A-KinGDom Program: Agent-Based Models for the Emergence of Social Organization in Primates

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Abstract

Social organization in primate societies is a complex and self-organized phenomenon that integrates kinship, competition and cooperation behaviors, and which can be explained using simple rules according to the adaptive behavior approach. Although it is not currently a common approach in Primatology, some incipient agent-based simulations have been used in order to study the emergence patterns of social organization in primates. Hemelrijk [1] presented an agent-based model, called DomWorld, where dominance interactions (i.e., dyadic agonist encounters between two agents) determines both the dominance hierarchy and the spatial distribution of group members observed in macaque societies. More recently, and based on the co-variation hypothesis [2], Puga-González et al. [3] developed GrooFiWorld, an agent-based model that is an extension of DomWorld and includes agonistic and affiliative behaviors in order to reproduce the emergence of patterns of social organization observed in macaque societies.

Dolado & Beltran [4] obtained data from observation of a captive group of *Cercocebus torquatus* (a species that is phylogenetically close to macaques) and compared them with data from GrooFiWorld agent-based simulations [3]. The results suggested that, although the GrooFiWorld model can be used as a starting point to study the flexibility observed in behavior patterns in macaques and close species, some other parameters should be taken into account in order to determine the emergence patterns of social organization in primates. A good candidate to include as a factor in GrooFiWorld model is kinship. Many studies have identified kinship (i.e., the genetic relationship among group members) as a factor that can account for certain individual differences in aggressive and affiliative patterns observed among members of the same group [5]. Moreover, the females of the macaques, baboons or mangabeys remain in their natal groups and spend much time in contact with their relatives searching for food, in grooming sessions or by taking care of offspring. Therefore, including kinship in a model of social organization may modify the durations and frequencies of affiliative interactions in the group [6] and contribute to achieve a better fit of the model.

We have developed an agent-based program called A-KinGDom, which is written in C and Delphi and Open GL, and runs in Windows. The program implements DomWorld [1] and GrooFiWorld [3] models, plus a new KinWorld model that is an extension of GrooFiWorld which includes the kinship factor in order to modulate affiliatives interactions. The simultaneous application of dyadic interaction rules for all agents in the current model allows us to simulate the emergence of patterns of social organization in a group of primates. The KinWorld model includes dominance and affiliatives interactions, as well as kinship relations between agents (see Figure 1). According to the DomWorld and GrooFi World models, whenever an agent does not perceive any other agent within its personal distance, grouping rules come into effect. However, if one agent enters the personal distance of another, a social interaction may or may not take place. When two agents meet, one of them decides whether or not to engage in either a dominance or an affiliative interaction. Then, if an agent expects to win, dominance interaction takes place: if the agent's current dominance value is greater than a random value, it wins the interaction. If its dominance value is lower, it loses. An agent only considers grooming its partner if it expects to be defeated. Grooming behavior is modeled according to the level of *anxiety:* when the agent's *anxiety* value is greater than a random value, the agent grooms its partner; otherwise, the agent displays non-aggressive proximity without interacting socially with the other agent. In the KinWorld model, kinship is defined as $kinfactor=1+r^2$, where r is the coefficient of relatedness or the level of consanguinity between two given

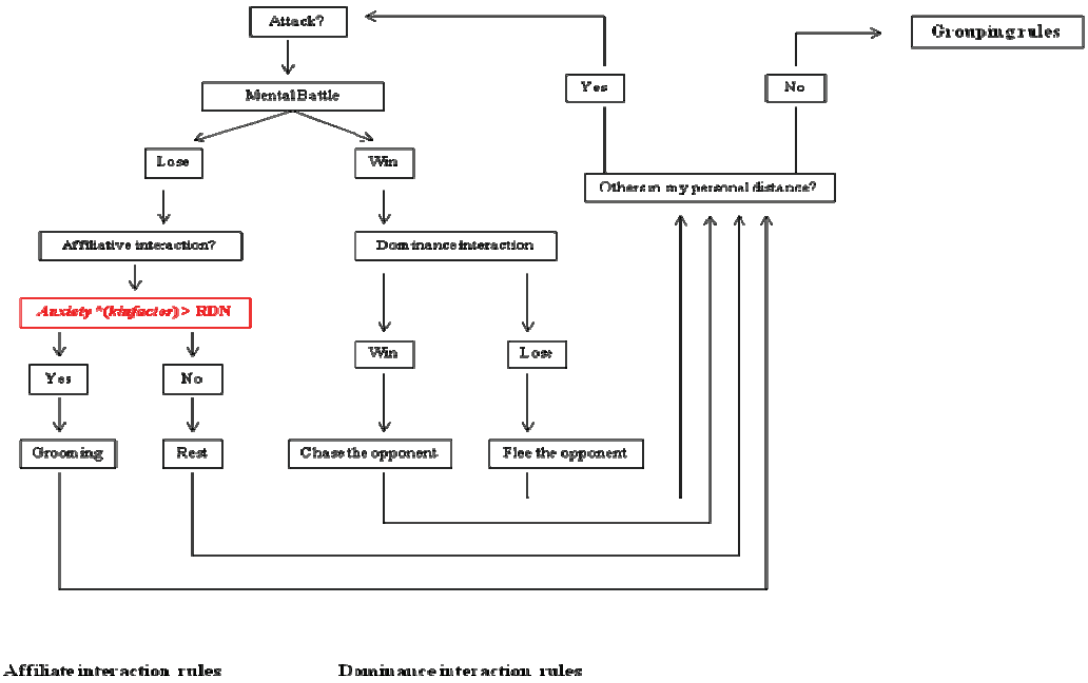

Figure 1. Social interactions according to the KinWorld model.

agents; *kinfactor* multiplies *anxiety,* thus increasing the likelihood of executing an affiliative interaction between two agents that have a close kinship.

In this study we also present results from a set of simulations comparing the GrooFiWorld and KinWorld models, and analyze how they fit with data obtained from a captive group of seven individuals of *Cercocebus torquatus* [4]. As expected, data obtained when the KinWorld model is simulated provide a better fit.

The agent-based models implemented in A-KinGDom program can be adapted to different biological conditions in order to compare results in different groups and species of primates. A-KinGDom simulations provide data that characterize the main quantitative measurements of social organization (i.e., gradient of hierarchy, undirectionality of aggression, grooming reciprocation or grooming up the hierarchy), which can be compared with empirical data. The comparison provides evidence for the plausibility of the KinWorld model and is useful for making predictions about patterns of the social organization in other groups of the subfamily Cercopithecinae (i.e., macaques, baboons or mangabeys).

Keywords. Agent-Based Models, Social Structure, Primates.

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