

From Experiential-Based to Relational-Based Forms of Social Organization: A Major Transition in the Evolution of *Homo sapiens*

DWIGHT READ

The evolutionary trajectory from non-human primate to human forms of social organization encompasses an extraordinary series of social and cultural changes that belie our close anatomical affinity with other primates. Through our capacity to transfer what is in the conscious mind of one individual to another, we have developed adaptations that incorporate collective and not just individual thinking and learning and thereby have been able to integrate together into larger scale social entities what would be, for our non-human primate ancestors, disparate, spatially and behaviourally differentiated social groupings such as a primate troops or communities. This trajectory is not simply one of elaboration on characteristics already present in non-human primates in nascent form, but one that initially reached a hiatus due to a cognitive constraint acting on the consequences of interaction between two trends in primate evolution. One trend has been elaboration and intensification of social interactions, especially through alliance or coalition formation (de Waal 1992). The other is a phylogenetic trend towards increased individualization of behaviour, which places exponentially greater cognitive demands on individuals having to cope with a social unit composed of behaviourally individualized members (Read 2004, 2005). The difficulty that individualization poses for social coherence was graphically described almost a century ago by the sociologist F. H. Hankins:

Social life would become utterly impossible because of the utter chaos of individual behavior ... a society of free-willers in the sense now under discussion [‘an undetermined, unrelated, and uncaused factor in human action’] would be Bedlam and Babel thrown into one (1925, 622).

A more modern phrasing than “free will” would be behavioural unpredictability of a completely individualized actor, the antithesis of a necessary condition for coherent and on going social interaction to take place (Misztal 2000:7).

Jointly, these two trends led to an exponential increase in the complexity of the field of social interactions with which the members of a primate social unit must cope, thereby running into a cognitive constraint. The cognitive constraint stems from intersection between increase in the complexity of social interactions and conceptual restrictions imposed by the limited size of working memory in non-human primates (Read 2008). The negative consequence of this intersection was identified by the French anthropologist, Claude Lévi-Strauss for the great apes:

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, 8).

The great apes, in their evolutionary trajectory, found resolution to the conflict between exponentially increasing social complexity and cognitive constraints by reverting to smaller social units (Read 2004, 2005). In contrast, the evolutionary trajectory leading to modern *Homo sapiens* developed a different basis for the social organization of social groups than the ancestral, primate pattern of social learning through extensive face-to-face interaction. This different basis, it will be argued, arose out of a shift from experiential to relation based social behaviours. Relation based behaviours stem from categorization of individuals according to the relation of one individual to another (such as biological mother-biological offspring categorization among the macaques [Dasser 1988a, b]) and not the traits of individuals per se (such as a category of aggressive males). But even more, unlike trait based categorizations, relation categorizations lend themselves to the formation of new relation categories through the conceptual “product” of relations; that is, categorizations constructed from computing the relation of a relation. This made possible social integration freed from primarily being an epiphenomenon of experiential based social interaction.

Though the details of the evolutionary trajectory from experiential to relation based social organization are necessarily speculative, the end-result has been extensively studied through ethnographic fieldwork among the small-scale hunter-gatherer societies whose

mode of adaptation preceded the larger, more complex social systems that arose as part of the neolithic revolution. These precursor, small-scale societies are structured around relations among individuals defined through a cultural kinship system expressed concretely by a society specific kinship terminology that both defines and structures the domain of kin for the members of that society. Whereas face-to-face interaction is a necessary component of, and precursor to, long term, ongoing and non-disruptive social interaction in non-human primates, the organization of behaviour provided by culturally constructed kinship relations is a necessary component of, and precursor to, extensive social interaction and stable organization in hunter-gatherer -- and subsequent -- human societies. Consequently, we can identify the outcome of the evolutionary trajectory leading to relation based forms of social organization by considering the organizational principles embedded in a kinship terminology and through which social organization is then built around kin relations defined and expressed through a kinship terminology. Once the outcome is identified, we can then consider a possible evolutionary trajectory that begins with experientially based forms of social organization as found in non-human primates and leads to the form of relation based forms of social organization that we find in extant human societies. Our goal in this paper, then, is two-fold. First, to briefly characterize the way in which kin relations in human societies are organized and structured through a kinship terminology as providing the basis for relation based forms of social organization and second to identify a plausible trajectory beginning with experiential based forms of social organization and leading to relation based forms.

KIN RELATIONS AND KINSHIP TERMINOLOGIES

Human societies can be usefully, if not precisely, distinguished by the organizational structure for the society as a whole. Characterization of human societies in this manner led to Elman Service's (1962) long-standing typology of band, tribal, chiefdom, and state level forms of organizational structure for human societies, which has provided a framework for considering evolutionary change in human societies despite its oversimplification of variability in the forms of organizational structure (Crumley 1995; Hass 1998). In this sequence of organizational structures, social units defined through culturally defined kinship relations are integrated together at higher ontological levels using criteria derived from the structural properties of kinship

terminology systems. These structural properties do not relate, though, in a straight-forward manner to external constraints on behaviour derived from factors such as ecological conditions, interaction with other societies and the like but instead are based on an internal logic for the form of the kinship terminology, hence to culture specific criteria that provide the terminology with its structural form (Leaf & Read n.d.; Read 1984, 2001, 2007b). The organization of behaviour, both individually and collectively, provided by the structure of a kinship terminology as a system of logically interconnected concepts is, therefore, constructed, as opposed to emergent. As a consequence, it is only those whose enculturation encompasses the same cultural kinship system who will interact in a mutually understood manner as culturally determined kin, thereby enabling social interaction that does not depend on prior, face-to-face interaction for it to be effective.

The structure of a kinship terminology can be worked out and formally expressed by eliciting from informants the way kin terms form a system of interconnected concepts (Leaf 2006; Leaf & Read n.d., ch 4). This may be done by asking for all pairs of kin terms what kin term one person (ego) would use to refer to a third person (alter 2) when ego refers to a second person (alter 1) by one term in the pair of terms and alter 1 refers to alter 2 by the other term in that pair of terms. For example, in the American/English kinship terminology and for the pair of terms aunt and child, if ego refers to alter 1 by the kin term aunt and alter 1 refers to alter 2 by the kin term child, then ego (properly) refers to alter 2 by the kin term cousin. Thus in the American kinship terminology, the terms aunt, child and cousin are conceptually interconnected via cousin being the kin term that ego would use when ego refers to alter 1 as aunt and alter 1 refers to alter 2 as child. The complete structure of a terminology may be elicited systematically in this manner and the elicited structure displayed as a directed graph where the nodes are kin terms connected by arrows (see Figures 10.1A and 10.1B).

In a directed graph showing the structure of a kinship terminology, each type of arrow (with an arrow type distinguished by features such as the shape of the arrow head and the features of the shaft) corresponds to one of the primary kin terms. The primary kin terms are the terms from which all other kin terms in that terminology may be computed; e.g., the primary kin terms are parent, child and spouse in the English/American terminology as all other terms may be generated by taking products of these primary kin terms (Read 1984; Read & Behrens 1990). An arrow points to the kin term that is the product of

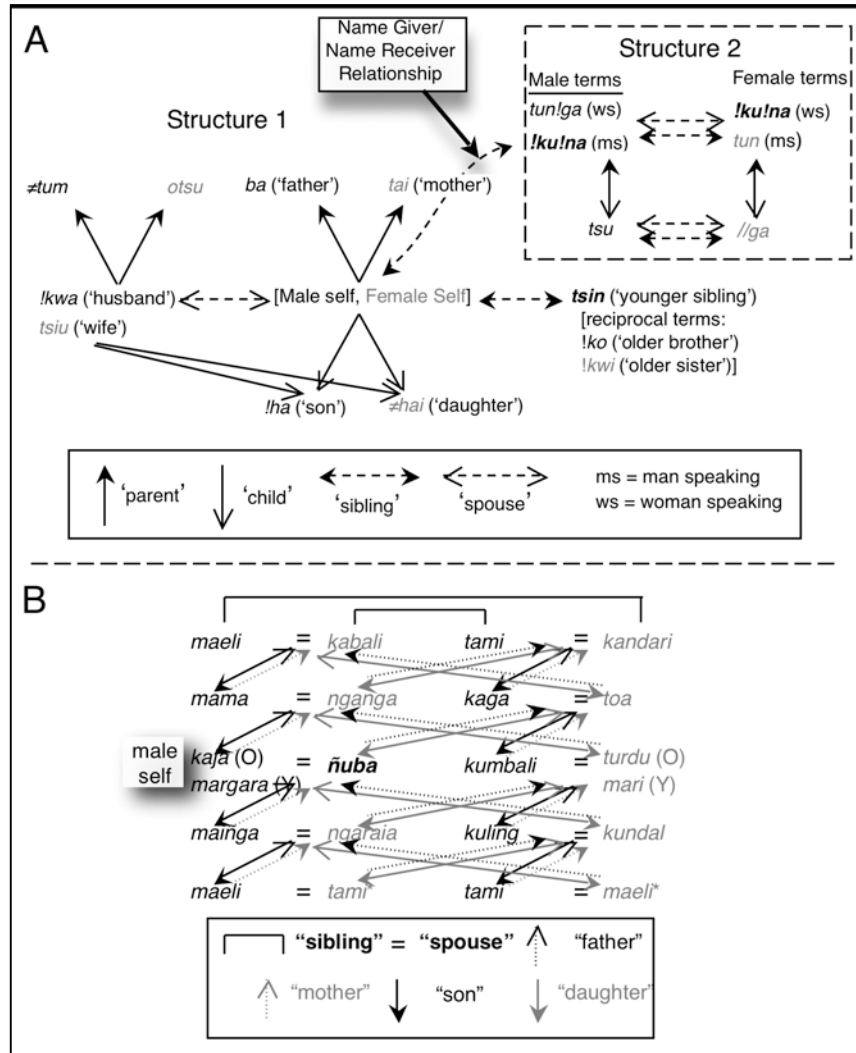


Figure 10.1: (A) Terminology structure (excluding affinal terms) for the !Kung San (hunter-gatherer group) in Botswana. Structure is based on two substructures joined by a name-giver/name-receiver (!ku!na) relationship activated by the parents giving the name of a close relative to a newborn child. The structure has a horizontal focus formed by spouse and sibling relations that are paralleled by residence groups structured bilaterally through chains of siblings and spouses of siblings. (B) Terminology structure for the Kariera (hunter-gatherer group) in western Australia from the perspective of a male speaker. Structure includes a prescriptive marriage rule for ego marrying a relative he/she refers to by the kin term *nuba*. The terminology has a vertical structure joined by spouse links paralleled by the Kariera dividing themselves into four 'sections' structured vertically through parent/child links and horizontally through spouse links. Both groups have comparable modes of resource exploitation. Terms with black font are male-marked, terms with gray font are female-marked, and terms in bold are neutral.

the primary kin term associated with the arrow and the kin term at the

node where the arrow begins. Thus in Figure 10.1A, an arrow with an open arrow head corresponds to the primary kin term ‘child’ in the !Kung San (a hunter-gatherer group in Botswana) kinship terminology and points, for example, from the kin term *ba* (‘father’) to the kin term *tsin* (‘younger sibling’) since the product of the kin term *ba* with the kin term ‘child’ is the kin term *tsin* in the !Kung San terminology.

The structure of a kinship terminology may vary widely from one terminology to another as a result of internal differences in structural properties enacted in one terminology but not the other. Compare Figure 10.1A, which displays the structure of the kinship terminology for the !Kung San, with Figure 10.1B, the graph for the structure of the terminology for the Kariera (a hunter-gatherer group in Australia). Structural differences in the terminologies are evident from their respective graphs and arise from differences, in this example, from the presence of non-sex marked primary kin terms, ‘parent,’ ‘child,’ ‘sibling,’ ‘spouse,’ and the ‘name-giver/name-receiver’ relation for the !Kung San kinship terminology (Read 2007a) versus the sex-marked primary kin terms ‘father,’ ‘mother,’ ‘son,’ and ‘daughter’ and structural equations that lead to a *n̄uba* (‘cross-cousin’) marriage rule for the Kariera terminology (Leaf & Read n.d., ch 7). These differences in choice of primary terms and structural equations determine the structural differences between terminologies without relating to different modes of resource procurement, ecological conditions, and the like. Both the !Kung San and the Kariera are hunter-gatherer groups that lived in desert-like environments organized in residence groups in similar ways for tasks such as resource procurement (Leaf & Read n.d.). The structural differences in the terminologies are culture specific, hence historically contingent, yet constrained in structural form by general, structural properties common to kinship terminologies (Leaf & Read n.d., ch 5; Read 2001, 2007b).

Culturally constructed kinship relations are a group, not an individual, level phenomenon whose functionality arises through, and depends upon, cultural knowledge being distributed among the members of a social group through enculturation. It is only with other persons who share the same kinship terminology knowledge that kin relations may be identified and are meaningful. When one person or group encounters another person or group for the first time and the latter also share the same kinship terminology knowledge, they can determine, according to their mutually shared conceptual system of kin relations, that they are kin to one another and in so doing their status *via-à-vis* each other changes from strangers perceived of as

likely to engage in unpredictable and possibly dangerous behaviour to kin who will act in a predictable and supportive manner. This contrasts sharply with the highly aggressive and lethal encounters between males in different chimpanzee communities (despite transfer of females between communities) and was a transformation in behaviour that had a profound impact on the evolutionary trajectory of our species. The transformation overcame the cognitive barrier reached by the great apes for more encompassing patterns of social behaviours (Read 2004, 2005) by changing the basis for social behaviour from face-to-face encounters to that of a constructed, kinship relational system for determining the domain of individuals among whom social interaction may take place along with expected behaviours when individuals acted in accordance with one's culturally constructed kinship system.

FORMS OF SOCIAL ORGANIZATION AND EVOLUTIONARY CHANGE IN SOCIAL BEHAVIOUR

In order to make evident the implications that change from experiential to relational social behaviours had for social organization, we will distinguish four forms of social behaviour between two individuals and their associated form of social organization. The four forms of social behaviour are:

- (1) asocial,
- (2) action/reaction,
- (3) interaction and
- (4) social interaction,

These forms of behaviour must be considered in the context of a temporal event consisting of the *prior* behaviour of an initiating individual and the *post* behaviour of a responding individual. The four forms of social behaviour will be distinguished by the probability of a prior behaviour by the initiating individual and an associated post behaviour by the responding individual.

These four forms of social behaviour do not exhaust all possibilities, but can be related usefully to changes in the form of social organization among primate species that evolutionarily led to *Homo sapiens*. Of these four forms of behaviour, the fourth is uncommon among the non-human primates and only partially incorporated among the chimpanzees. It only fully becomes central to systems of social organization with the appearance of our species, *Homo sapiens*.

Assume a repertoire of behaviours engaged in by one or more of the members of a group of individuals. We may use set notation to denote the repertoire of behaviours as a set of behaviours $\mathbf{B} = \{b\}$ and to denote the group of individuals as a finite set of individuals $\mathbf{I} = \{A, B, C, \dots\}$. For each individual, A , in \mathbf{I} , let b_A denote a behaviour from \mathbf{B} engaged in by individual A . (Individual A may engage in more than one behaviour from \mathbf{B} , but for notational simplicity we will focus on a single behaviour by individual A , hence we can use the same symbol to represent an individual and to index the behaviour engaged in by that individual.) We will refer to a *dyadic behaviour episode* as a sequence of behaviours in which one individual engages in a behaviour and another individual acts in response to the behaviour of the initiating individual. The same individual may sometimes be the initiator of a dyadic behaviour episode and sometimes the responding individual. When individual A initiates the dyadic behaviour episode with behaviour b_A , we will refer to the initiating behaviour by A as the *prior* behaviour b_A by individual A . By this we mean that A does behaviour b_A prior to another individual B doing some behaviour b_B in response to the behaviour b_A . When individual A is the responding individual in a dyadic behaviour episode, we will refer to the response behaviour b_A as the *post* behaviour by individual A . By this we mean that individual A does behaviour b_A in response to the behaviour b_B of some individual B .

In general, the occurrence of particular behaviour by an individual over some time frame and under specified conditions may be represented probabilistically. For a dyadic behaviour episode, we may say that, over a specified time frame, an individual I has some probability of engaging in a behaviour that initiates a dyadic behaviour episode. Similarly, an individual has some probability of engaging in a specific post behaviour in response to the prior behaviour by another individual. For some behaviours, these probabilities may not be subject to learning; e.g, genetically based, so-called instinctual behaviours. Other behaviours may be subject to learning and so the probability of a behaviour in the present will depend on the past consequences an individual has experienced when engaging in that behaviour. Our concern here is with dyadic behaviour episodes and so we will be concerned with the probabilities of prior and post behaviours. We may define the four forms of social behaviour we identified above as follows using probabilities for prior and post behaviours.

Box 10.1. Mathematical definitions.

1. Asocial behaviour

Prior behaviour: Probability, $Pr(b_A)$, for behaviour b_A by individual A depends only on the behaviour, b_A . Post behaviour: Conditional probability for behaviour b_A by individual A given prior behaviour b_B by individual B is independent of the prior behaviour b_B : $Pr(b_A | b_B) = Pr(b_A)$.

2. Action/Reaction behaviour

Prior behaviour: Probability, $Pr(b_A)$, for behaviour b_A by individual A depends only on the behaviour, b_A . Post behaviour: $Pr(b_A | b_B) \neq Pr(b_A)$.

3. Interaction behaviour

Prior behaviour: Let $\theta_j = Pr(b_B)$ be a parameter whose value may be specific to B . Probability for behaviour b_A by individual A is a function of θ_j : $Pr(b_A) = f(\theta_j)$. We will use the notation $Pr(b_A | \theta_j = Pr(b_B))$ to denote the probability that A does the behaviour b_A knowing that B does behaviour b_B with probability $Pr(b_B)$. Post behaviour: $Pr(b_A | b_B)^ \neq Pr(b_A)$. (The “*” indicates that the conditional probability is subject to updating by individual A through Bayesian learning.)*

4. Social interaction behaviour

Prior behaviour: Let $\varphi_B = Pr(b_B | b_A)$ be a parameter whose value may be specific to B and A . The probability for behaviour b_A by individual A is a function of φ_B : $Pr(b_A) = g(\varphi_B)$. We will use the notation $Pr(b_A | \varphi_B = Pr(b_B | b_A))$ to denote the probability that A does the behaviour b_A knowing that B does behaviour b_B with conditional probability $Pr(b_B | b_A)$. Post behaviour: $Pr(b_A | b_B)^ \neq Pr(b_A)$.*

5. Phylogenetic trend

We can express the phylogenetic trend by the sequence of probabilities for prior behaviour: (1) $Pr(b_A)$ (solitary behaviour), (2) $Pr(b_A | b_B) \neq Pr(b_B)$ (action/reaction behaviour), (3) $Pr(b_A | \theta_j = Pr(b_B))$ (learned interaction) and (4) $Pr(b_A | \varphi_B = Pr(b_B | b_A))$ (social interaction). The first three can be realized by individuals through Bayesian updating of prior probabilities in accordance with the outcomes of encounter events. Benefits obtained from these prior behaviours do not, generally speaking, depend on symmetry in behaviour between the individuals involved. The fourth behaviour depends upon a parameter value difficult to assess accurately without extensive face-to-face learning.

Asocial Behaviour

For asocial behaviour, the post behaviour of one individual, A , is statistically independent of the prior behaviour of another individual, B , hence individual A engages in behaviour b_A with probability that disregards the prior behaviour, b_B , by individual B . Associated with asocial behaviour is a solitary form of social organization, hence the distribution pattern of individuals in space will tend to be random after taking into account constraints such as resource location and

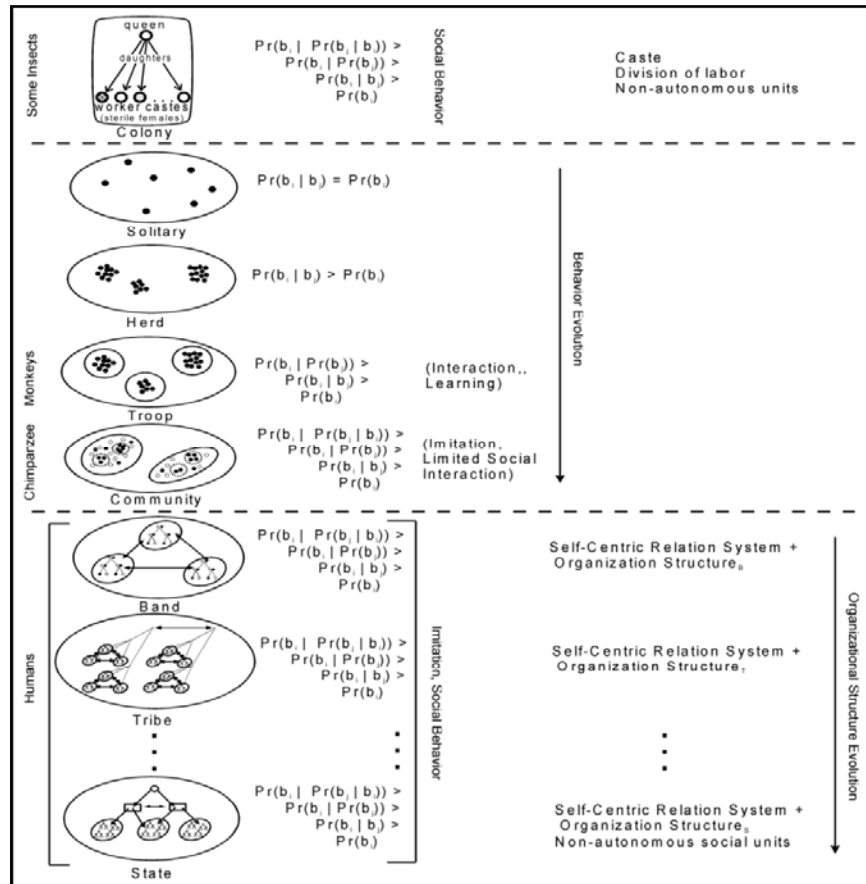


Figure 10.2: Left side – schematic diagrams of three kinds of social organization. Top section – social organization for eusocial insects. Middle section – evolutionary trend for social organization arising out behaviours between pairs of individuals. Bottom section – evolution in the organizational structure for human societies, keeping fixed the behavioural basis for social organization.

physical limitations on the spatial location of individuals (see Figure 10.2, solitary social structure). Among the primates, many of the prosimians have been characterized as having asocial behaviour. Asocial behaviour does not characterize any of the Old World monkeys (*Cercopithecoids*) or New World monkeys (*Ceboids*). Among the great apes, the orangutans (*Pongo pongo*) provide an example of behaviour that is close to solitary social organization as there is little interaction between individuals, other than chance encounters, outside of copulatory behaviour. For *Pan troglodytes*, females (at least in East Africa)

have been characterized as asocial in comparison to the highly social behaviour of males.

Action/reaction behaviour

The post behaviour of individual A depends, for at least some of the behaviours engaged in by A , on the prior behaviour of another individual B . For these behaviours individual A is reacting to prior behaviour by individual B . From an evolutionary perspective, the probabilities are fixed when the probabilities are genetically encoded and individuals do not yet have the cognitive capacity for updating probabilities through learning. Action/reaction behaviour may be asymmetric since an individual can react to the behaviour of another individual who acts asocially. Action/Reaction behaviour can directly affect the form of social organization. A response behaviour can be negative; e.g., the reaction, b_A , of A to an action, b_B by individual B , may be to move away or disassociate from B , in which case the social structure is pushed in the direction of dispersal of individuals. Alternatively, a response behaviour can be positive; e.g., the reaction of A may be to move towards B , in which case the social structure is pushed towards herding or flocking behaviour when each individual acts positively to a neighboring individual. Group boundaries may arise from the probability values for action/reaction behaviour, thereby leading to emergent social organization in the form of herds or flocks (see Figure 10.2, herd social structure).

Interaction behaviour

Interaction behaviour differs from action/reaction behaviour by the fact that prior behaviour by individual A anticipates the behaviour of B based on experience with the behaviour pattern of B . Like action/reaction behaviour, interaction behaviour can be asymmetric with individual A acting according to her/his experience with B while individual B may just be acting in response to behaviour b_A by individual A .

Experience can lead to genetic encoding for a behaviour based on prior experience (the Baldwin effect [Baldwin 1896; Simpson 1953]), though the likelihood of genetic encoding depends on consistency in interaction behaviour patterns and the latter decreases when behaviours become more individualized and need not be consistent over long enough time periods for parameter values to become genetically encoded. Non-genetic encoding arose with evolution of the cognitive capacity for learned behaviour. Individual A can learn the likelihood

of a behaviour by B through the outcomes of encounters with B , so more elaborated forms of social organization in species with more individualized behaviour can arise with increase in learning capacity through interaction behaviour. The capacity for learned behaviours also affects the post behaviours since the likelihood of doing behaviour b_A in response to behaviour b_B can be updated by taking into account the consequence of one's post behaviour in response to the prior behaviour b_B by individual B .

The form of social organization that arises from learned interaction among the primates will be referred to as a troop structure (see Figure 2). Troop structure organization is widespread among the Old World monkeys (*Cercopithecoids*) and the New World monkeys (*Ceboids*) and consists of cohesive, integrated social organization within a group and isolation of groups from one another, except for transference of individuals (typically males, except for the piliocolobines) from one troop to another around the time of sexual maturity (Di Fiori & Rendall 1994, 9944). The effectiveness of a troop form of social organization can be seen in the adaptation of different species of macaques to virtually every climatic condition as well as to co-existence with humans in India.

Social interaction

Here we use Talcott Parson's definition of social interaction:

... in the case of interactions with social objects a further dimension is added. Part of ego's expectation ... consists in the probable reaction of alter to ego's possible action, a reaction which comes to be *anticipated in advance* and thus to affect ego's own choices" (Parsons 1964, 5, emphasis added).

Social interaction differs from interaction by virtue of individual A taking into account, when doing behaviour b_A , what A assesses to be the likely response b_B by individual B should individual A do behaviour b_A . Interaction and social interaction behaviours also differ with respect to the consequences of asymmetric behaviour.

Asymmetric *interaction* behaviour by A is advantageous to A since s(he) takes into account past behaviour by B , whereas B does not take into account the behaviour of A ; i.e., A uses more information about the behaviour of B than B uses about A in responding to the behaviour by A . In contrast, asymmetric *social interaction* behaviour by A may be disadvantageous to A when A attempts to assess the likelihood for each of B 's possible responses to a behaviour by A , since A 's assessment of B 's likely response may be subject to error, thereby leading A to engage in a behaviour unrelated to B 's average behaviour

pattern, hence would do worse on the average than just acting on the basis of B 's average behaviour pattern. The latter would be the basis for behaviour by A based on A 's past experience with B . In addition, B may simply revert to novel post action/reaction behaviour in response to the behaviour b by A and thereby engage in behaviour unanticipated by A .

For example, if A assesses in a Prisoner's Dilemma context that B will act cooperatively since jointly cooperative behaviour would have the highest payoff and therefore acts cooperatively, B may simply respond with non-cooperative behaviour. Social interaction will, therefore, be most effective when this behaviour pattern is symmetric and leads each actor to engage in the behaviour anticipated by the other. With symmetric social interaction, each of A and B may be biasing independently one's own behaviour in the direction anticipated by the other individual and so any updating of anticipated behaviours by A and/or B simply reinforces their respective behaviours. When social interaction is symmetric, cooperative behaviour such as in a Prisoner's Dilemma context will be reinforced when each individual acts under the assessment that the other individual will act cooperatively since that has the highest payoff and thus both individuals receive the reward for jointly cooperative behaviour and thereby reinforce their respective assessments. But continuing with symmetric social interaction is not necessary and one or the other of the interacting individuals may revert to action/reaction as a post behaviour. Next, consider conditions for symmetric social interaction.

Symmetric Social Interaction

Social interaction as a learned behaviour depends both on (1) a sufficiently evolved, cognitive learning system so as to be able to estimate the parameter values for the likelihood of post behaviour b_B by individual B when individual A engages in prior behaviour b_A (i.e., $\varphi_B = \text{Pr}(b_B | b_A)$) and (2) sufficiently stable encounter outcomes between individuals so that individual A can track the response of individual B in situations where A has engaged in behaviour b_A in the presence of individual B and vice-versa. The non-human primate taxa leading to *Homo sapiens* include an increasingly evolved cognitive learning system, hence we might expect social interaction to be introduced with the more developed non-human primates. However, acting against this is the trend towards increased individualization of behaviour (Read 2004). The latter makes learned behaviour as a basis for interaction of individuals in the same group problematic, thus reducing the

likelihood of conditions under which learned social interaction would arise even with an evolved cognitive learning system.

Interference between these two trends occurs with the common chimpanzees (*Pan troglodytes*). Their form of social organization has evolved from a prior, cohesive troop form of social organization based on learned interaction into communities. Though a community can be as large as, or larger than a troop, its internal dynamics are more complex and less cohesive. Briefly, a chimpanzee community is characterized by:

- dispersal of females at time of puberty (Wrangham 1979)
- significantly more frequent and longer rates of grooming with more time spent in social dyads by males in comparison to females (Lehmann & Boesch 2008 and references therein)
- variation in sociality of females: asocial females in East Africa (Arnold & Whiten 2003, Goodale 1986, Wrangham et al. 1992), more social females in West Africa (Lehmann & Boesch 2008),
- temporary, fission-fusion subgroups in larger communities composed primarily of males (Gagneux et al. 1999),
- unstable male dominance hierarchies (Muller & Mitani 2005),
- extensive grooming of adult males (Spruijt et al. 1992), especially upon subgroup reformation (Bauer 1979) (in contrast with extensive biological mother/daughter and sister/sister grooming among female philopatric (females remain in natal troop) cercopithecoids [Gouzoules & Gouzoules 1987]),
- high levels of conflict within communities (female-female conflict over access to food and defense of offspring, male-male conflict over dominance rank and male-female conflict over sexual access) (Nishida 1979) and
- highly aggressive and violent community territorial defense by males that can lead to inter-community killings (Nishida & Hiraiwa-Hasegawa 1987).

Rather than a cohesive, well-integrated social system as is found with the Cercopithecoids, a community is characterized by instability at virtually all levels except aggressive maintenance of its boundaries.

Embedded within this pattern of instability are several examples of learned social interaction. First, males form “short-term coalitions in which two individuals join forces to direct aggression toward third parties” (Muller & Mitani 2005, 278). These dyads are not based on kin-relatedness (Mitani et al. 2002). Instead, “Individuals belonging to the same age cohort may be particularly attractive social partners

because they grow up together, are generally familiar with each other, and share similar social interests and power throughout their lives” (Mitani et al. 2002, 14); that is, the two males forming the dyad have had sufficient encounters with each other for each to learn the parameter values for the other for social interaction (i.e., $\varphi_B = \Pr(b_B | b_A)$ and $\varphi_A = \Pr(b_A | b_B)$). Second, although the reasons why male chimpanzees may share meat after killing a prey are not fully known, one “hypothesis proposed to explain meat sharing implicates the use of meat as a political tool” via “male chimpanzees share meat strategically with others in order to curry their favor and support” (Mitani et al. 2002, 18). Third, when patrolling community boundaries “males who patrol together also groom and form coalitions with each other frequently” (Muller & Mitani 2005, 308) and patrol “with partners with whom they have strong social bonds and on whom they can rely to take risks” (Mitani et al. 2002, 19). And fourth, grooming by males is not along biological kin lines. Instead “Male chimpanzees use grooming to cultivate and reinforce social bonds with others upon whom they rely for coalitionary support” (Muller & Mitani 2005, 306).

In sum, the non-human primates present us with a phylogenetic evolutionary trend of individuals incorporating more precise information about the behaviour of other group members while collective social behaviour increases in complexity with increased individuation. When symmetric social interaction takes place, each individual acts in the manner anticipated by the other individual, thereby reinforcing coordinated behaviour, but asymmetric social interaction behaviour may arise through the well-known problem of cheaters. Either party to symmetric social interaction can cheat and revert to a post behaviour action/reaction strategy that may be more beneficial, at least in the short run, than social interaction behaviour.

Symmetric social interaction is also costly to learn and must be maintained constantly: “Given the importance of coalitions, *male chimpanzees work hard* to obtain this valuable social service” (Muller & Mitani 2005, 314, emphasis added), and is hence a barrier for learned symmetric social interaction to be the behavioural basis for social groups. The solution to forming large, cohesive groups based on symmetric social interaction that was found in the evolution of *Homo sapiens* involved a shift to a constructed cultural kinship relation basis for symmetric social interaction, rather than learned, experiential interaction.

From Emergent to Constructed Systems of Symmetric Social Interaction

The evolutionary pathway undertaken by our hominin ancestors from experiential to relational based social interaction builds on two cognitive capacities, the first of which appears to be present in the chimpanzees but the evidence for the second is more equivocal: (1) a concept of self and (2) a “theory of mind.” Unique to the evolution of *Homo sapiens* is the introduction of two other cognitive capacities critical to the shift from experiential to relational based social interaction: (3) categorizations based on the concept of a relation between individuals and (4) formation of new social categories/units through recursive composition of relations. We begin this section by briefly describing the first two of these four capacities. Then we consider in more detail how (3) and (4) gave rise to an internally coherent, stable system of socially interacting individuals through a conceptually formulated, logically consistent, computational system of relations – the precursor to a kinship terminology system -- that defines the cohort of socially interacting individuals comprising what we refer to as a society. A cultural transmission process that cultural anthropologists refer to as enculturation enabled the faithful transmission (both vertically and horizontally) of this conceptual basis, a necessary condition for a group of individuals to form a society based on kin relations (Read et al. in press).

Four Cognitive Capacities

Concept of Self

By the ‘concept of self’ is meant the cognitive awareness of one’s existence, or identity, in contrast to the existence of others. Experimental evidence for a concept of self, at least as measured through recognition of oneself in a mirror image, is substantial for the chimpanzees (Schilhab 2003), so we may assume that a concept of self was already present in a primate ancestor common to the chimpanzees and the hominins.

Theory of Mind

By a theory of mind is meant not only that one has awareness of one’s own basis for action and one’s own mental representations, but that one is able to conceptualize that other conspecifics may also have the same basis for action and/or mental representations. Experimental work on the presence of a theory of mind in chimpanzees is equivocal

(Heyes 1998, Povinelli & Vonk 2004), though there is general agreement that while chimpanzees do not have a theory of mind capacity comparable to humans (Call & Tomasello 2008), they are capable of reasoning about behaviour. Less clear is whether they are able to attribute and reason about mental states in others (Focquaert et al. 2008). We will assume that if a cognitive capacity for theory of mind was not already present in a common ancestor, it arose early during hominin evolution.

Categorization Based on Relations

By categorization based on relations is meant a shift to categorization based on a conceptual relation linking pairs of individuals rather than on properties of individuals. The extent to which categorization based on relations occurs among the non-human primates is unknown except for one experiment with long-tailed Macaques (Dasser 1988a, 1988b). Though categorization based on relations may be rare among the non-human primates, the capacity for this kind of categorization did arise among our hominin ancestors. Categorization based on relations contrasts with the more common categorization based on attributes of objects. The shift from categorization based on attributes of objects to categorization based on a conceptual relation linking pairs of individuals was a critical, evolutionary development as it makes possible the formation of new relations from already defined relations through recursion-based products of relations rather than just through experience. Categorization based on attributes of objects depends on experience with those objects and new, non-hierarchical, attribute categories cannot be inferred from existing attribute categories. In contrast, relation categories coupled with recursive reasoning makes possible cognitively powerful ways to form new relations and relation categories directly from the currently identified relations. However, the power of recursive reasoning is not available to non-human primates, including chimpanzees, as they do not have the cognitive capacity for this kind of reasoning (Hauser et al. 2002, Spinozzi et al. 1999). The inability for the non-human primates to do recursive reasoning is most likely due to insufficient working memory (Read 2008).

Recursive Reasoning and Relation Formation

We can illustrate the way in which a new relation may be formed from an already identified relation through recursion by considering how a family tree can be constructed recursively. Assume we already know that a mother relation assigns to a given person that person's

mother. We can now form a new relation, mother's mother, by defining it recursively from just the mother relation. To do so, start with ego, the focal person for the family tree, apply the mother relation to ego and trace to ego's mother. Now take ego's mother as ego, apply the mother relation to this new ego and trace to (ego's mother)'s mother; that is, to ego's mother's mother. We now define the mother's mother relation to be the female determined in this manner; that is, the mother's mother relation applied to ego traces from ego to ego's mother's mother. Other relations such as mother's father, father's mother, or father's father may be defined recursively in a similar manner if the father relation is already known. Or the recursion may be continued further to define the relation, mother's mother's mother, and so on. Thus, unlike the situation with attribute categorization, recursive reasoning makes possible the formation of new relation categories based just on already identified relations.

Next, we want to sketch out how a system of relations define recursively might arise, from an evolutionary viewpoint, and the implications this had for social organization and structure. We will begin by assuming a single relation, the *M* ("mother") relation based on categorization of actual biological mother/offspring relations, is already part of the cognitive repertoire of individuals. (Note that the argument will apply equally to any relation that characterizes dyads among individuals in and not just the mother relation.) Now assume that we have a set of individuals, *I*, each having the four cognitive properties discussed above as part of one's cognitive repertoire. In Figure 10.3(1), female *A*, the biological daughter of female *B*, conceptualizes the relation between herself and her biological mother as an instantiation of the *M* relation. By virtue of the Theory of Mind, she believes her mother, *B*, also instantiates the same *M* relation between herself (*B*) and a female *C* believed by *A* to be the biological mother of *B*. Thus the (*B*, *C*) dyad is believed by *A* to be an instantiation of the *M* relation perceived by her mother, *B* (see Figure 10.3(2)). The instantiation is a belief from the perspective of *A* since *A* projects onto her mother *A*'s belief that her mother also perceives an *M* relation. The thought cloud in Figure 10.3(2) is dashed and in gray for female *B* to indicate that this is the relation that *A* believes is held by her mother, which may, or may not, correspond to what is actually conceptualized by her mother.

By recursion, individual *A* can now construct the *MM* relation through which individual *A* perceives that she and female *C* form an instantiation of the constructed *MM* relation (see Figure 10.3(3)). The relation *MM* differs in a crucial way from the *M* relation. The *MM*

Box 10.2: Recursive relation construction

To illustrate the recursive construction of relations, let the two-place predicate $M(_, _)$ represent the biological mother/biological daughter relation for a set of individuals, B , so that, for all A, B in I , $M(A, B)$ is true when, and only when, B is the biological mother of A . We can recursively form a new relation, $MM(_, _)$, where $MM(A, C)$ is true if, and only if, there is a B in I with $M(A, B)$ and $M(B, C)$ both true, as follows. Since there is a single B for which $M(A, B)$ is true, let $B = M(A, _)$, hence we can think of B as the unique outcome of applying the single-place predicate $M(A, _)$ to the set I . Similarly, we can let $C = MM(A, _)$ when $MM(A, C)$ is true. Note that there is a single C for which $MM(A, C)$ is true. Then $C = MM(A, _) = M(B, _) = M(M(A, _), _)$, hence MM can be constructed recursively by applying the M relation to the outcome of the M relation.

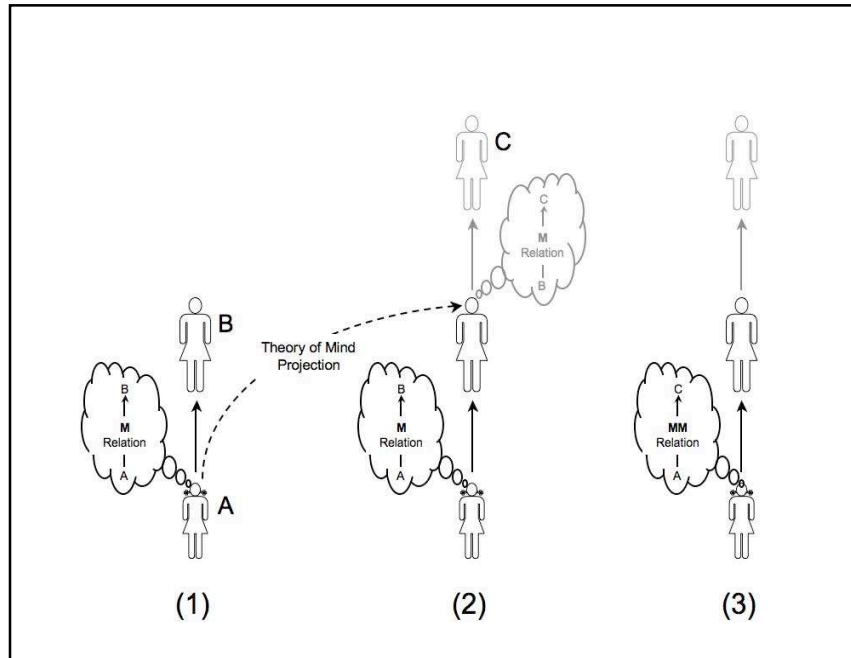


Figure 10.3: (1) Individual A , biological daughter of B , conceptualizes a mother relation and (2) projects, via the Theory of Mind, the same relation concept to her biological mother B . (3) By composition of relations, individual A constructs a relation linking her to individual C , the female A believes to be the target of the mother relation

relation is constructed from the M relation through recursive reasoning and not from categorization of actual “biological grandmother/biological granddaughter” dyads. Though the M rela-

tion may arise from a categorization of biological relations, recursive reasoning leads to the construction of a new relation, MM , without depending upon prior categorization of dyads based on biological relations. Instead, categorization now becomes a *consequence* of the new relation formed via recursive reasoning and would encompass all those instances where, by virtue of the Theory of Mind, individual A projects onto another individual the relation, MM . Hence once constructed, the MM relation gives rise to a category of dyads that are the perceived instantiation of the MM relation. In other words, one of the consequences of constructing a new relation such as MM using recursion is that the newly constructed relation does not depend on the biological facts of who is related genetically to whom, but on beliefs held by individuals about what allegedly are the biological facts. *Recursion of relations leads to decoupling of constructed relations from the biological basis for conceptualizing the relations involved in forming the constructed relations.*

Reciprocal relations

If we consider the relation between B and A from the perspective of

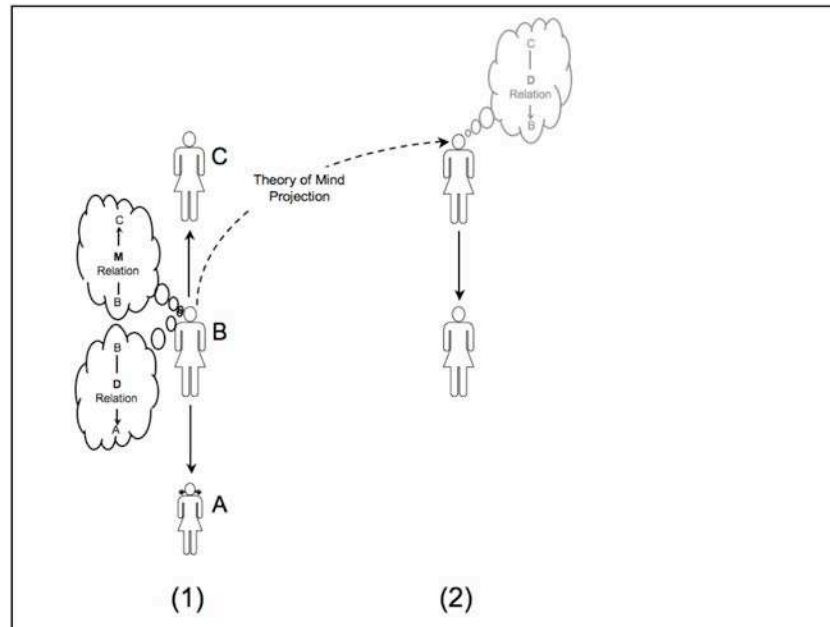


Figure 10.4: (1) Individual B conceptualizes an M (mother) relation to C and a D (daughter) relation to A . (2) Individual B attributes the D relation to C , hence B believes that C has B as a target for the D relation, a precursor for a reciprocal social relationship from B 's perspective.

B , then A will be in a biological daughter relation D with respect to B . Now consider that individual B perceives both an M relation with C and a D relation with A (see Figure 10.4(1)) and projects the D relation onto individual C (see Figure 10.4(2)). An instantiation of the projected D relation will be individual B , hence from the perspective of B , B perceives that individual C will have a daughter relation for which individual B is the instantiation from C 's perspective. In other words, B will perceive not only that B has an M relation to C , but B will believe that C perceives a D relation from C to B . Consequently, B will believe that B and C are conceptually linked to each other. Hence the precursor for reciprocal social interaction from B 's perspective, namely that B not only perceives a relation with C , but B believes C also perceives a reciprocal relation with B , is in place.

Though illustrated with the M and D relation, the pattern can arise with any relation R that B has with C where there is a corresponding reciprocal relation S that B may be believed to have with A . The projection of the relation S onto C will have B as an instantiation of the S relation from B 's perspective and so B will perceive that B has a relation R with C and will believe that C perceives a relation S between C and B .

Functionality of the Projected Relation: Symmetric Social Interaction

The importance of perceiving a relation R lies not in the relation, per se, but in behaviours and/or motivation for behaviours that can be associated with the relation and thereby lead to social interaction and not just interaction. A behaviour such as altruism introduced through selection based on biological kinship is not part of social interaction when there is no anticipation on the part of the actor that the behaviour will be reciprocated in some manner. In contrast, a behaviour based on a cultural kinship relation satisfies the conditions for social interaction since the conceptual system that structures cultural kinship (namely a kinship terminology) forms a system of reciprocal relations with expected, reciprocal behaviour. If A recognizes B as a cultural kin, that is, A has a kin term used to refer to B and A knows that B shares with A the same kinship terminology, then A also knows that B has a kin term for A , hence B recognizes A as a cultural kin. Therefore A has expectations about reciprocal behaviour on the part of B by virtue of the fact that A is a cultural kin of B and A and B share the same knowledge about the particular cultural kin relation that A has towards B from B 's perspective.

To initiate social interaction, each of *A* and *B* needs to recognize that the one is conceptually linked to the other.¹ Otherwise, there is no reason for expecting reciprocal behaviour. In kin-based societies, typically there cannot be social interaction between individuals *A* and *B* without *A* and *B* first establishing that they are (cultural) kin -- which means that *B* is already in the conceptual domain of *A*'s cultural kin and *A* is in the conceptual domain of *B*'s cultural kin and both know that this is true of the other person. Absent a cultural kin relation, an encounter between two individuals who are strangers to each other may be conceived of as a dangerous state of affairs and in some cases may lead to one person killing the other. Among the traditional Waorani of South America, for example, if person, *B*, comes to *A*'s village and *B* does not have a cultural kin relation with *A*, then whether social interaction can occur between them was resolved in the negative by *A* killing *B* (Davis & Yost 2001). Even this extreme fear of a non-kin is hardly an isolated case. On Anuta in the South Pacific "[a]nyone not incorporated into the kinship system is an outsider ... an open enemy" (Feinberg 1981).

We can include under the Theory of Mind projection a behaviour (or kind of behaviour), that one individual might engage in vis-à-vis another individual when the behaviour is viewed as being part of a relation *R* linking this pair of individuals. More precisely, suppose that individual *B* has an **R** relation with individual *C* and a reciprocal **S** relation with some individual *A*, where the biological relations among *A*, *B* and *C* may be indeterminate. Suppose that individual *B* associates directing behaviour *b* (or the kind of behaviour represented by *b*) towards an individual when that individual is a target of the relation **S** conceptualized by *B* (see Figure 10.5(1)); for example, *B* may be engaging (even non-socially) in behaviour *b* with *A* as a consequence of *A* being a target of the **S** relation conceptualized by *B*. By the Theory of Mind, individual *B* projects the relation **S** and the conceptually associated behaviour *b* (or the kind of behaviour represented by *b*) to individual *C* (see Figure 10.5(2)). Via the Theory of Mind projection, individual *B* believes that individual *C* will engage in the behaviour *b* (or in *b*-like behaviour) towards oneself since individual *B* is a target of the **S** relation that *B* believes to be a relation concept held by *C*. Now if individual *B* believes that individual *C* will engage in the behaviour *b* (or *b*-like behaviour) with respect to oneself, then individual *B* can engage in the behaviour *b* directed towards *C* in the

¹ A conceptual linkage between individuals is not universally a necessary prerequisite for social interaction as shown by the eusocial insects.

belief that individual C will reciprocate with behaviour b (or b -like behaviour) directed towards B (see Figure 10.5(3)). *We now have a basis for interaction to become social interaction: one individual acts towards another individual under the belief that the other individual will act in a reciprocal manner. Further, and critically, this basis for social interaction is decoupled from any requirement of biological*

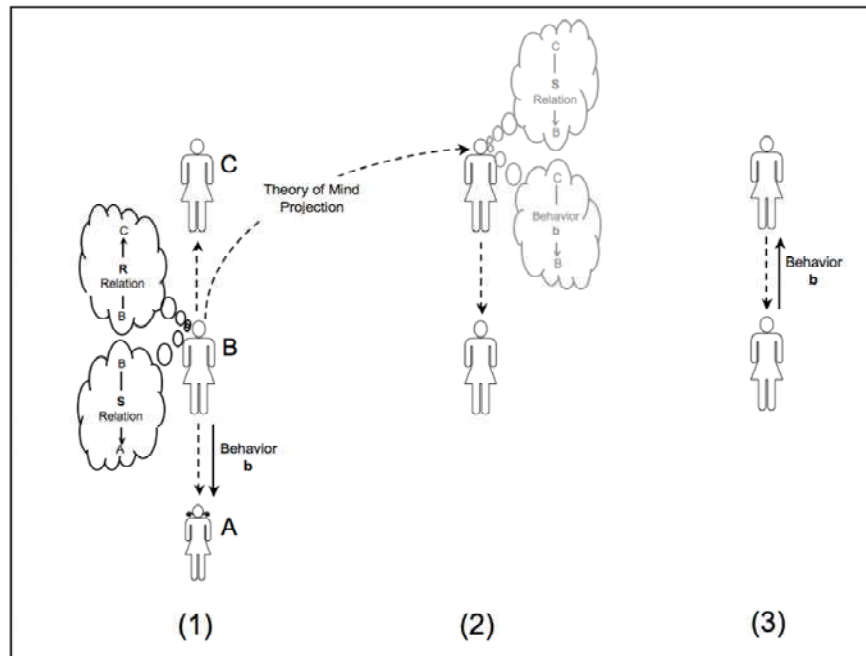


Figure 10.5: (1) Individual B conceptualizes a relation R with C and a reciprocal relation S with A . In addition, B directs behaviour b towards individual A when A is the target of the S relation conceptualized by B . (2) Individual B projects the relation S to individual C and B is the target of the relation S believed by B to be a relation conceptualized by C . (3) Individual B directs behaviour b towards C due to B 's belief that B is a target of the S relation held by C . That is, B believes C will direct behaviour b towards C since B directs behaviour b towards A due to B 's relation B with A , hence B expects C to direct behaviour b towards B .

linkages among the individuals in question.

Reciprocal Relations as a Basis for Symmetric Social Interaction

While the projection of a behaviour linked to a relation may lead to the belief that this or a comparable behaviour will be engaged in by the other individual, the reciprocal behaviour need not actually occur unless the other individual has both constructed a complementary be-

belief system about the behaviour of the initiating individual and reciprocates with a behaviour directed towards the initiating individual. Cheating, used here to include the situation where the reciprocal behaviour is not initiated despite having the complementary belief system, is always possible and if

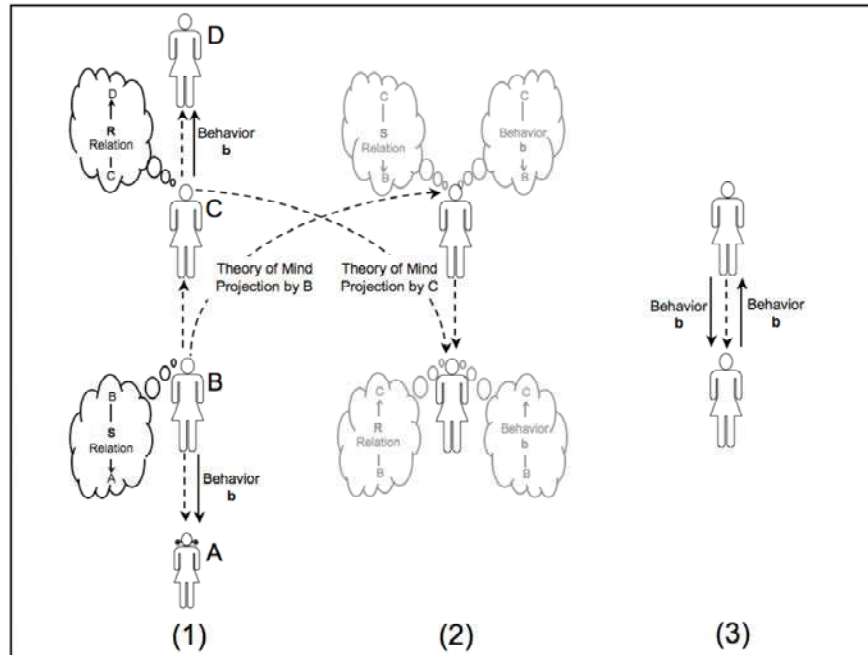


Figure 10.6: (1) Individuals B and C each share the same pair of reciprocal relations (only one relation from each pair shown for clarity) and each associates behaviour b with a relation, with individual C directing behaviour b to individual D and individual B directing behaviour b to individual A . (2) Each of B and C projects their conceptual relations onto the other individual. (3) Each of B and C directs behaviour b towards the other individual on the basis of one's belief that the other individual will reciprocate with b or b -like behaviour. The beliefs of both B and C are reinforced by the behaviour of the other individual.

B acts towards C just under the *belief* that C will reciprocate, then B has also initiated conditions that favor cheating by C .

Symmetric social interaction depends upon each individual actually engaging in reciprocal behaviour. If each person believes that the other will reciprocate the behaviour in question, then the basis for continued, reciprocal behaviours will have been established. For individuals B and C to each have the belief that the other individual will reciprocate with behaviour b , it suffices for individual C to associate the behaviour b with the relation R in addition to individual B associ-

ating the same behaviour with relation S , where R and S are reciprocal relations, as shown in Figure 10.6. (The reciprocal relations have not been drawn for each individual B and C for clarity of the figure.) Under these conditions, individual B will construct the belief that individual C will reciprocate with the behaviour b and independently individual C will construct the belief that individual B will reciprocate with the behaviour b . When each individual engages in behaviour b directed towards the other individual based on one's beliefs, one's beliefs are reinforced through confirmation of that belief by the actual behaviour of the other individual.

Coordination Through Computational Conceptual Systems

For the functional benefit of reciprocal behaviours to be realized, it is necessary that the individuals in the population recognize in a comparable manner the kind of relation with which a behaviour or complex of behaviours is associated. The relation becomes a marker for individuals who will reciprocate a behaviour b and agreement between actor and recipient with respect to enactment of the behaviour will occur when both the actor and the recipient happen to associate the behaviour b with the same relation R and its reciprocal relation S . Consequently, the likelihood of the functional benefit potentially accruing from behaviour b actually being realized through reciprocal behaviours is determined by the degree of coordination/agreement among group members with regard to the relations that are recognized and the behaviours associated with those relations. The latter is a precursor to institutionalized social action/role systems (Nadel 1957) that "are clothed in cultural meaning systems so that institutions cannot be properly represented without ... reference to shared meanings" (Fararo 1997, 76).

The coordination problem was solved with the construction of cultural kin relations transmitted through enculturation by virtue of the fact that the system of cultural kin relations we find in a human society and expressed through a kinship terminology is: (1) a computational system through which kin relations may be calculated in a simple manner, (2) a generative computational system (which facilitates faithful transmission of the conceptual system) and (3) a system of reciprocal kin relations. By a computational system is meant that two individuals A and B can compute the kin relation they have to each other just by reference to a third individual, C , for whom each of A and B knows his or her kin term relation:

[Maori kin] terms permit *comparative strangers* to fix kinship rapidly.... 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*, whereas 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* (Sahlins 1962, 155, emphasis added).

This permits defining a binary product, denoted by \circ , of kin terms as follows. If \mathbf{K} is the kin term A (properly) uses to refer to B and \mathbf{L} is the kin term B (properly) uses to refer to C , then $\mathbf{L} \circ \mathbf{K}$ is the kin term (if any) that A (properly) uses to refer to C . The computational system of kin terms is generative in the algebraic sense that there is a subset of the set of kin terms from which all other kin terms can be generated through use of the binary product for the generating kin terms in conjunction with a set of structural equations that determines the structure for the kinship terminology (Read 1984, 2001, 2009).

It follows that when person A and person B share the same kin term computational system, then they can compute if they are kin to each other through a third individual as indicated in the above quote. Once A knows that A has a kin term relation to B , A also knows that B has a kin term relation to A and A knows that the relation A has to B (from A 's perspective) is the reciprocal (in A 's computational system) of the relation that B has to A . Further, A also knows that from B 's perspective, the relation B has to A is the reciprocal (in B 's computational system) of the relation A has to B . Consequently, once A knows that B is in the domain of individuals with whom A has a kin relation, then the belief that A constructs regarding B (namely B is a person towards whom behaviours associated with kin relations may be directed) should be reciprocated by the behaviour of B by virtue of B also forming a reciprocal belief about A from B 's perspective, as indicated in Figure 10.6. Hence the conditions necessary for symmetric social interaction are satisfied.

The set of persons who mutually recognize each other as cultural kin (or who can compute that they are cultural kin) can form a bounded social system based on symmetric social interaction that does not depend on prior, extensive prior face-to-face interaction for predicting what behaviour will likely be reciprocated. The fact that individuals can compute whether they have a cultural kin relation implies that the size of the group of socially interacting individuals is limited only by the connectedness of individuals through mating/marriage networks and the latter relates to the likelihood that when individuals A and B encounter one another they can identify a third individual, C , for whom each already has a known cultural kin relation. Empirically,

this appears to be around 500-800 persons, the modal size for hunter-gatherer societies when social organization is based primarily on a kinship system expressed through a kinship terminology and society specific marriage rules (either negative in the form of proscription or positive in the form of prescription) (Leaf & Read n.d., Appendix).

The modal size of hunter-gatherer societies relates to structural/organizational properties of the kinship terminology conceptual system whose implementation enables symmetric social interaction. Evolutionary change at the conceptual level can restructure social and environmental relationships in a system of interacting individuals through their organization into a structured system of social groupings such as families and residence groups. Connection is made downward through cultural instantiation of the units of the conceptual system with individuals, or groups of individuals, rather than the conceptual system emerging out of behavioural processes. A kinship terminology -- a system of concepts with a generative structure -- does not emerge *from* behaviour, but instead provides a model *for* behaviour and constructs the boundaries for the individuals among whom social interaction may take place.

CONCLUSIONS

Evolution among the non-human primates leading to the hominins and then to modern *Homo sapiens* shows two parallel trends – evolution in the degree to which information regarding individuals that are encountered can be taken into account and evolution in the form of social organization. Although symmetric male-male social interactions do occur among the common chimpanzees (and in the form of female-female dyads among the pygmy chimpanzees), the dyads are not stable and depend on extensive interaction to be formed. These two trends appear to reach a biological limit with the chimpanzees due to a third trend of increasing individualization of behaviour. Individualization of behaviour increases the “cognitive load” when behaviour is modified according to the range of behaviours, including alliances and coalitions, that are encountered. With evolution of the hominins, another trend also came to the fore, namely the cognitive capacity to conceptually categorize on the basis of the relation of one individual to another.

The evolutionary importance of this innovation in categorization away from features of individuals to relations between individuals lies in the manner in which new relations may be constructed from current relations through the recursive composition of relations. Through

relation composition, new categories of relations can be constructed without the relations requiring prior identification through patterns of behaviour. In addition, a relation that is part of the cognitive repertoire of one individual can become a reciprocal relation when others who are the target of the relation share the same cognitive repertoire and mutually include one another in the range of instantiation for relations. Reciprocal relations provide a basis for symmetric social interaction. The functionality associated with symmetric social interaction will be realized in a community of individuals sharing the same conceptual system of relations, hence the boundary for the community will be determined by those individuals who are mutually enculturated. With social organization based on cultural instantiation of conceptual systems transmitted through enculturation, evolution at the organizational level comes to the fore, driven internally both by the cohesiveness of a conceptual system and through its culturally instantiated form that provides the social context for behaviour (van der Leeuw et al. in press) and externally by the functionality provided by a system of social organization in competition with the functionality of other systems of social organization.

References

- Arnold, K. & A. Whiten. 2003. Grooming interactions among the chimpanzees of the Budongo forest, Uganda: Tests of five explanatory models. *Behaviour*, 140, 519–552.
- Baldwin, J. 1896. A new factor in evolution. *The American Naturalist* 30:441-451.
- Bauer, H. R. 1979. "Agonistic and grooming behaviour in the reunion contexts of Gombe Stream chimpanzees," in D. A. Hamburg & E. R. McCown (Eds.) *The Great Apes*, The Benjamin/Cummings Publishing Co., Menlo Park, pp. 395-404.
- Call, J. & M. Tomasello. 2008. Does the chimpanzee have a theory of mind? 30 years later. *Trends in Cognitive Science* 12:187-192.
- Crumley, C. 1995. "Heterarchy and the analysis of complex societies," in R. M. Ehrenreich, C. L. Crumley, & J. E. Levy (Eds.) *Heterarchy and the Analysis of Complex Societies*, Archaeological Papers of the American Anthropological Association No. 6, Washington: American Anthropological Association, pp. 1-5..
- Dasser, V. 1988a. A social concept in Java monkeys. *Animal Behaviour* 36:225-230.
- . 1988b. "Mapping social concepts in monkeys," in *Machiavellian intelligence: Social expertise and the evolution of intellect in monkeys*,

- apes, and humans*. Edited by R. W. Byrne & A. Whiten, pp. 85-93. New York: Oxford University Press.
- Davis, E. W., & J. A. Yost. 2001. "The creation of social hierarchy," in *Ethnographic essays in cultural anthropology*. Edited by R. B. Morrison and C. R. Wilson, pp. 82-120. Belmont: Thomson Publishers.
- de Waal, F. B. M. 1992. "Coalitions as part of reciprocal relations in the Arnhem chimpanzee colony," in *Coalitions and alliances in humans and other animals*. Edited by A. H. Harcourt & F. B. M. de Waal, pp. 233-257. Oxford: Oxford Science Publications.
- Di Fiore, A., & D. Rendall. 1994. Evolution of social organization: A reappraisal for primates by using phylogenetic methods. *Proceedings of the National Academy of Sciences, USA* 91:9941-9945.
- Fararo, T. J. 1997. Reflections on mathematical sociology. *Sociological Forum* 12:73-101.
- Feinberg, R. 1981. "The meaning of 'sibling' on Anuta," in *Siblingship in Oceania*. Edited by M. Marshall, pp. 105-148. Ann Arbor: University of Michigan Press.
- Focquaert, F., J. Braeckman, & S. M. Platek. 2008. An evolutionary cognitive neuroscience perspective on human self-awareness and Theory of Mind. *Philosophical Psychology* 21:47-68.
- Gagneux, P., C. Boesch, & D. S. Woodruff. 1999. Female reproductive strategies, paternity and community structure in wild West African chimpanzees. *Animal Behaviour* 57:19-32.
- Goodall, J. 1986. *The chimpanzees of Gombe: Patterns of behaviour*. Cambridge: Harvard University Press.
- Gouzoules, S. & H. Gouzoules. 1987. Kinship, in B.B. Smuts, D.L. Cheney, R.M. Seyfarth, R.W. Wrangham & T.T. Struhsaker (Eds.) *Primate Societies*, Chicago: University of Chicago Press.
- Hankins, F. H. 1925. Individual freedom with some sociological implications of determinism. *The Journal of Philosophy* 22:617-634.
- Hass, J. 1998. A brief consideration of cultural evolution: Stages, agents, and tinkering. *Complexity* 3:12-21.
- Hauser, M. D., N. Chomsky, & W. T. Fitch. 2002. The faculty of language: What is it, who has it and how did it evolve? *Science* 298:1569-1579.
- Heyes, C. 1998. Theory of mind in nonhuman primates. *Behavioural and Brain Sciences* 21:101-134.
- Leaf, M. 2006. Experimental analysis of kinship. *Ethnology* 45:305-330.
- Leaf, M. & D. Read n.d. *Empirical Formal Analysis in Anthropology: the New Science* (Manuscript).
- Lehmann, J. & C. Boesch. 2008. Sexual differences in chimpanzee sociality. *International Journal of Primatology* 29:65-81.
- Lévi-Strauss, C. (1969)[1967], *The Elementary Structures of Kinship*, Revised edition. Translated by Bell, Harle, J. R. von Sturmer, & R. Needham. Beacon Press, Boston.
- Misztal, B. 2000. *Informality: Social theory and contemporary practice*. New York: Routledge.

- Mitani, J. C., D. P. Watts, & M. N. Muller. 2002. Recent developments in the study of wild chimpanzee behaviour. *Evolutionary Anthropology* 9:9-26.
- Muller, M. N., & J. C. Mitani. 2005. Conflict and cooperation in wild chimpanzees. *Advances in the study of behaviour* 35:275-331.
- Nadel, S. F. 1957. *The theory of social structure*. London: Cohen and West.
- Nishida, T. 1979. The social structure of chimpanzees of the Mahale Mountains, in D.A. Hamburg & E.R. McCown (Eds.) *The Great Apes*, Menlo Park: The Benjamin/Cummings Publishing Co.
- Nishida, T. & M. Hiraiwa-Hasegawa 1987. Chimpanzees and bonobos: Cooperative relationships among males," in B.B. Smuts, D.L. Cheney, R.M. Seyfarth, R.W. Wrangham & T.T. Struhsaker (Eds.) *Primate Societies*, Chicago: University of Chicago Press, pp. 165-178.
- Parsons, T. 1964. *The social system*. New York: Free Press of Glencoe.
- Povinelli, D. J. & J. Vonk. 2004. We don't need a microscope to explore the chimpanzee mind. *Mind and Language* 19:1-28.
- Read, D. W. 1984. An algebraic account of the American Kinship terminology. *Current Anthropology* 25:417-440.
- . 2001. "What is kinship?," in *The cultural analysis of kinship: The legacy of David Schneider and its implications for anthropological relativism*. Edited by R. Feinberg & M. Ottenheimer, pp. 78-117. Urbana: University of Illinois Press.
- . 2004. The emergence of order from disorder as a form of self organization. *Computational & Mathematical Organization Theory* 9:195-225.
- . 2005. Change in the form of evolution: Transition from primate to hominid forms of social organization. *Journal of Mathematical Sociology* 29: 91-114.
- . 2007a. Culture: the challenge for computational modeling. Symposium: Computational Models in Anthropology: What Are They Good For? Why Should You Care? Annual Meeting, American Anthropological Association, 2007
- . 2007b. Kinship theory: A paradigm shift. *Ethnology* 46: 329 - 364.
- . 2008. Working memory: A cognitive limit to non-human primate recursive thinking prior to hominid evolution. *Evolutionary Psychology* 6:676-714.
- Read, D. & C. Behrens. 1990. KAES: An expert system for the algebraic analysis of kinship terminologies. *Journal of Quantitative Anthropology* 2:353-93. Postprint available at: <http://repositories.cdlib.org/postprints/2647>.
- Read, D., D. Lane, & S. van der Leeuw. (In Press). "An innovation innovation," in *Complexity perspectives on innovation and social change*. Edited by D. Lane, S. van der Leeuw, D. Pumain & G. West, pp. xx-xx. Berlin: Springer Verlag.
- Sahlins, M. 1962. *Moala: Culture and nature on a FBaan Island*. Englewood Cliffs: Prentice-Hall.

- Schilhab, T. S. S. 2004. What mirror self-recognition in nonhumans can tell us about aspects of self. *Baology and Philosophy* 19:111-126.
- Simpson, G. G. 1953. The Baldwin effect. *Evolution* 7:110-117.
- Spinozzi, G., F. Natale, J. Langer, & K. E. Brakke. 1999. Spontaneous class grouping behaviour by bonobos (*Pan paniscus*) and common chimpanzees (*P. troglodytes*). *Animal Cognition* 2:157-170.
- Spruijt, B. M., J. A. R. A. M. van Hooff, & W. H. Gispen. 1992. Ethology and neurobiology of grooming behaviour. *Physiological Reviews* 72:825-852.
- Tomasello, M. 1998. Uniquely primate, uniquely human. *Developmental Science* 1:1-30.
- van der Leeuw, S., D. Lane, D. Read, & D. White. In Press. "The long-term evolution of social organization," in *Complexity perspectives on innovation and social change*. Edited by D. Lane, D. Pumain, S. van der Leeuw & G. West, pp. xx-xx. Berlin: Springer Verlag.
- Wrangham, R. W. 1979. "Sex Differences in Chimpanzee Dispersion," in D. A. Hamburg & E. R. McCown (Eds.) *The Great Apes*, Benjamin/Cummings, Menlo Park.
- Wrangham, R. W., A. P. Clark, & G. Isabirye-Basuta. 1992. "Female social relationships and social organisation of the Kibale Forest chimpanzees," in *Topics in primatology, Human origins Vol. 1*. Edited by T. Nishida, W. C. McGrew, P. Marler, M. Pickford, & F. D. M. de Waal, pp. 81-98. Tokyo: University of Tokyo Press.