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Publication Date

2005-03-26

Peer reviewed

Foraging society organization: A simple model of a complex transition

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Abstract: The evolutionary development of the hominids that culminated in the appearance of *Homo sapiens* included the subdivision of the species into societies on the basis of culturally, instead of biologically, constructed differentiation. It is argued that this change must have occurred after the mental ability to formulate and culturally express conceptual structures of extended relationships had been biologically introduced, and that intergroup competition within a species provided the selective impetus for this more complex form of organization. The combination of conceptual structures for organization at a more extensive scale and the effects of intergroup competition would lead to a restructuring of the whole species into society like groups.

Keywords: Adaptive processes, behavior, ecology, networks, organization

Introduction

At some point during hominid evolution a profound change in the form of social organization took place which laid the foundation for the distinctive way in which *Homo sapiens* is socially organized as a species. The change, from a primate to a foraging society form of social organization, had profound implications for both the subsequent genetic evolution of the hominid lineage (Read, 1985) and its internal organization. In the hominid lineage, unique amongst the primates, developed the capacity, as the anthropologist Leslie White has phrased it, for an 'extrasomatic means of adaptation'. The latter has provided *Homo sapiens* with the means to be a species divided into groups known as societies that are virtually as distinctive from one another as are species from each other.

In this paper I outline an intergroup competition model that accounts for the general features of this change from a primate to a foraging society form of organization. Then, since the model does not use parameters that are specific to *Homo*

sapiens, the question arises of why only the hominids amongst the primates made this transition. I will argue that the answer lies in the necessary conditions for the behavior patterns upon which the new form of social organization is based, and the information needed to exhibit those behavior patterns.

The model has as implication that the various systems of kin classification and the institutionalized systems of interpersonal relations built upon kin classification which are the basis of foraging society structure, serve, in part, to provide native constructed, simplified models of otherwise impossibly complex networks of interpersonal relations that would have to be learned by the members of the society for the society to be internally cohesive. If this conclusion is valid, it is possible that our early forebearers may have been the first to 'develop' models for complex systems.

For the purposes of this paper, primate social organization will be characterized as a configuration in which the species is partitioned into groups - to be called troops - that are more or less closes social units and which exhibit a high degree of intertroop competitiveness with respect to resources and home range: "Most interactions between primate troops are characterized by compe-

Received March 1985

0377-2217/87/\$3.50 © 1987, Elsevier Science Publishers B.V. (North-Holland)

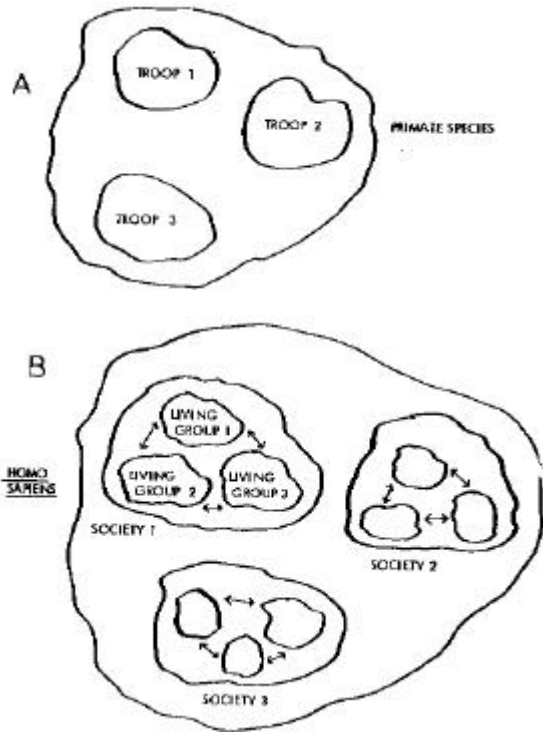


Figure 1. (A) Schematic diagram of primate social organization. The species is divided into troops that are more or less closed social units. (B) Schematic diagram of foraging society social organization. The species is divided into societies made up of living groups that are more or less open social units as indicated by the connecting arrows. The societies are closed units.

tion or avoidance, not co-operation" (Jolly, 1985, p. 152). Within this general form there is extensive variation in the form of social organization (Sussman, 1979, pp. 341-342), but as this is largely variation within that form, an idealized version will suffice here.

The foraging, or hunting and gathering, society form of social organization will be characterized by first a subdivision of the species into societies that are more or less closed social units and within societies a further subdivision into living groups the structural equivalent of the primate troops that are more or less open social units. The two forms of social organization are shown schematically in Figure 1.

Primate society dynamics: A baseline model

Consider first the impact of intertroop competition for resources in a primate species on troop

longevity in a home range. We may form a simple model for this competition after we make the following first order assumptions. First, assume that each individual in a troop exploits the same range of resources in essentially the same manner. Second, assume that each troop has a home range of fixed size within which it searches for resources. The home ranges need not be disjoint. Third, assume that resource distribution is sufficiently fine-grained in comparison to daily foraging range so that local effects due to a patchy resource distribution will not be important. Fourth, assume that each primate potentially has direct access to all resources in the region over short time periods so that instabilities due to time delays (May, 1973, pp. 94-100) are negligible. And fifth, assume negligible stochastic variance in the periodicity and quantity of resources.

The magnitude of intertroop competition can be measured by the degree of overlap of home ranges. Under the above conditions, intertroop competition may be modeled using the logistic competition equations for *species* since we are taking the troops as more or less closed social units. The equations are:

$$\begin{aligned} dP_1/dt &= r_1P_1(1 - a_{11}P_1 - a_{12}P_2), \\ dP_2/dt &= r_2P_2(1 - a_{21}P_1 - a_{22}P_2) \end{aligned}$$

where:

$$\begin{aligned} P_1(t) &= \text{population size of troop 1 at time } t, \\ P_2(t) &= \text{population size of troop 2 at time } t, \\ r_1 &= \text{intrinsic growth rate for troop 1,} \\ r_2 &= \text{intrinsic growth rate for troop 2,} \\ a_{ij} &= \text{growth dampening effect of troop } i \text{ on} \\ &\quad \text{troop } j, 1 \leq i, j \leq 2. \end{aligned}$$

As is well known, there is no exact analytical solution for this pair of differential equations. We follow the usual practice (e.g. Pielou, 1969, p. 56) of graphing the steady state conditions in the phase space for the 2 troops. Under the assumptions we have made, each troop will have the same value for $1/a_{11}$ and $1/a_{22}$, the equilibrium carrying capacities that would occur without the presence of a competing troop, assuming that food supply is the main long term limiting factor (see Jolly, 1985, pp. 92-95).

The impact of a second troop on the first is measured by the degree of overlap of the respective home ranges. For simplicity, assume the over-

lap is symmetric with respect to both troops. Then the two values a_{12} and a_{21} will be the same. This leads to the configuration shown in Figure 2.

The configuration given in Figure 2 implies that there will be a stable equilibrium point at the intersection of the two lines representing steady state conditions for each troop. As overlap increases, the configuration has as its limit the situation where the two lines are identical and all points on that intersection represent stable/neutral equilibrium points.

These results are based on a completely deterministic situation with fixed parameters. To make the scenario more realistic, let one or the other of the troops 'redefine' the situation. First consider territoriality. Suppose only one of the troops exhibits territorial defense of a feeding area, the most common form of territorial defense, (Jolly, 1985, p. 142). With perfect territorial defense the defending troop decouples itself from the outer one. An asymmetry is introduced as the territorial troop can reduce the size of the home range of the second troop if there is overlap of the

original home ranges. If the overlap increases, the troop with territorial defense expands in size against the 2nd troop and the troop exhibiting territoriality can increase in size until the second troop is driven to extinction.

A second alternative would be for one of the troops to alter its mode of resource exploitation in such a manner as to increase its equilibrium carrying capacity in the same home range (e.g. by utilizing preciously unused resources). This also tends to decouple it from the second troop through reducing the values of the terms a_{ij} . At low levels of overlap there will be little effect, but as overlap increases, the competition becomes restructured as shown in Figure 3. The troop with the greater carrying capacity will win out as competition increases.

In both of these two situations competition through overlap of home range leads to one troop or the other winning out. Under these conditions we can expect high turnover in troop occupancy of a given home range.

A third alternative has both troops exhibiting territorial defense and thus each become decoupled from the other. The configuration remains

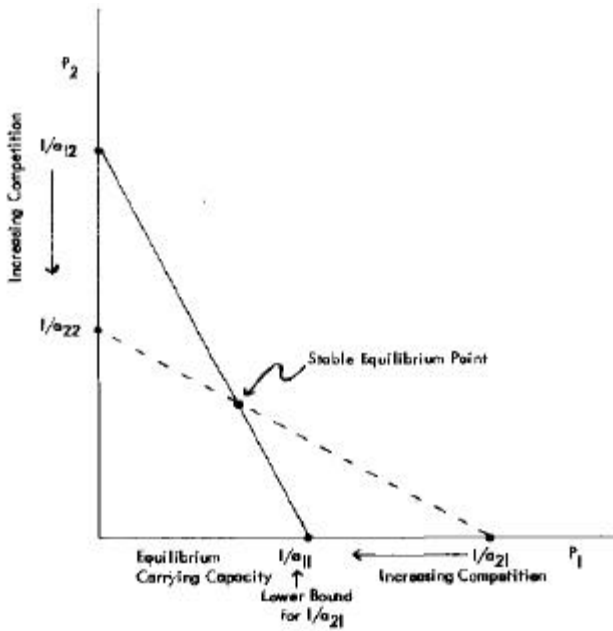


Figure 2. Graph of the steady state conditions for the competition model. The solid line represents states for which population P_1 has zero growth and the broken line represents states for which population P_2 has zero growth. The intersection of the two lines is an equilibrium point for both populations, and is a stable equilibrium point for the configuration shown in the graph.

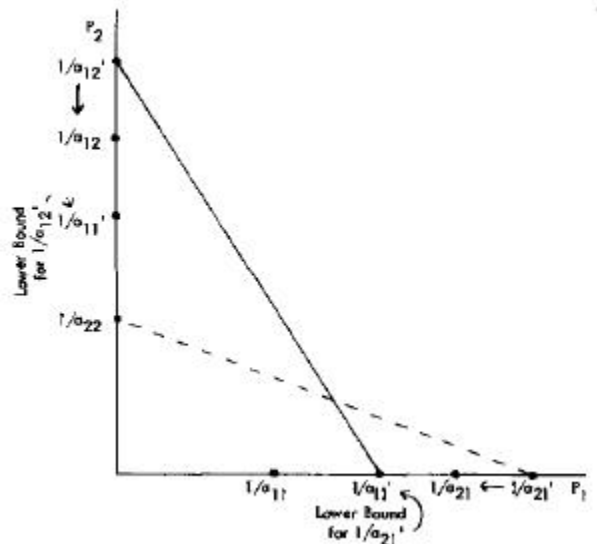


Figure 3. Population P_1 has increased its carrying capacity in its home range, thus increasing the value of $1/a_{11}$. The increase in carrying capacity also increases the value of $1/a_{21}$ which measures the impact of population P_1 on population P_2 . In the limit the broken line will be below the solid line, implying that population P_2 has been driven to extinction.

more or less symmetric and troop longevity will be dominated by internal, stochastic demographic effects.

Under the first set of conditions, where one of the troops is led to extinction, the surviving troop has an increased home range and hence the potential for increase in troop size. However, empirical observations show that under these conditions the usual outcome is troop fission (Eisenberg et al., 1972, pp. 867-868). Under the second set of conditions with both troops exhibiting territorial defense, home ranges tend to remain fixed in size, hence again troop size is bounded below some maximum value. The expected pattern under any of these conditions, then, is one of troop size remaining within certain bounds, and with either a high rate of troop turnover if there is competition through overlap of home ranges, or a lower rate of troop turnover if each troop exhibits territorial defense. This gives us the base line conditions for the transition to foraging societies.

Model for transition to a foraging society form of organization

Now consider a new situation. Suppose that troops 1 and 2, instead of exhibiting territoriality and/or competitive use of resources, are able to cooperate in the following manner: first, when each home range has adequate resources there is no overlap in home ranges and second, if the home range of troop 1, for example, has reduced resources (over short time periods), then it is able to utilize the resources of troop 2 if they are simultaneously plentiful. Further, suppose that in fact when troop 1's resources are decreased through environmental causes then troop 2's resources are possibly augmented. That is, assume the scale for measuring the spatial location of the respective home ranges is large in comparison to the scale for measuring variance in resource quantities.

Now consider a third troop driven into composition with troop 2 due, for example, to environmental degradation. Consider the dynamics of competition between troops 2 and 3. Under the posited conditions, if troop 1 has resources that can be used by troop 2 when the home range of troop 2 is degraded, the measure of the impact of troop 3 on troop 2, namely $1/a_{23}$, will be bounded

above troop 2's equilibrium carrying capacity and the configuration will be as shown in Figure 4.

Under these conditions increasing competition leads to the extinction of troop 3, for as troop 3 is driven into increased competition with troop 2., the equilibrium point for troops 2 and 3 is driven towards the horizontal axis and the only stable equilibrium point occurs when troop 3 has zero population (see Figure 4B). In effect, competition becomes 'self-destructive'. As long as troop 2 has the home range of troop 1 to fall back on, and as long as that home range can be exploited by troop 2 without competition with troop 1, then troop 3

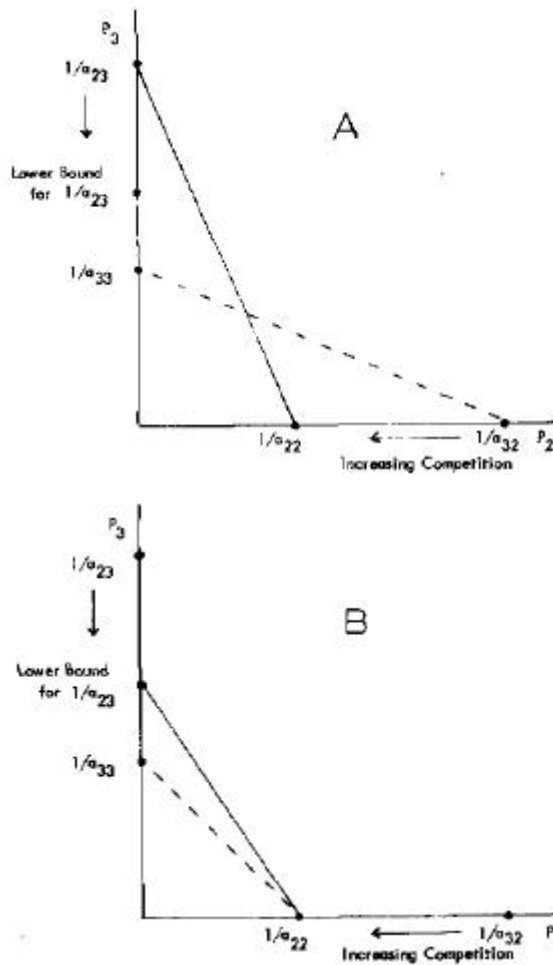


Figure 4. (A) Initial conditions for competition between populations P_2 and P_3 . As competition increases, $1/a_{32}$ decreases to its lower bound and $1/a_{23}$ decreases to its lower bound. (B) With complete overlap in home ranges the dashed line will lie below the solid line, implying that population P_3 has been driven to extinction.

will lose out in increased competition with troop 2.

We may expand the argument to the level of the species for which the troops are a part. Define a society to be a maximal set S of troops such that if A and B are troops in S then the members of troop A can have access to the resources of troop B and vice-versa in the manner already discussed. If the scale for measuring resource variability is small in comparison to the scale for measuring the spatial location of home ranges for the troops in a society, then the situation changes from the primate one where each troop is limited in its population size by its *minimum* quantity of resources over an appropriate time period, to a situation where the troops are limited in population size by the *average quantity* of resources over the *union* of the home ranges. The average quantity will be greater than the local minimums so that the local equilibrium carrying capacities will increase, or alternatively, the size of local home ranges will decrease. Under this new set of conditions, competition between a troop which *is* a member of a society and a troop which *is not* a member of a society will be doubly stacked against the latter: first, by the fact that the former has the resources of other troops to fall back on, and second, by its increased equilibrium carrying capacity which restructures the competition situation in the manner already discussed. Under these circumstances troops not members of a society will be driven to extinction.

This yields the following significant implication: the stable configuration for troops in a species initially only partially organized into societies (that is, some troops are members of societies and some troops are not members of societies) occurs when each troop is a member of some society of troops. In other words, *the society form of organization drives the entire species to that form of organization* and now the species will be organized in the form of a partition of the species into 'subspecies' with each subspecies structured in the form of a foraging society. We will refer to the groups making up a society as *living groups*.

Now consider competition between two living groups, A and B , each a member of different societies with the societies having the same demographic parameters. Suppose living group A impinges on the home range of living group B due to reduced support from its network linking it to

other living groups. While the respective equilibrium carrying capacities will be the same, group B continues to have support through its network linking it to the other members of the society to which it belongs, hence the intruding group A will lose out in the competition as discussed above. Thus *societies* are relatively stable, closed social units, *without* need for territorial defense to maintain equilibrium in the face of an intruding living group, in contrast to the primate form of organization where *troops* are stable only *with* territorial defense. This conclusion is supported by ethnographic data on foraging societies which show little propensity for one society to have a defended territory. The exceptions occur when one entire society enters into competition with another society - namely warfare.

Observe that the model of a species organized into societies posits that living groups within a society are open in the sense of permitting temporary relocation of individuals from one home range to another. Two questions arise: (1) Why does not the society simply become the species, and (2) Why has not this form of organization occurred among the non-human primates? The answer appears to lie in how open interrelation of living groups can take place.

Model for open living groups

For the members of one group to temporarily enter the home range of a second living group without competition there must be a non-antagonistic relation amongst the members of the two groups. Empirically, non-antagonistic relations of individuals from different social units would appear to be the exception and not the rule in primate species. (The exceptions usually relate to mate selection and/or pairing for sexual reproduction.) The same is true in foraging societies. Rasmussen recounts a Netsilik eskimo informant's statement as follows:

" When they broke camp in his grandfather's day and moved from one hunting place to another, they drove sledge behind sledge ... in a long line A man in the procession could not stop to make water without great risk, for the one who walked in front might easily get the idea that the man for some reason or other

would strike him down from behind, and this suspicion alone might be a sufficient cause of bloodshed. They did not trust each other; even if they apparently were the best of friends they could never be sure that the one had not evil intentions. *So it is no wonder that they were doubly cautious when meeting strangers.*" (1932, p. 202, emphasis added.)

This extreme, fearful/antagonistic behavior occurs even though the males in question and their families were totally dependent on one another during the winter for survival (Balicki, 1970, pp. 133-138).

The theme that runs through observations such as these is that of stranger versus non-stranger with the general reaction to a stranger being antagonistic and fearful. The latter precludes any social relation from taking place. This is in marked contrast to the reaction to a non-stranger where social relations can be initiated and these social relations can serve as the basis for the sharing of a resource base, and so on. What, then, makes for one being a stranger? In primate troops the basis for the stranger/non-stranger dichotomy is largely a consequence of day-to-day interactions. The infant is born in a troop and is constantly involved, on a day-to-day basis, with the members of the troop. The infant learns its social position and the others learn to accommodate themselves to the new member of the troop. With the exception of intertroop movement which generally appears to be related to reproduction, the troop tends to remain cohesive along the lines of 'non-strangers', and members of different troops are 'strangers' to one another.

If day-to-day interaction is a necessary part of developing the ties needed for social interaction in a troop, then it follows that for troops sufficiently separated in space to allow for differential abundance of resources in their respective home ranges there will be insufficient interaction to establish the close ties needed for temporary sharing of home ranges. Thus, it would seem that at the level of mechanisms available to non-human primates for defining interpersonal relations, the foraging type of organization, even though it may be more effective as measured by equilibrium carrying capacity and stability under competition for resources, cannot occur. It is a potential form of organization that cannot be realized.

In effect, what is needed is a means for all possible dyads between the members of troops or living groups to be transformed from stranger/stranger dyads to non-stranger/non-stranger dyads. Under interpersonal 'learning', as the size of the population increases, the number of dyads increases exponentially. Consequently, both the spatial separation of individuals and the number of dyads that would have to be 'learned' makes it impossible to substantially increase the number of dyads which would be of the non-stranger/non-stranger form. The problem essentially becomes one of how to reduce the size of a large network of relations into a comprehensible, learnable and usable form.

In foraging societies the interpersonal relations that are used to permit movement of persons between living groups are based on conceptually defined kin relations. The kin relations form a conceptual structure (Read, 1984) modeled on (but not equivalent to) the familial relations of parent/child and sibling/sibling. Elementary kin relations (such as Mother, Father, Daughter, and Son in the American/English terminology) may be conceptually expanded upon to form a structure that encompasses a network of persons through taking the 'product' of the elementary relations (Read, 1984). Thus, 'Mother of Mother = Grandmother' in the American/English kinship terminology.

The conceptual structure formed in this manner makes it possible to extend relations, call them kin ties, to persons who otherwise have no direct connection through immediate acquaintance, or even have an unknown genealogical connection. The conceptual structure allows for genealogical relations to be embedded on them (Read, 1984), thereby permitting the terminology to define kin relations amongst hundreds of persons without knowing their actual genealogical connections. If I know my relation to alter *B* and alter *B* knows his/her relation to alter *C*, then the terminology defines my relation to alter *C* even when I do not know my genealogical connection to alter *C*.

The conceptual structure may also serve as a model for other conceptually defined relations. For example, the males who were fearful of each other when moving from one camp to another in Netsilik society were also linked together as sealing partners (a kin-like conceptual relation) and that link made it possible for them to cooperate in hunting for seals in the winter.

In effect, kinship is the precursor for, and the model of, social relations in foraging societies and is the language used by the members of the society to both organize and distinguish themselves as a human group of persons from other, less than human groups of persons.

I suggest that kinship systems - that is the structured conceptual systems that establish the relation of ego to alter - are the means by which the problem of reducing large networks (at the level of interpersonal dyads) becomes reduced to a comprehensible and learnable task.

Though kinship may be modeled on familial relations, it is not merely a restatement of such relations but a structure of abstract relations which serves to transform a potential stranger into a non-stranger through structurally establishing a kin relation and using the fundamental understanding that someone with whom one has a kin relation is one with whom social relations are possible. The structure of positions defined by the terminology (Leaf, 1971) provides the conceptual basis for this transformation.

Thus in foraging societies individuals become closely linked who otherwise may be genetically distant and/or spatially isolated. The linguistically expressed, conceptual structure of abstract relations provides a model for social integration beyond what can be achieved through direct individual learning of one's complete social network, thereby allowing for an expanded network of social ties (e.g. the *hxaro* system of the !Kung San (Lee, 1979, pp. 97-105; Wiessner, 1982)) upon which sharing of territory and resources contained therein can take place beyond the limits of the home range of each living group.

I suggest that a linguistically expressed, conceptual structure was necessary to achieve the form of

social organization represented by foraging societies. This would account for both the absence of such organization among nonprimates and the subdivision of early *Homo sapiens* into numerous foraging societies since, empirically, the conceptual structure cannot encompass the entire species. In this fashion the native conceptual structure represented by the kinship terminology may be the first model for comprehending and dealing with complex systems.

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