- of Intellect in Monkeys, Apes and Humans*, Byrne and Whiten eds, Clarendon Press: Oxford, pp. 85-93
- Dunbar, R.I.M. and E.P. Dunbar 1975. *Social Dynamics of Gelada Baboons*. Karger: Basel.
- Dunbar, R.I.M. 2003. The social brain: Mind, language, and society in evolutionary perspective. *Annual Review of Anthropology* 32: 163-81.
- Durham, William 1992 *Coevolution: Genes, Culture and Human Diversity*. Stanford University Press: Palo Alto.
- Fitch, W. Tecumseh and Marc D. Hauser 2004. Computational constraints on syntactic processing in a nonhuman primate. *Science* 303:377-380.
- Galef, B. 1998 Social learning. In: *Social learning in animals: The roots of culture*, eds., C.M. Heyes and B.G. Galef. Academic Press: New York.
- Goodale, Jane 1971. *Tiwi Wives*. U. of Washington Press: Seattle.
- Gouzoules, S. and H. Gouzoules 1987. Kinship, in B.B. Smuts, D.L. Cheney, R.M. Seyfarth, R.W. Wrangham and T.T. Struhsaker (Eds.) *Primate Societies*, Chicago: University of Chicago Press.
- Hamilton, W.J., R.E. Buskirk and W.H. Buskirk 1976. Defense of space and resources by chacma (*Papio ursinus*) baboon troops in an African desert and swamp, *Ecology* 57: 1264–1272.
- Hauser, Marc D. 2001 in *Language, Brain, and Cognitive Development: Essays in Honor of Jacques Mehler*. E. Depoux (ed.), MIT Press Cambridge, pp. 417-434.
- Hauser, Marc D., Noam Chomsky and W. Tecumseh Fitch 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science* 298:1569-1579.
- Humphrey, N.K. 1976. The social function of intellect, in P.P.G. Bateson and R.A. Hinde (Eds.) *Growing Points in Ethology*, Cambridge: Cambridge University Press.
- Isabirye-Basuta, Gilbert 1988. Food competition among individuals in a free-ranging chimpanzee community in Kibale Forest, Uganda. *Behaviour* 105(1-2): 135-147.
- Izar, Patricia 2004. Female social relationships of *Cebus apella nigrurus* in a southeastern Atlantic forest: An analysis through ecological models of primate social evolution. *Behaviour* 141:71-99.
- Janson, Charles H. 1988 Food competition in brown capuchin monkeys (*Cebus apella*): Quantitative effects of group size and tree productivity *Behaviour* 105: 53 – 76.
- Klüver, J., 2002 *An Essay Concerning Sociocultural Evolution*, Kluwer Academic Publishers: Dordrecht.
- Komarova, Natalia L. and Martin A. Novak 2001 The evolutionary dynamics of the lexical matrix. *Bulletin of Mathematical Biology* 63: 451–484.
- Kummer, H. (1967), Tripartite relations in Hamadryas baboons,” in S.A. Altmann (Ed.) *Social Communication Among Primates*, Chicago: University of Chicago Press.
- Kummer, H. (1968), *Social Organization of Hamadryas Baboons*. Karger, Basel.
- Lévi-Strauss, Claude 1969[1949] *The Elementary Structures of Kinship*. Beacon Press: Boston.
- Marshall, L. 1976. *The !Kung of Nyae Nyae*. Cambridge: Harvard University Press.
- Maryanski, Alexandra and Jonathan H. Turner. 1992. *The Social Cage: Human Nature and the Evolution of Society*. Stanford University Press: Stanford.
- McGrew, W. C. 1992 *Chimpanzee Material Culture: Implications for Human Evolution*. Cambridge University Press: Cambridge.
- McGrew, W. C. 2003. Ten dispatches from the chimpanzee culture wars. In *Animal Social Complexity: Intelligence, Culture, and Individualized Societies*. Frans B. M. de Waal and Peter L. Tyack, eds. Harvard University Press: Cambridge, pp. 419-438.
- Melnick, Don J. and Mary C. Pearl 1987. Cercopithecines in multimale groups: Genetic diversity and population structure. In B.B. Smuts, D.L. Cheney, R.M. Seyfarth, R.W. Wrangham and T.T. Struhsaker (Eds.) *Primate Societies*, Chicago: University of Chicago Press, pp. 121-145.
- Nishida, T. (1979), The social structure of chimpanzees of the Mahale Mountains, in D.A. Hamburg and E.R. McCown (Eds.) *The Great Apes*, Menlo Park: The Benjamin/Cummings Publishing Co.
- Nishida, T. and M. Hiraiwa-Hasegawa 1987. Chimpanzees and bonobos: Cooperative relationships among males,” in B.B. Smuts, D.L. Cheney, R.M. Seyfarth, R.W. Wrangham and T.T. Struhsaker (Eds.) *Primate Societies*, Chicago: University of Chicago Press, pp. 165-178.



- Premack, David and Marc Hauser 2001. A whale of a tale: Calling it culture doesn't help. *Behavioral and Brain Sciences* 24: 350-51.
- Premack, David and G. Woodruff 1978. *Behavioral and Brain Science* 4:515.
- Pusey, A.E. and C. Packer 1987. Dispersal and philopatry, in B.B. Smuts, D.L. Cheney, R.M. Seyfarth and T.T. Struhsaker (Eds.) *Primate Societies*, Chicago: University of Chicago Press.
- Read, D.W. 1984. An algebraic account of the American kinship terminology. *Current Anthropology* 25:417-440.
- Read, D.W. 2000. Formal analysis of kinship terminologies and its relationship to what constitutes kinship (complete text), *Mathematical Anthropology and Cultural Theory*, 1: 1-46.
- Read, D.W. 2001, What is kinship? in R. Feinberg and M. Ottenheimer (Eds.) *The Cultural Analysis of Kinship: The Legacy of David Schneider and Its Implications for Anthropological Relativism*, Urbana: University of Illinois Press.
- Read, D.W. 2002. Cultural construct + instantiation = constructed reality. *Human Complex Systems*. <http://repositories.cdlib.org/hcs/DWR2002>
- Read, D.W. 2003 From behavior to culture: An assessment of cultural evolution and a new synthesis. *Complexity* 8(6)14-41.
- Read, D.W. 2004. The emergence of order from disorder as a form of self organization. *Computational & Mathematical Organization Theory* 9:195-225.
- Read, D.W. and C. Behrens 1990. KAES: An expert system for the algebraic analysis of kinship terminologies, *Journal of Quantitative Anthropology*, 2, 353-393.
- Read, D.W. and S. Leblanc 2003. Population growth, carrying capacity, and conflict. *Current Anthropology* 4(1): 59-85.
- Reader, Simon M. and Kevin N. Laland 2002. Social intelligence, innovation, and enhanced brain size in primates. *Proceedings of the National Academy of Sciences (USA)* 99:4436-4441.
- Rendell, Luke and Hal Whitehead 2001. Culture in whales and dolphins. *Behavioral and Brain Sciences* 24: 309-324.
- Ripoll, Thierry and Jacques Vauclair 2001. Can culture be inferred only from the absence of genetic and environmental actors? *Behavioral and Brain Sciences* 24: 355-56.
- Rodseth, Lars, Richard W. Wrangham, Alisa M. Harrigan and Barbara B. Smuts 1991. The human community as a primate society. *Current Anthropology* 32(3):221-254.
- Salamon, Elliott 2002. Mechanisms of knowledge learning and acquisition. *Medical Science Monitor* 8(7):133-139.
- Sahlins, M. 1962. *Moala: Culture and Nature on a Fijian Island*. Englewood Cliffs: Prentice-Hall.
- Sharman, P.W. 1981. Feeding, Ranging and Social Organisation of the Guinea Baboon, *Papio papio*. Ph.D. Diss., University of St. Andrews.
- Strier, Karen B. 2000 *Primate Behavioral Ecology*. Allyn and Bacon: Boston.
- Symington, M. McFarland 1988 Food competition and foraging party size in the black spider monkey (*Ateles paniscus chamek*). *Behaviour* 105:117-133.
- Tomasello, Michael 1999. The adaptation for culture. *Annual Review of Anthropology* 28:509-29.
- White, Frances J. and Richard W. Wrangham. 1988. Feeding competition and patch size in the chimpanzee species *Pan paniscus* and *Pan troglodytes*. *Behaviour* 105(1-2): 148-164
- Whiten, A. and R.W. Byrne 1988. The Machiavellian intelligence hypotheses: Editorial, in R.W. Byrne and A. Whiten (Eds.) *Machiavellian Intelligence: Social Expertise and the Evolution of Intellect in Monkeys, Apes, and Humans*, Oxford: Clarendon Press.
- Wrangham, Richard 1987. Evolution of social Structure. In B.B. Smuts, D.L. Cheney, R.M. Seyfarth, R.W. Wrangham and T.T. Struhsaker (Eds.) *Primate Societies*, Chicago: University of Chicago Press, pp. 282-298.
- Yerkes, Robert M. 1927 A program of anthropoid research. *American Journal of Psychology* 39:181-199.