Action Selection for an Artificial Life Model of Social Behavior in Non-Human Primates

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This abstract describes research into modeling primate social interactions, including some very early pilot results. We are attempting to model the relationship between social intercession behaviors for damping or terminating conflict in a colony, and the social structure of that colony. In our pilot research, have begun to model the interplay of varying motivations, both social and individual.

The Domain: Primate Conflict Management

We are interested in how individuals negotiate their social relationships: how conflict among lower level units (individual group members) is regulated in the formation of higher level units (societies). Although research on non-human primate societies indicates that there are a variety of mechanisms — such as aggression, social tolerance, and avoidance — by which conflict is managed or resolved (de Waal, 2000), it is not well understood how and why the expression of these mechanisms varies across and even within social systems. For example, there is tremendous variation across the macaque genus in terms of how conflict is managed despite similar patterns of social organization (Thierry, 2000; Preuschoft & van Schaik, 2000). Aggression in some species is common and severe while in others, it is extremely frequent but rarely escalates to levels that produce injuries (de Waal & Luttrell, 1989; Thierry, 2000). Corresponding to this variation in the degree to which aggression is employed to settle conflicts of interest is variation in the degree of social tolerance by dominant individuals of subordinate ones, particularly in the context of resource acquisition, and variation in the degree to which relationships damaged by aggression are repaired via reconciliation (de Waal & Luttrell, 1989). Although it appears that this co-variation in conflict management mechanisms varies in predictable ways across species, it does not appear that the co-variation can be explained by ecological factors. Rather, the variation seems to be emergent from patterns of social interaction among individuals, and self-reinforced through social learning.

The importance of social learning on styles of interaction was made clear by the results of a cross-fostering study of two macaque species the individuals of which have drastically different proclivities for aggression and reconciliation (de Waal & Johanowicz, 1993). In this study, juvenile rhesus macaques, which typically live in social systems characterized by high levels of severe aggression and low levels of reconciliation, were cross-fostered with slightly older "tutor" stumptailed macaques, which live typically in social systems characterized by

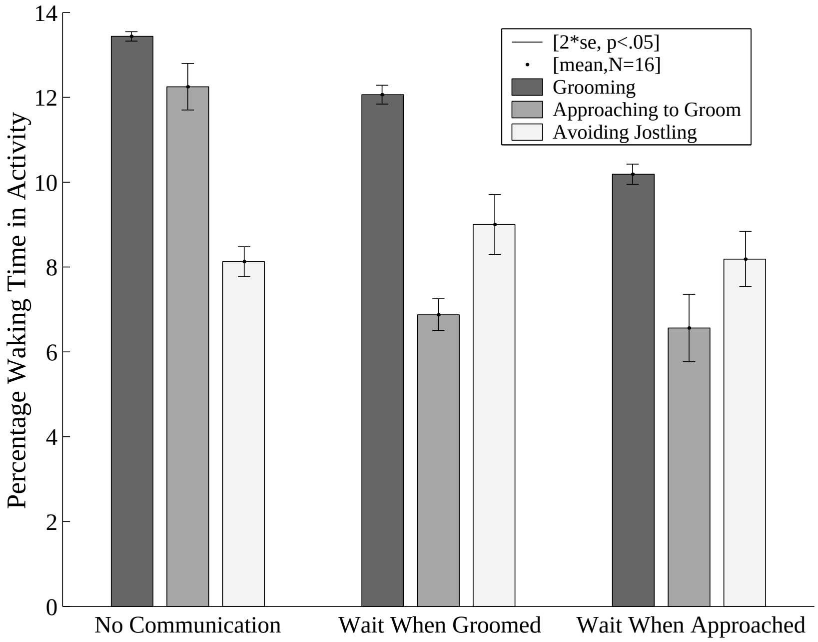

Figure 1: Results showing the impact of adding the simple social behavior of *tolerance* to facilitate grooming. In the first condition there is no tolerance, in the second agents tolerate active grooming, in the third they facilitate when being approached.

high levels of mild aggression and high levels of reconciliation. Over the course of the study, the rhesus monkeys learned to reconcile more frequently and adopted the stumptailed style of interaction, and even retained this pattern after all stumptail tutors were removed.

Action Selection and Competing Motivations

We intend to test this hypothesis by exploring the space of possible social organizations using artificial life (ALife) simulations, then testing predictions from these models by experimenting with the behavior of real primate colonies given extended periods of absence or presence of individuals who express particular social behaviors. When modeling behavior of any sort in a complex, at least partially embodied agent (e.g. artificial life or virtual reality), one must consider the problem of action selection. Action selection is the ongoing problem for an autonomous agent of deciding what to do next. Early research in artificial intelligence (AI) attempted to solve this problem via *constructive planning* — taking time to create reasoned plans. This proved combinatorially intractable and the solutions fragile.

One demonstrated solution to problems of complexity and robustness is to decompose intelligence into a set of specialized modules, each relatively simple and reliable. Although modular theories of intelligence are currently popular in both AI and Psychology, they have the disadvantage of that they make it harder to explain the amount of coherence that *does* exist in an animal.

To develop our simulations we are using Behavior Oriented Design (BOD) (Bryson & Stein, 2001a). BOD can be used to develop a modular architecture which provisions for behavior coherence made through a system of specialized action selection. When more than one behavior competes for a limited resource, arbitration is performed using structured predetermined patterns of prioritization. These structures, called *reactive plans*, take into account perception of both external events and internal motivation levels. Although action selection arbitrates between behavior modules, it is these modules which determine the precise expression of action, and perform the perception that guides both the action and the arbitration. This model is neurologically plausible (Bryson & Stein, 2001b).

Pilot Results

We have successfully adapted BOD to operate in on multiple agents. These are currently rectangular 2-D agents with extent living in a walled, rectangular enclosure. The results in Figure 1 reflect 11,000 observations in each of three different conditions with 16 homogeneous agents in three conditions (see figure caption.) The fact that the agents must deal with walls and bodies provides at least a minimal level of embodiment relevant to social modeling. For example, grooming requires being adjacent to and properly aligned with an agent, while other activities require greater regions of personal space. This latter problem motivates the activity *avoid jostling* also graphed in the figure. This activity serves no consummatory goal directly, but is rather a part of navigation in a social environment.

In conditions 2 and 3, the behavior *tolerance* has been added to the repertoire of agents who otherwise alternate between grooming neighbors or wandering (feeding) in relative isolation. Grooming is the only behavior graphed with an endogenous motivation: the agents would prefer to spend 14 percent of their time grooming. In condition 2, tolerance is triggered by being groomed, in condition 3 it is triggered by being approached for grooming.

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