

Dominance Style, Social Power, and Conflict Management in Macaque Societies: A Conceptual Framework

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1.0 Introduction

Following Kroeber & Parsons (1958), 'society' refers to the relational system of interaction among individuals and subgroups, taking into account the statuses and roles of all individuals within the larger group. Studying how societies arise requires systematic, comparative study to identify the general laws or principles that underlie their diversity. However, as noted by Radcliffe-Brown in the preface to *African Political Systems* (Fortes & Evans-Pritchard, 1940), comparative empirical observation does not by itself lead to the identification of underlying general principles; the diversity of types must be classified to make abstraction possible. And this process requires in its preliminary phases, focus on particular aspects of society, such as the political system or kinship system, even though these subsystems are likely to be highly interrelated. Having said this, the goal of this paper is to provide a preliminary taxonomy of the political systems, defined here in the Parsonian sense as the interplay between power structure and conflict management, of macaque societies.

The macaque genus is an ideal starting point for investigating how societies arise from aggregates of individuals. There are three reasons for this, the details of which are reviewed in Thierry (2000), (1) the kinship and demographic structures across macaque species are relatively similar, which decreases the number of variables that need to be taken into account when testing hypotheses about how societies arise, (2) there does not seem to be ecological variability of significant importance across macaque habitats, and (3) there is, nonetheless, interesting variation in conflict and conflict management patterns across species that does not always fall out along phylogenetic lines. The confluence of these factors has produced a natural experiment that is particularly ripe for comparative investigation of the social causes and consequences of variation in power distributions and conflict management mechanisms across macaque species.

For example, despite similar kinship and demographic structures, the social relationships of rhesus macaques are characterized by large agonistic asymmetries, whereas social relationships of tonkean macaques appear to be characterized by agonistic *symmetries* (reviewed in Preuschoft & van Schaik, 2000). Stumptailed macaques are reported to exhibit more reciprocity in interventions and higher rates of post-conflict affiliative behavior than rhesus macaques (de Waal & Luttrell, 1989). Reviews of this variation by a number of authors have revealed co-variation in conflict and conflict management traits: In macaque species in which there is less of an emphasis on kinship, conflict is frequent, low intensity, often bidirectional, and post-conflict affiliative behavior is relatively high. In species with more of an emphasis on kinship, conflict is frequent but severe, unidirectional, and not typically followed by affiliative post-conflict behavior.

This covariation in conflict and conflict management mechanisms, first documented by Thierry (1985), has been used to characterize macaque societies, and various explanations from phylogenetic inertia (Thierry, 1990; 2000) to differences in aggression levels (Hemelrijk, 1999), have been offered to explain why one social organization arises rather than another. Here we propose a possible framework for how macaque societies arise that differs from previous accounts primarily in its attention to mechanism

and the processes by which a particular system emerges from social interactions at the relationship level. The framework we present links the degree of agonistic asymmetry (or symmetry) at the relationship level, dominance style, the distribution of social power at the system level, and the resulting conflict management system.

2.0 Dominance style: A relationship-level concept

The term ‘dominance style’ was originally introduced to the animal behavior literature as a relationship-level concept that referred to species-typical pattern of expressed asymmetry in agonistic relationships (de Waal & Luttrell, 1989). However, it is often used to describe the observed covariation in conflict and conflict management traits across macaque species. Although this usage has provided a starting point for comparative studies of animal social systems, it has also confounded the relationship and system levels thereby making it difficult to study the processes by which a particular power distributions or conflict management systems emerge from individual interactions. We favor a slightly modified version of the term’s original usage, for reasons we make clear in the following paragraphs.

When discussing species-typical dominance styles, researchers have relied upon four terms: ‘despotic’, ‘tolerant’, ‘relaxed’, and ‘egalitarian’. Before discussing how we use these terms, we provide a brief history of their meaning. ‘Despotic’ was originally a sociological term applied to human societies in which power is concentrated in a single individual, and in which there are no limitations on rule by that individual. Its meaning in the sociological literature is, for our purposes, more or less synonymous with ‘absolutism’, ‘authoritarianism’, and totalitarianism. ‘Egalitarian’ was originally used by anthropologists to describe variation in the degree to which individuals in human societies divided benefits in proportion to investment (e.g. Fortes & Evans-Pritchard, 1940; Sahlins, 1958; Flanagan, 1989).

Building on the ideas of Alexander (1974) and others, Vehrencamp (1983) formally introduced the terms “despotic” and “egalitarian” to the study of animal behavior by developing an optimization model that specified the conditions under which despotic and egalitarian societies might evolve. In Vehrencamp’s treatment, despotic and egalitarian dominance relationships describe the degree of asymmetry in agonistic relationships, and the term that best summarizes the dyad typical degree of agonistic asymmetry, designates whether the society is described as egalitarian or despotic. It is important to note that whereas sociologists and anthropologists used the terms despotic and egalitarian to qualitatively describe a particular distribution of social power in society, Vehrencamp used them to refer to the degree of agonistic asymmetry in relationships, and then extrapolated to society. The implicit assumption was societal types, a system level characteristic, corresponded directly and linearly to degree of agonistic asymmetry at the relationship level.

Wrangham (1980), van Schaik (1989), and Sterk, Watts, & van Schaik (1997) have provided potential ecological explanations for why dyadic relationships in some species are best characterized as egalitarian whereas in others, despotic is the more appropriate classification. At about the same time, van Rhijn and Vodegel (1980) and

Hand (1986) discussed despotic (dominance-subordination) and egalitarian relationships in terms of conflict resolution, which complemented a view de Waal (1986) was developing of dominance-subordination relationships as the product of resource competition and social bonding. Thus emerged the view that the degree of agonistic asymmetry in relationships should co-vary with other conflict and conflict management traits, such as conflict severity, rate of post-conflict affiliation, and diversity of grooming partners.

Thierry's (1985) study of tonkean, rhesus, and longtailed macaques and de Waal and Luttrell's (1989) study of stumptailed and rhesus macaques were the first cross-species comparisons of conflict management patterns that attempted to empirically verify co-variation of conflict management related traits in primate social systems. De Waal (1989) suggested that this co-variation is due to the different dominance styles of each species, a view perhaps first expressed by Maslow (1940). This initial usage of 'dominance style' was meant to capture the discrepancy in some species between the degree of inherent agonistic asymmetry in relationships and the degree of expressed or manifest asymmetry. In de Waal's usage, despotic dominance relationships are those in which there is a high degree of inherent agonistic asymmetry and this is expressed in behavior. 'Tolerant' relationships, in de Waal's usage, are those with high to moderate inherent agonistic asymmetry, but moderate to weak expression of that asymmetry during social interaction. Since those studies, the classification of dominance style has become increasingly fine-grained. Thierry (2000), for example, attempted to classify the 22 species in the macaque genus into 'grades' along the despotic – egalitarian continuum. Based on a review of the data, it was argued that traits relating to dominance, conflict management, and nepotism cluster around four social system attractors resulting from phylogenetic inertia.

In the course of validating the observed covariation in traits across macaque societies, and in testing whether that covariation might be due to dominance style, the dominance style concept and the observed covariation converged in meaning and are now at risk of being collapsed into one phenomenon. For example, despotic dominance style has been used to describe systems in which there is unidirectional aggression that is directed at subordinate individuals, frequent severe aggression, strong emphasis on kinship, and infrequent post-conflict affiliation following conflicts (e.g. Preuschoft & van Schaik, 2000; see also Sterk, Watts, & van Schaik, 1997). Rhesus, Japanese, and possibly long-tailed macaques are thought to fall into this category. Tolerant, relaxed, and egalitarian are applied by different (and occasionally the same authors) (B. Thierry, personal communication, 2003) to systems that are characterized by higher levels of bidirectional aggression, less emphasis on kinship, more frequent post-conflict affiliation, and more frequent but less intense conflicts. For example, stumptailed macaques have been described as more tolerant than rhesus macaques because of their lower levels of severe aggression, higher rates of post-conflict affiliative behavior and bidirectional aggression. Moore macaques have been described as having a relaxed dominance style (Matsumura, 1998) because of their relatively high rates of bidirectional aggression, infrequent intense aggression, and relatively high rates of post-conflict affiliation.

There are several reasons for restricting the dominance style concept to the relationship level. The first of these is that dominance style allows for a discrepancy between the degree of inherent agonistic asymmetry between two individuals and the expression of that asymmetry, as originally noted by de Waal. Consider the following example: individual A has won all of its agonistic encounters with individual B and B acknowledges that it is subordinate. A can take from B whatever it wants. However, A nonetheless exercises restraint towards B, and is tolerant of B's 'transgressions', making the relationship seem less asymmetrical than it actually is. This is the case for pigtailed macaques. The degree of agonistic asymmetry that characterizes pigtailed dominance relationships is variable: in some case there is substantial asymmetry, in others, very little. However, regardless of the degree of asymmetry, almost all relationships are weakly expressed in that they are reinforced through weak to moderate, rather than severe, aggression (Flack & de Waal, unpublished data). Variation of this sort has been reported for other macaque species as well, including Moore macaques (Matsumura, 1998) and Barbary macaques (Deag, 1974).

This distinction facilitates disentangling those contextually stable and temporally invariant proximate factors (like the presence of many long-term allies or individual fighting ability) that influence the degree of *inherent* asymmetry in relationships from those socio-ecological and demographic factors (such as within group scramble competition as opposed to within group contest competition) that influence through evolutionary processes and social learning how tolerant dominants generally are of subordinates, and thus the degree of *manifest* or *expressed* asymmetry in relationships. Dominance style is a useful concept because it describes this interface by summarizing whether the inherent asymmetry in the relationship tends to match its expression or is discrepant.

To summarize, we favor distinguishing between relationship-level concepts, such as dominance style, and system level concepts, such as political system type. Restricting the dominance style concept to the relationship level in no way devalues the observation that sets of conflict and conflict management traits co-vary. What it does do is facilitate disentangling causes and consequences of this covariation. For example, is the higher-rate of post-conflict affiliation observed in stumptailed macaques (compared to rhesus) a direct consequence (a) of the degree of inherent agonistic asymmetry that characterizes relationships, (b) of dominance style, or (c) is it more directly a consequence of a system level characteristic, such as societal power structure, that is itself influenced by dominance style?

Another advantage of restricting the dominance style concept to the relationship level is that it enables the study of the processes by which a particular political system emerges from dominance style. This allows for the possibility that, under certain conditions (we will discuss these in later sections of this chapter), different political systems can result from the same species typical dominance style.

3.0 Determining dominance style

In the first column of Table 1 we present four dominance style types, which include: despotic, tolerant, relaxed, and egalitarian, and clearly distinguish the criteria of each. Thierry (personal communication, 2003) has pointed out that the term 'egalitarian dominance style' is somewhat of a misnomer. This is a reasonable objection from a semantic perspective. However, because we define dominance style as the discrepancy between inherent and expressed agonistic asymmetry, an egalitarian dominance style is not an inappropriate usage of terms. This is because there are two possible ways of producing an egalitarian dominance style: (1) when no or little inherent agonistic asymmetry is matched with no or little expressed agonistic asymmetry and, (2) when moderate or high inherent agonistic asymmetry is matched with no or little expressed agonistic asymmetry (this latter case is a less interesting example of egalitarian relationships because individuals have largely overlapping interests).

Specified in the first and second columns of Table 1 are the defining characteristics of each dominance style, as well as those macaque species that tentatively fit into each one. This dominance style taxonomy is identical to Thierry's (2000) four grades, except that the defining criteria of each dominance style includes only the direction of aggression, the level of aggression used to reinforce the relationship, and the type of signal used to indicate roles in the relationship. We favor this classification system because it allows for distinguishing those traits that are directly related to dominance style from those traits, such as level of post-conflict affiliation and grooming partner diversity, which might be mediated by additional factors at higher levels of analysis.

One of the criteria we use to determine dominance style is the type of signal used to indicate role or status in the agonistic relationship. Status signals were first observed by Agnst (1975) and de Waal (1977) in longtailed macaques and by Bygott (1974), Nishida (1979), Nöe, de Waal, & van Hooff (1980), and de Waal (1982) in chimpanzees. They are discussed in detail by Preuschoft and van Schaik (2000). De Waal & Luttrell (1985) called these signals formal dominance signals because they have the following properties (1) they are nearly 100% unidirectional signals in peaceful contexts regardless of the presence of third-parties or other factors that might influence the expression of the relationship, (2) the individual emitting the signal in peaceful situations is typically the one to yield in agonistic ones, and (3) because these signals are found in species that have tolerant as well as despotic relationships, suggesting that they indicate the presence of a perceived agonistic asymmetry, rather than whether the agonistic relationship is characterized by a despotic or tolerant dominance style.

Preuschoft (1999) divided formal dominance signals into two classes: formal signals of subordination (FSS in Table 1), which includes those signals that are emitted in peaceful situations by the individual that typically yields in agonistic situations, and formal dominance signals (FSD in Table 1), which includes those signals that are emitted in peaceful situations by the individual that typically aggresses in agonistic situations. Preuschoft introduced this division because the original signals observed by de Waal and others were emitted by subordinates, not dominants, as the original term implied, and because of data indicating that in some macaque species, such as Barbary macaques (see Preuschoft, 1995), the dominant individual also signals its role in

peaceful situations. Preuschoft & van Schaik (2000) identified in the data on macaques a co-variation between dominance style and type of formal status signal used. Specifically, they suggested that in despotic species, only subordinates signal their roles, whereas in species with tolerant dominance styles, both the dominant and subordinate individual signal their respective roles.

We modify the status signaling concept one step further by referring to the entire class of signals as formal status signals. We do so to leave open the possibility that individuals in agonistic relationships characterized by power symmetries might exchange formal signals of equal status (FSE in Table 1) to indicate their accepted status in their relationship. We include brief mention of these signals here only to direct attention to their possible existence, which would make sense from a theoretical perspective if status signals generally serve to reduce uncertainty in the receiver about its state in its agonistic relationship with the sender (Flack, Krakauer, & de Waal, in review a). It is important to note, however, that signals of equal status will be particularly difficult to identify because if such signals do exist they will probably be used in peaceful greeting situations and are likely to be simultaneously bidirectional.

The form that formal status signals take differs across species. Formal status signals of subordination (FSS) have been documented in several macaque species including rhesus (de Waal & Luttrell, 1995), longtails (Angst, 1975; de Waal, 1977, Preuschoft, 1995), and Japanese macaques (Chaffin, Friedlen, & de Waal, 1995). In all of these species, the FSS is the silent-bared teeth display (SBT), *when it is emitted in peaceful situations*, outside the agonistic context. The SBT is marked by a retraction of the lips, so that both the upper and lower teeth are visible, and either a closed or slightly closed jaw.

Formal dominance signals have also been tentatively documented. These include the 'mock-bite' in stump-tailed macaques (Demaria & Thierry 1990), and the 'rounded-mouth threat face' in Barbary macaques (Deag, 1974). No formal signals have thus far been identified in macaque species with an apparently more relaxed dominance style, including the tonkean macaques, according to reports by Thierry, Demaria, Preuschoft, & Desportes (1989), and Preuschoft (1995,) and the lion-tailed macaques (reviewed in Preuschoft & van Schaik, 2000). However, it is important to note that researchers have only looked for formal signals of subordination, and in some cases, formal dominance signals. To our knowledge, there has been no effort to identify formal signals of equal status in any macaque species.

4.0 Dominance style and social power

Two primary points have come out of attempts to classify macaque societies. Firstly, it is clear that within and between societies there is variation in dominance style. Dominance style might (a) vary across different subgroups of a population, as reported for male and female Barbary macaques (Preuschoft et al., 1998), (b) vary across different communities of the same species, or (c) be species typical. Until a more comprehensive comparative data set on multiple communities of the same macaque species is available, it is impossible to say whether dominance style is species typical.

Secondly, there seems to be variation across societies in the distribution of social power (e.g. 'dominance gradient' of Thierry, 2000), where social power is defined as the degree of implicit agreement among group members that an individual is capable of successfully using force in polyadic social situations (Flack, Krakauer, & de Waal, in review, a; see also: Bierstedt, 1950; Parsons, 1963). This variation is not necessarily coupled with dominance style, and, consequently, a second, higher-level concept is needed to describe it. Although many researchers have recognized the potential importance of the distribution of social power to understanding conflict management behavior, attempts to measure social power have primarily been qualitative --focusing on the so-called 'steepness' of the dominance hierarchy. For example, Leinfelder, de Vries, Delue, & Nelissen (2001) present several predictions about the distribution of grooming interactions in hamadryas baboons based on whether the rank order is "steep", "not steep", or "more or less steep". This approach, although correct in principle, has several significant weaknesses.

The most obvious of these is that the 'steepness' of the dominance hierarchy cannot be quantitatively assessed using conventional methods, such as those developed by Appleby (1983) and elegantly extended by de Vries and colleagues (1995; 1998; de Vries & Appleby, 2000) for calculating dominance rank. One reason for this is that the objective of the de Vries method, called the I&SI method, is to ". . .find an ordinal rank order that is most consistent with a linear hierarchy by first minimizing the number of inconsistencies [in direction of the dominance related behavior being measured] *I* and subsequently, minimizing the total strength of the inconsistencies, *SI*, subject to the condition that *I* does not increase" (de Vries & Appleby, 2000, p. 239).

Measuring social power should not assume nor aim to generate a linear hierarchy in which there is one top ranking individual that dominates all others, a second ranking individual that dominates all others except the top one, and so on. This is because the distribution of social power is not necessarily coupled with rankings of dominance relationships. This is illustrated by the following hypothetical example: one individual dominates all others in its agonistic interactions, and a second individual dominates all others except the first. These two individuals would be ranked one and two in a dominance hierarchy even if there was more agreement among group members that the second individual could more successfully introduce force into social situations than the first. Measures of social power must not preclude this possibility.

Another reason why the I&SI method, and others like it, cannot be used to measure social power is that such measures produce ordinal rank orders. Measuring social power requires at least a cardinal index. Unfortunately, existing cardinal indices of dominance rank, such as Boyd & Silk's method, and Jameson, Appleby, & Freeman's (1999) BBS method, also assume transitivity, and have other restrictive assumptions that make their application to social power questionable (see de Vries, 1998, de Vries & Appleby, 2000).

In addition to restrictive assumptions, there are at least two other problems with using ranking methods rooted in the dominance hierarchy tradition to measure social power. Behaviors, like supplant, direction of aggression, outcome of contest, and priority of access to resources, typically used to determine agonistic status and calculate dominance rank are, at best, correlates of status, rather than direct measures of it. Perhaps, however, the most significant problem is that none of the existing methods for calculating dominance rank assess the degree of implicit agreement among group members about whether an individual can successfully introduce force into social situations.

The remaining sections of this paper are devoted to (1) a discussion of social power and more appropriate ways to measure it, (2) discussion of the social processes leading to particular distributions of social power, and (3) developing the hypothesis that variation in the distribution of social power across societies predicts different conflict management mechanisms for those societies.

5.0 The meaning of social power

There are three classes of factors that can affect the predictability of agonistic encounters. Here, we summarize them briefly to make clear where social power fits into this scheme.

- *Contextually and Temporally Stable Factors*: fighting ability, alliance partners (permanent or long-term supporters), and social knowledge, which are contextually stable and temporally invariant *proximate* factors. When linked through social learning to the predictability of agonistic outcomes, these factors underlie the development of dominance-subordination and egalitarian relationships.
- *Transient Factors*: competitive motivation, coalitions (defined as opportunistic supporters), and leverage, which are temporally and contextually variable *proximate* factors. Leverage, which might be especially important to negotiating the outcomes of stalemates that occur when individuals in egalitarian relationships have conflicts of interests (Preuschoft et al., 1998), is defined here as an asymmetry in a dyad in access to a resource that is possessed by one individual and desired by the other (for broader definitions that include socio-ecological factors, see Hand, 1986; Preuschoft & van Schaik, 2000; Lewis, 2002). It is also assumed that the resource is only obtainable if the possessor grants access to it. If an individual cannot complete a task without the help of a second individual, that second individual has leverage over the first because it possesses something that the first needs, but which cannot be easily taken by force. The second individual can use its leverage as a bargaining chip. Transient factors can modify the outcomes of agonistic encounters and the expression of agonistic relationships, but they do not influence the formation of those relationships.
- *Socio-ecological Factors*: such as demography, the degree of relatedness, and the availability of alternative living situations (i.e. ease of emigration, prospects of solitary survival, type of competitive regime: see Wrangham, 1980; van Schaik, 1989; Sterck et al. 1997). Socioecological factors can indirectly mediate agonistic relationships in other ways as well. For example, if males in a particular species

disperse and mortality among females is high, then it will be difficult for matriline to form in groups, and the size of an individual's kinship network is unlikely to be an important factor determining its status in its agonistic relationships. These types of factors do not directly influence agonistic relationships, but instead influence the arena in which these relationships are expressed. For example, socioecological factors can influence the general degree of tolerance that dominant individuals show subordinates.

Only factors that are temporally and contextually invariable can lead to the acquisition of social power. As stated, following Bierstedt (1950) and Parsons (1963), we have defined social power as the degree of implicit agreement or consensus among group members about whether an individual is capable of successfully introducing force into polyadic, agonistic situations –where force leads to the reduction or elimination of the choices of others. According to this definition, for individual A to have social power, individuals B and C must implicitly agree that A is more capable than D of introducing force into social situations. Social power, when defined this way, is only relevant in those systems in which there are polyadic conflicts. It differs from *dyadic power*, which describes the degree to which one individual perceives another as capable of successfully using force when conflicts arise between them alone.

The concept of power (whether dyadic or social) is unlikely to be applicable in species in which individuals do not signal outside the agonistic context about their statuses in their agonistic relationships. We call such relationships informal agonistic relationships, and those relationships in which individuals do signal outside the agonistic context about their agonistic statuses, formalized relationships, following de Waal (1986). The reason why we restrict application of the power concept to formalized relationships is that in order for an individual to exercise its power, and it first needs to know that others perceive it as powerful, and thus that they are unlikely to challenge its authority. As the sociologist, Bierstedt, wrote (p.733), power is –unlike force—“always successful . . . [and thus] symbolizes the force which *may* be applied in a social situation and supports the authority which is applied.” In informal agonistic relationships, the subordinate individual communicates its willingness to yield only when conflicts arise; this means *after, or upon being threatened, however mildly, by the dominant partner*. The subordinate in informal relationships does not communicate a general willingness to yield to the preferences of the dominant partner.

In informal relationships the dominant partner therefore has to threaten force to learn whether it has power. Prior to the conflict, it only knows that subordinate has no power over it, not whether it has power over its dyad partner. Once it has learned how it is perceived, the dominant has power over the subordinate as long as the conflict lasts. As soon as the conflict ends, however, the same problem again arises because the subordinate has only communicated a willingness to yield after being threatened in a specific context. The specificity of this situation makes it difficult to generalize to others. This is not a problem in formalized relationships –those in which individuals signal about their status in peaceful situations in which there is no precipitating event or immediate

functional application (such as submission or appeasement) to stimulate signal emission.

To summarize, the dyadic power concept only applies to those relationships that are formalized, and the social power concept only applies to those species in which (1) there are polyadic conflicts and, (2) at least some individuals have formalized relationships. Later in the paper we discuss why only some relationships need to be formalized for the social power concept to apply.

It is worth noting that concept of power has a long and controversial history in the social sciences. For other treatments of power by ethologists, we refer the reader to Chapais (1991), Lewis (2002), and Preuschoft & van Hooff (1995). The major difference between our approach to power and these others is that our conception (1) applies to the larger social context that exists beyond the dyad, hence the qualification 'social' and, (2) is grounded in perception and acknowledgment, in the sense that A has power over B only if B perceives A to be stronger and communicates this to A outside the agonistic context. Although the stability of the perception is rooted in the validity of the perception (i.e. if A actually is a stronger fighter than B), the perception and subsequent acknowledgement count more than the validity. Thus, in our view (and in contrast to Preuschoft, 1995) it is not appropriate to use agonistic asymmetry and power asymmetry interchangeably because these terms refer to different, albeit related, phenomena.

6.0 Measuring social power

Although most treatments of power in the ethological literature have focused on dyadic power, several researchers have discussed social power without calling it that (e.g. de Waal, 1982). That work has served as the foundation for our approach, and perhaps for the work of others who have used dominance rank implicitly as a measure of social power (for discussion of this tendency, see de Vries, 1998).

A more appropriate assay of social power than dominance rank is a measure of the degree of implicit consensus among group members about whether an individual has the capacity to introduce force into social situations. This approach has two advantages. Unlike dominance rank, the implicit consensus approach (1) directly taps into social power and (2) also allows for a mixture of dominance-subordination, unknown, and egalitarian relationships in groups, which, as Hand (1986) has suggested, is more realistic than assuming all relationships are dominance-subordination relationships (cf. Mori, 1977; de Waal, 1982; Preuschoft et al., 1998). Mori's work on Japanese macaques, for example, suggests that when groups are large, low interaction rates for many dyads keeps many relationships unresolved. This intra-group variation in agonistic relationship types is likely to affect the degree of consensus about an individual's coercive potential and thus should be taken into account when quantifying the distribution of social power.

Flack, Krakauer, & de Waal (in review, a) proposed that the degree of consensus among group members about whether an individual can introduce force into social

situations should be quantifiable by measuring the degree of uniformity in the distributions of formal status signals of subordination that are sent and received by group members. It is important to note that this operational definition of consensus is informational not behavioral. Consensus cannot be defined behaviorally because it not a property of individuals, but of groups.

Flack, Krakauer, & de Waal (in review, a) suggested that if the distribution of formal signals of subordination within the dyad tells us that the sender perceives the receiver as capable of successfully using coercion when conflicts of interest arise, the distribution of these signals across the population of senders and receivers should reflect the degree of implicit consensus among group members about whether an individual can introduce force into social situations. Thus, the distribution of agonistic status signals of subordination across individuals confers power in a manner analogous to the election for president in American society: it is the cumulative actions of independent voters that confer power.

The decision to vote for a particular candidate is presumably based on that candidate's perceived capacity to run the country. The number of votes received by one candidate relative to another is thus a measure of this perception. Power is conferred to the candidate who is most widely perceived to have the appropriate skills. An important point to note is that even if a candidate does in fact have the skills to run the country, he or she will not be granted the power of the presidency unless his or her skills are recognized by the populace and acknowledged through votes received. In the case of animal societies, the social power of individual A can be conceptualized as the degree to which group members implicitly agree and acknowledge that they perceive A's coercive potential to be greater than that of B. Status signals of subordination are thus analogous to votes. Flack, Krakauer, and de Waal (in review, a) assessed the legitimacy of the assumption that implicit consensus is measurable using the distribution of candidate formal status signals of subordination, such as the silent-bared teeth display of pigtailed macaques, or the pant-grunt of chimpanzees.

Using data from a socially housed pigtailed macaque (*Macaca nemestrina*) group, Flack, Krakauer, & de Waal (in review, a) evaluated this hypothesis by testing predictions about (1) the distribution of formal status signals of subordination and, (2) the relationship between the distribution of these signals and the rate at which third-parties receive requests for support from conflict participants. They found that individual *i* does not signal with the same frequency to all individuals dominant to it. However, they also found that there was a significant difference in how the set of subordinates signal to individual *j* compared to other dominant individuals, suggesting that subordinates implicitly agree that individual *j* differs from other individuals. This result was interpreted as support for the conclusion that although group members are not entirely in agreement about the degree to which an individual is capable of introducing force into social situations, they are in agreement about the degree to which one individual is better at this than another. This result was supported even after rank distance was controlled.

Moreover, Flack, Krakauer, & de Waal's results indicate that individuals who frequently receive many formal status signals of subordination from many different individuals receive more requests for support from many different individuals than do individuals who receive few signals from few individuals. Thus, conflict participants disproportionately solicit intervention from individuals to whom they also send many formal subordination signals, suggesting that the distribution of status signals is related to the distribution of social power.

Encouraged by these results, Flack, Krakauer, & de Waal (in review, a) developed a mathematical formalization of social power, called the Social Power Index (SPI), which quantifies the amount of social power that each individual in a study population has depending on its distribution of formal status signals of subordination sent and received relative to the distributions of others. This formalization of social power is based partly on information theoretic principles in that it takes into account both the frequency and the 'evenness' or uniformity of the distribution of formal status signals of subordination sent and received in noncontest, peaceful situations. An individual will have a high SPI value if it receives many status signals of subordination from many different individuals relative to others, whereas an individual will have a low SPI value if it receives relatively few signals from a relatively small number of group members. Below we review the operational definition of social power that was used to develop the formalization. The formalization is also briefly reviewed.

7.0 An operational definition of social power

The SPI was developed based on the following assumptions:

- Differences in social power do not exist among individuals who have only egalitarian agonistic relationships. Thus, in such societies, the distribution of social power is concentrated around a single value.
- The distribution of social power in most societies is likely to reflect a mixture of egalitarian, unresolved, and dominance-subordination relationships.
- Differences in social power cannot arise in a population comprised of only two individuals because social power is fundamentally about an individual's perceived capacity for coercion in polyadic situations (Bierstedt, 1950).
- Social power increases for each formalized agonistic relationship in which an individual has dominant status and decreases for each formalized agonistic relationship in which an individual has subordinate status (but see Flack & Krakauer, in review).
- Social power is maximal when an individual has dominant status in all of its agonistic relationships and receives signals of subordination with equal frequency from all other group members. Only one individual per group can have maximum social power.
- Social power is at its minimum when an individual has subordinate status in all of its agonistic relationships and gives more signals of subordination to more group members than any other individual.
- Social power increases as the number of agonistic status signals received increases, and decreases as the number of agonistic status signals given increases (but see Flack & Krakauer, in review).

8.0 The Social Power Index

A detailed explanation of the Social Power Index (SPI) can be found Flack, Krakauer, & de Waal (in review, a). Briefly, the formalization takes into account two factors: (1) **information value**: the overall number of agonistic status signals of subordination an individual receives (r_i^T) and gives (s_i^T) and (2) **information content**: the distribution of these signals across the population, which is measured using Shannon's Information

Index, $H_i(R) = -\sum_{j=1}^N r_{ij} \log r_{ij}$, where r is either the frequency of signals sent or received

(depending on the term) from the i th individual by the j th individual. Information content is then multiplied by information value for the signaling and receiving components to produce the following index: $P_i = \alpha H_i(R) r_i^T + (1 - \alpha) H_i(S) s_i^T$, where the alpha term specifies whether the receiving (R) and signaling (S) terms are weighted equally. It is important to note that P_i is an index of social power. A positive P_i value indicates that group members implicitly agree that an individual can introduce force into a social situation, whereas a negative P_i value indicates that group members implicitly agree that an individual *cannot* introduce force into social situations.

The SPI thus has several major components: the receiving and signaling terms, and within each of those, information content and information value. In Flack, Krakauer & de Waal (in review, a), it was suggested that alpha should be set at 0.5, so that the receiving and signaling terms are weighted equally, unless data are available indicating that one of these processes is more important than the other. However, we have shown that for our group of pigtailed macaques, the most appropriate level of alpha is 1.0 (Flack & Krakauer, in review). We expect that the appropriate level of alpha will vary across species.

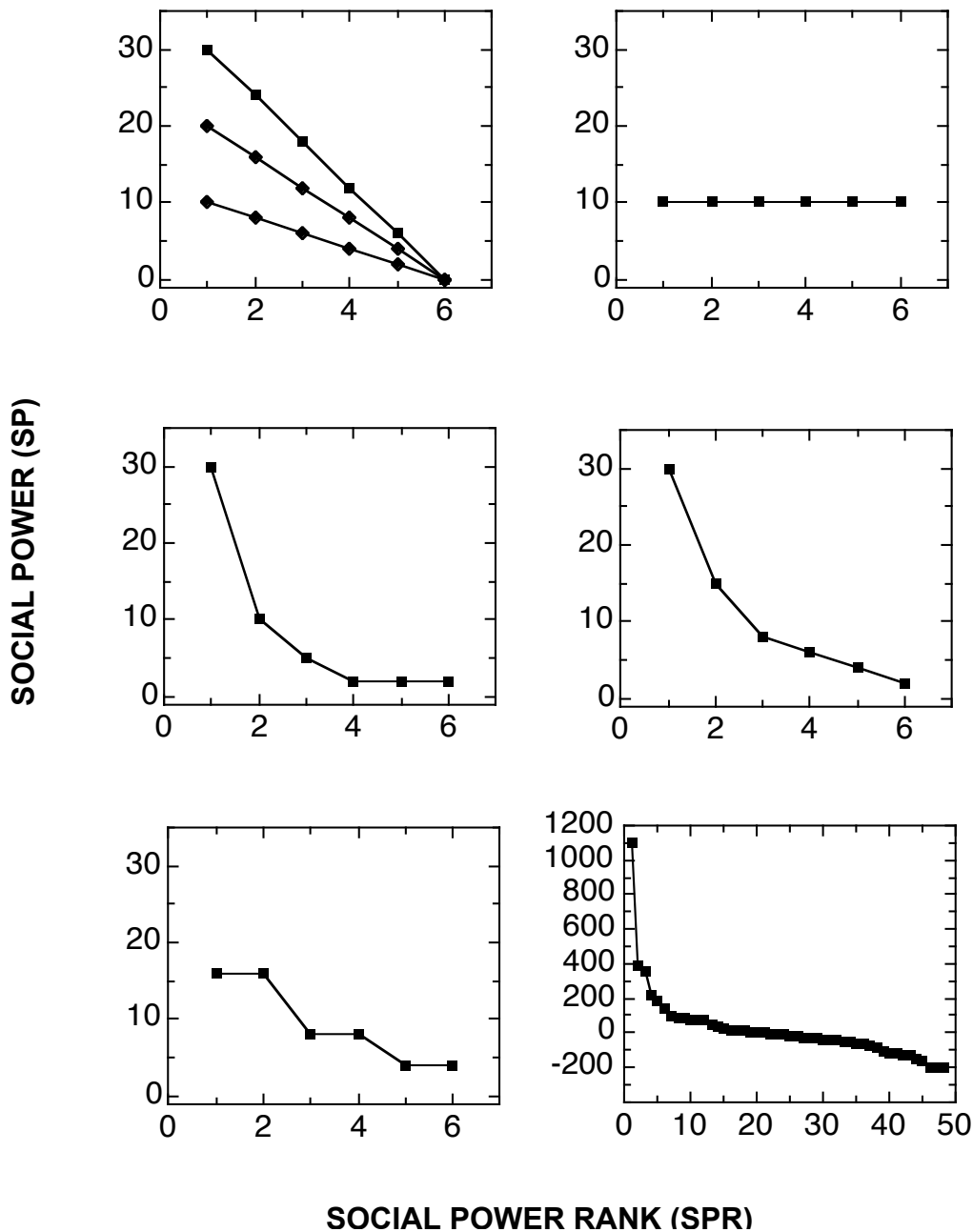
9.0 Hypothetical distributions of social power

We have plotted several different social power functions in Figures 1a-f. In some societies social power might be distributed uniformly, such that it increases by some constant quantity across individuals. Three such distributions, each with a different Social Power by Social Power Rank slope, are shown in Figure 1a. A uniform distribution of social power implicitly underlies most ideas about dominance hierarchies (de Vries, 1998), and probably best characterizes rhesus and Japanese macaque societies. As shown in Figure 1b, social power might also be distributed around a single value such that it is spread more or less evenly over individuals (with the extreme case being a delta function). This distribution of social power might be found in equal outcome or equal opportunity societies (see section 11.0), or in societies in which many individuals have unresolved relationships, as might be the case for some of the Sulawesi macaque species. Although there are no differences in social power in such societies, some individuals might be more influential than others because of non-coercive capabilities such as social knowledge or experience. Shown in Figure 1c is a society in which social power is concentrated largely in a few individuals and distributed more or less evenly over all others, as might be the case for stump-tailed macaques. Figure 1d corresponds to a society in which social power is again concentrated in a few

individuals, but distributed uniformly over the rest. This distribution of social power might be the correct characterization of societies in which some individuals are thought to be “super-dominant” (e.g. Tokuda & Jensen, 1968; Das, 2000). Using the SPI, Flack, Krakauer, & de Waal. (in review, a) determined that the distribution of social power in their pigtailed macaque group was log-normal, such that power was disproportionately concentrated in a few individuals. Figure 1f, which bares considerable similarity to Figure 1c, shows this result. SBT matrix data reported in Preuschoft (1995) suggest that the distribution of social power in longtailed macaques might also be of the type shown in Figure 1c. In Figure 1e, we show a society with a class system. This type of distribution might be found in those macaque species in which different dominance styles have been reported for males and females, such as Barbary macaques (Preuschoft et al., 1998), or it might only apply to human societies.

Both the shape of the underlying distribution and the slope of these graphs are likely to be important causal factors determining the types of conflict management mechanisms that are present in a social system.

Figure 1a-f. The Social Power Index is plotted as a function of Social Power Rank for five hypothetical societies and one real one: (a) a society in which social power is distributed uniformly but hierarchically (three possible slopes are presented), (b) a society in which everyone has more or less the same amount of social power, (c) a society in which power is concentrated in a few individuals and distributed relatively evenly over the rest, (d) a society in which power is concentrated in a few individuals and distributed uniformly but hierarchically over the rest, (e) a society in which there is a class system and, (f) the actual distribution of social power in a captive pigtailed macaque group.



10.0 A test of the index against other potential measures of social power

If the SPI is a good measure of social power then it should predict behavioral patterns that in theory should be functionally linked to the distribution of social power in non-egalitarian societies. Moreover, the SPI should be a better predictor of these variables than other potential measures of social power. To evaluate these hypotheses, the empirical validity of the Social Power Index was tested against other potential measures of social power, including ordinal and cardinal dominance rank indices (Flack, Krakauer, & de Waal, in review, b). The SPI was tested against dominance rank because dominance rank is the traditional measure of social power in studies of animal social organization. As with the SPI, Flack, Krakauer, & de Waal used formal status signals of subordination to determine dominance rank. The difference between the SPI and dominance rank is in the way that each is calculated: The SPI uses ideas from information theory concerning the distribution of signals sent and received to measure consensus, whereas dominance rank is either determined using a statistical procedure to minimize inconsistencies in dominance related behaviors (de Vries, 1998) or using the Boyd & Silk (1983) or Jameson et al (1999) BBS approach for generating a cardinal index (all of which assume transitivity).

Using data gathered from a socially housed pigtailed macaque group, Flack, Krakauer, & de Waal (in review, b) tested the SPI and the cardinal and ordinal dominance indices against three intervention-related dependent variables, which in theory should be causally linked to social power: the frequency with which third-parties receive requests for support, the intensity of aggression *received by* interveners (in response to their interventions), and intensity of aggression *used by* interveners. Flack et al. hypothesized that if an individual is widely perceived to be of greater coercive potential in polyadic agonistic situations than others, that individual should receive more requests for support from conflict participants. That individual should also not need to use much aggression to affect the behavior of others, and should rarely be challenged when intervening. Flack et al. found that the SPI is the most informative predictor of the measures that were tested. As expected, its fit to each of the dependent variables was better than that of either the cardinal or ordinal dominance indices: it explained at least 40% more of the variance. It was also a substantially better multivariate predictor of the set of dependent variables.

11.0 Dominance style and political system type

We have argued throughout this chapter for keeping dominance style, a relationship level concept, separate from political system type, a social system level concept. In Table 1 we introduce five political system types: Hierarchy, Informal Oligarchy, Constrained, Equal Outcome, and Equal Opportunity. We identified these five because they span the range of possible political systems into which nonhuman animal societies, particularly macaque societies, might fall. Many human societies, and perhaps some macaque societies, however, have mixed system types, either because different rules apply to each age-sex class --as is the case in societies in which there are egalitarian relations among men but not among men and women (see Sahlins, 1958; Flanagan, 1989), or because there is a class structure in place in which each class is best

described by a different system (Figure 1e). A mixed system type is possible in those macaque societies in which, for example, males and females have different dominance styles, as has been proposed for Barbary macaques.

We define a hierarchical system as one in which the enforcement of status differences is the primary mechanism by which conflict is controlled. We expect that interventions occur in such systems, but are typically performed against the lower-status conflict opponent and function to opportunistically reinforce the dominance relationship between the intervener and target at low cost. Most researchers who work with macaques probably assume that the hierarchical system best characterizes the style of conflict management typical of their study species. We suspect, however, that in actuality only a few macaque species, including rhesus and Japanese macaques, have such systems.

We have borrowed the term 'oligarchy' from sociology, where it means 'rule by a few.' Here we append the term 'informal' to indicate that there is not necessarily any explicit communication among those who 'rule' in this system. In Michel's (1911) sociological conception, oligarchy describes a system in which the elected come to dominate the electors in order to maintain the status quo. In such systems powerful third parties manage conflicts by policing group members. Effective policing involves conflict management and resolution but not necessarily suppression. We suspect that conflict monitoring becomes more impartial as dominance style moves from tolerant to relaxed. Policing is also sometimes called the 'control role', and it might be related to the big-man / great-man concept in anthropology (Godelier, 1986; Boyd & Richerson, 1992). Policing probably facilitates the development of social bonds between individuals with unresolved relationships. Because our data indicate that social power (SP) in pigtailed society is concentrated in a few individuals, and distributed uniformly over the rest such that SP increases by some constant as social power rank (SPR) increases, it is possible that pigtailed have an oligarchical system. This possibility is also supported by data indicating that the alpha male intervenes using low levels of aggression (Flack & Krakauer, in review), and effectively terminates conflict (Oswald & Erwin, 1977; Tokuda & Jensen, 1968; Flack & de Waal, unpublished data).

A constrained system is one in which power is again concentrated in a few individuals, but is distributed more or less evenly over the remaining group members. The remaining group members are able to form leveling coalitions and alliances that check the behavior of the powerful individuals. Leveling coalitions have been described by Boehm (1993; 1999) and de Waal (1982; 1996) for chimpanzees (we include mention of these results for comparative purposes) and by Preuschoft & van Schaik (2000) for male Barbary macaques. We suggest here that leveling coalitions work best when the subordinates joining forces are relatively similar in social power, because this facilitates the formation of reciprocal relationships. It is not possible to say from available data whether any macaque species are best described by this system. However, this system does seem to be characteristic of chimpanzees (see Boehm, 1999; de Waal, 1982).

An equal outcome system was defined by Flanagan (1989) as one in which there are structural constraints to prevent individual differences in aptitudes from leading to large

differences in resource control. This system might characterize some species of Sulawesi macaques, which have been reported to have a relatively even distribution of social power (see Thierry, 2000). An equal-opportunity system was defined by Flanagan (1989) as one in which all individuals are given equal chance to acquire resources, and any differences in resource control that result are due to individual differences in acquisition strategy. This type of system probably only applies to some human societies.

In Table 1, we sketch what we think is the relationship between dominance style and political system type. Although we do not know how dominance style translates into system type, three factors seems to be important:

- (1) The conflict resolution efficacy (CRE) at the dyadic level given the dominance style. We suspect that the CRE determines whether (a) the agonistic relationship is sufficient as a conflict management mechanism or (b) if dyadic conflict management should shift to polyadic conflict management to maintain social stability. The CRE should be dependent on the degree of mismatch between inherent and expressed asymmetry: when there is little mismatch, such that dominants rarely tolerate subordinates, the CRE at the dyadic level should be quite high, although biased towards the interests of the dominant individual. As the degree of mismatch increases, the CRE should decrease (assuming that expressed asymmetry can never exceed inherent). The CRE should also be high when relationships are unresolved or are egalitarian (i.e. when degree of inherent asymmetry is low or unknown, or when the degree of expressed asymmetry is very low). An operational definition of CRE might be the dyadic frequency of bidirectional aggression for a given dominance style.
- (2) Translation error. We use the term 'translation error' to refer to errors made in formal status signaling, either because an individual has (1) incorrectly assessed its role in its relationship based on its agonistic interaction history or, (2) because it incorrectly makes the decision to signal despite knowing its state (see Flack & Krakauer, in review). Status signaling error can under certain circumstances generate a distribution of social power in which information about the relative coercive potential of individuals in polyadic agonistic situations has been inaccurately encoded. In such cases, individuals are perceived to have more or less social power than they should actually have given their agonistic interaction histories. Thus, when translation error is low, such that individuals make few signaling mistakes, the distribution of social power is likely to correspond correctly to the actual coercive potential of individuals in polyadic agonistic situations.

If senders have the capacity to strategically signal in that they understand the implications of signaling to one individual more frequently than to another, this would facilitate control of dominants by subordinates because subordinates would be able to partially decide in whom power should be concentrated. Because few papers on macaques report raw matrix data on the exchange of SBT's or on the social contexts (i.e. if SBT's are emitted preferentially to one individual over another when both are in proximity to the sender) in which SBT's

are emitted, it is impossible to say whether this capacity is present in any macaque species. Preliminary data do suggest, however, that chimpanzees might have this capacity and do use signals to vote for alpha males (de Waal, 1982; Flack & de Waal, unpublished data).

- (3) The distribution of social power. In systems in which the distribution of social power is coupled to the dominance hierarchy, as is likely to be the case in hierarchical systems, the need for conflict management by third-parties will probably be low. This is because the conflict resolution efficacy at the dyadic level will be high. When interventions do occur, they will either be in favor of kin or against the lower ranking opponent. The latter type of intervention, called polarizing support by Preuschoft & van Schaik (2000), probably functions to opportunistically reinforce the dominance relationship between the third-party and target at low cost. Rhesus macaque intervention data conform to this pattern (Ehardt & Bernstein, 1992).


Polyadic conflict management will probably only occur in systems in which the conflict resolution efficacy of the dyad is reduced. However, the type of polyadic conflict management mechanism that can arise should be constrained by the distribution of social power, which we hypothesize determines for potential interveners the cost-benefit ratio of engaging in conflict management. This is of course based on the assumption that the probability of receiving aggression increases the closer third-parties get to ongoing conflicts, particularly if the third-party approaches aggressively or targets one opponent. The cost-benefit ratio (i.e. likelihood of receiving aggression) of engaging in conflict management should be small for those individuals who have disproportionately more power than other group members. We have shown this to be the case in our study group of pigtailed macaques (Flack & Krakauer, in review). In such systems, policing (impartial monitoring of conflicts by powerful third-parties) should be the primary form of conflict management. On the other hand, when social power is relatively evenly distributed, the cost-benefit ratio of engaging in conflict management will be relatively large for most individuals. In this situation, impartial conflict management by third-parties is unlikely to evolve unless an additional cost is imposed against those individuals who do not punish norm breakers or help resolve disputes. This kind of conflict management has been termed 'meta-policing' by Axelrod (1986). Alternatively, conflict intervention style might switch from aggressive or threatening interventions to peaceful interventions that serve to appease opponents. Peaceful interventions are less likely to provoke aggressive responses from the conflict opponents.

If the distribution of social power does constrain the type of conflict management mechanism that is present in a system, the degree to which the distribution accurately reflects the coercive potential of individuals will be important. When there is a serious mismatch between the observed distribution of social power and the actual coercive potential of individuals, an inappropriate conflict management mechanism might arise. It is unlikely that inappropriate conflict management mechanisms will be sustainable over the long-term because the cost of implementing the mechanism will overtime outweigh

the benefits. This correction process will eventually reveal errors in the signaling distribution. For example, a uniform distribution of social power should not support a policing mechanism because no individual should have enough social power relative to others to make engaging in policing interventions profitable. Moreover, a policing mechanism should not be necessary in such a system, because most conflicts should be resolved using severe unidirectional aggression that reinforces the existing dominance relationships. If, however, status-signaling error leads to a log-normal distribution of social power when the distribution should actually be uniform, a policing mechanism might inappropriately arise. The policing mechanism should not be sustainable in such cases because the mismatch between the coercive capacities that individuals are perceived to have and the capacities that they actually have will probably be revealed in inefficient and potentially costly (to the intervener) interventions.

A final note: It is possible that the type of conflict management mechanism that emerges at the system level will feed back to the relationship level to effect dominance style. For example, if powerful individuals police the conflicts of group members, this might pressure dominant individuals to exert restraint when interacting with subordinates, thereby leading to a more tolerant dominance style, or even a relaxed one.

Table 1. Possible Relationship Between Dominance Style, Distribution of Power, and Conflict Management

Relationship Level		Relationship-System Interface		Social System Level	
Dominance Style & Species Example	Type of Status Signal	Dyadic Conflict Resolution Efficacy (resolution can be 'unfair')	Translation Error (From Relationship Level to System Level)	Distribution of Social Power	Political System Type
Despotic: Large dyadic asymmetries exist and are reinforced through severe aggression; relationships are formalized. Rhesus, Longtailed, Japanese Macaques	FSS	High	If low	Uniform, such that SP increases by some constant as Social Power Rank (SPR) increases (Figure 1a).	<i>Hierarchy: resource allocation is based on SPR, which is largely determined by the number of subordinates one has. Conflict intervention reinforces this system: most intervention is against individuals that fail to act in accordance with their roles in their agonistic relationships, and is typically against the lower-ranking opponent, or in favor of kin.</i>
Tolerant: Large dyadic asymmetries exist, but are reinforced through moderate to mild aggression; many relationships are formalized, some unresolved. Pigtailed, Stumptailed Macaques?	FSS FSD?	Medium	If low	Concentrated in a few individuals and distributed uniformly over the rest, such that SP increases by some constant as SPR increases (Figure 1d).	Informal Oligarchy: some resource allocation by SPR, powerful third-parties manage conflict by policing. Some impartial policing, most in favor of conflict participant with least social power. Other individuals intervene in pattern typical of hierarchical system.
Chimpanzees 	FSS FSD? FSE?	Medium	If low & controllable	Concentrated in a few individuals, other individuals have more or less the same degree of social power. (Figure 1c).	Constrained: maintained through leveling coalitions among less powerful individuals against individuals with high social power, policing by individuals with high social power and some mediation by socially influential individuals. Policing is increasingly impartial or rule-based.
Relaxed: Asymmetries exist in some dyads, and these relationships are formalized, but are reinforced through aggressive displays rather than through aggression. Most relationships are unresolved. Some might be formalized egalitarian ones. Sulawesi macaques?	FSD? FSE?	Low	If low	Temporally stable differences in social power but these are small and subject to low amplitude oscillations (Figure 1b).	Equal Outcome System: maintained by formation of coalitions against individuals who are intolerant of subordinates; and some mediation ¹ by socially influential ² individuals. Can lead to division of labor ⁴ for arbiters, impartial policing to divide resources equally. If institutional roles arise, need for status signaling decreases.
Egalitarian: Dyadic asymmetries are uncommon; most relationships are either unresolved or formalized egalitarian ones. Some human societies	FSE?	Low	If low	No temporally stable differences in social power but high amplitude oscillations can occur, such that individuals temporarily have more power than others (Figure 1b).	Equal Opportunity System: maintained through meta-policing ³ of norm-breakers and retaliation. Can lead to division of labor ⁴ for arbiters / impartial policing to mediate conflicts between coalitions, If institutional roles arise, need for status signaling decreases.

¹Mediation: Mediation has been described by de Waal (1982) in chimpanzees. He noted that some individuals, especially older females, exert influence over others in conflict situations. This ²influence: is non-coercive in nature and presumably based on cognitive empathy, or the ability to take the perspective of others and see how to correct the situation. This ability essentially enables the 'mediator' to be persuasive. Influence based in persuasion has been distinguished from power by Parsons (1963) (see also: Weber, 1947).

³Meta-policing: The term 'meta-policing' has been used by Axelrod (1986) to refer to policing or punishment of non-policers and other norm-breakers. In systems in which there is meta-policing, all individuals are required to police and meta-police.

⁴Division of Labor: In sociology, the division of labor generally refers to individual components of a system performing different, but integrated or complementary tasks in a coordinated fashion. Durkheim (1933) emphasized that the division of labor can increase the solidarity of a society by reducing competition and increasing group-productivity

12.0 Conclusion

This framework now needs to be tested. Although we have begun testing several of its components on pigtailed macaques –namely, the ideas (1) that social power can be measured using the distribution of formal signals of subordination and, (2) that policing is the primary conflict management mechanism in societies in which social power is concentrated in only a few individuals --this work needs to be extended to other macaque species.

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