The Social Organization of the Domestic Dog; A Longitudinal Study of Domestic Canine Behavior and the Ontogeny of Canine Social Systems

Abstract

The theory that a hierarchy based on dominance relationships is the organizing principle in social groups of the sort *canis lupus* is a human projection that needs replacing. Furthermore, the model has unjustifiably been transferred from its original place in the discussion of the behavior of wolves to the discussion of the behavior of domestic dogs (*canis familiaris*). This paper presents a new, more adequate model of how *familiaris* organizes itself when in groups. This paper is based on a longitudinal study of a permanent group of five randomly acquired dogs living in their natural habitat, as they interact with each other within the group, with newcomers of various species who joined the group, and with fleetingly met individuals of various species in their outside environment. This study shows that the existence of the phenomenon "dominance" is questionable, but that in any case "dominance" does not operate as a principle in the social organization of domestic dogs. Dominance hierarchies do not exist and are in fact impossible to construct without entering the realm of human projection and fantasy. The hypotheses were tested by repeatedly starting systems at chaos and observing whether the model predicted the evolution of each new system. The study shows that domestic canine social groups must be viewed as complex autopoietic systems, whose primary systemic behavior is to gravitate as quickly as possible to a stable division of the fitness landscape so that each animal present is sitting on a fitness hill unchallenged by other group members. Aggression is not used in the division of the fitness landscape. It is not possible for an observer to measure the height of respective hills. There is no hierarchy between or among the animals. The organization of the system is based on binary relationships, which are converted by the agents as quickly as possible from competitive to complementary or cooperative binaries, through the creation of domains of consensus. The production processes by which this is done are twofold. The first is an elegant and clear, but learned, system of communicative gestures which enables the animals to orient themselves adequately to each other and emit appropriate responses in order to maintain or restore the stability of their fitness hills and the larger social landscape. The second is learning. It is the learning history of each animal, which determines how adequately the animal can operate within the system and what the components of its individual fitness hill will be, and which, in the end, is more crucial to the animal's survival than even presumed genetic factors or some human-constructed "dominance" position.

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Introduction

The theory of a linear hierarchy based on dominance relations, originally developed from observations of ants, was one of the first models used in ethology to describe or account for the behavior and the social structure of wolves and the groups they live in (Mech 1995, 2000; Sax 1997). The dominance hierarchy model was adopted by others to explain the behavior of *canis familiaris,* and is still broadly in use today among both scientists and laymen who deal with domestic canine behavior.

This model as applied to wolves was from the beginning, based on dubious evidence (Mech 2000). Furthermore, it has been shown that throughout history humans have modeled the animal kingdom in ways analogous to the societies humans themselves were living in (Dahles 1993; Darnton 1985; Evans 1994), and that perceptions of scientists are influenced by their belief systems and the need to protect various kinds of investment (Kuhn 1962; Pernick 1985; Phillips 1993; Rollin 1989). The dominance hierarchy model was developed in a period in which many human societies were struggling with authoritarian forms of government and the culture and ideologies that form of government propagated (Deichmann 1996; Sax 1997). Its spread continued in a post-war world in which a competitive market economy and its ideologies, based on a selective and flawed interpretation of Darwin's theory of natural selection, shaped a new generation of humans' perceptions of natural reality. A final factor is that the model was developed in a period in which there were very few women involved in scientific research. This means that a limited group of existential repertoires and paradigms was used as background in the search for explanations of observed animal behavior. For example, it is now widely known that human males and females differ from a very early age, with males displaying largely competitive behavior in groups even before they develop verbal skills, while females tend at the same age to show cooperative and appeasing strategies in dealing with group membership. This raises the question of whether observations were not biased in advance toward perceiving mostly the competitive elements of any observed social system. It is also a widely investigated psychological fact that the first thing human males do when two or more of them have to share a physical space is investigate and order their relative power relations within the (fleeting) group. The conclusion that dogs are equally preoccupied with establishing “dominance” in their social interactions is most likely a failure of imagination. Unable to conceive of any other way of organizing a group, scientists seem to have projected their own existential paradigm onto the animals they were observing. Secondly, most of the legal and illegal violence in human societies is committed by males. This raises the question of a third observer bias, namely the possible tendency to give more weight than is really justified to seemingly violent encounters between observed animals, and thus the model's focus on what it calls aggression. Finally, it has also been shown that women make the scientific effort in a different way from men, less career oriented, more interested in fundamentally sound and thorough research (Kollantaj 1982; Holton 1998; Sonnert 1998a, b). This, combined with the proven tendency of humans, including scientists, to impose their own existential paradigms in modeling the world around them, suggests that the model contains, besides a cultural bias, a gender bias in its perceptions and models of the behavior of other species as well as the methods by which models are developed.

The use of statistical analysis to prove the existence of and unravel dominance hierarchies does not provide a solution to any of the above mentioned biases. These analyses begin based on definitions derived from the dominance hierarchy model, counting only behaviors that already fit the model, and are therefore unable to do anything but recirculate and affirm the model on which they are based. A reanalysis of data often shows no hierarchy, or a different hierarchy emerging when group members are isolated and then reassembled in the same group; shifting patterns over time remain unpredictable (Dickey 2002; Dickey *et al* 2002a; Mesterton-Gibbons 1999). Patterns found also shift when delineations of behavior to be counted are changed (e.g. resource holding rather than "wins" in exclusively aggressive agonistic conflicts). The definitions themselves have been sloppy. What is a "win"? What is a resource? How are resources designated as such, and by whom? This point has been missed, and this hiatus seems to have led to a search for other, presumably better, statistical approaches. However, the measure of a "better" statistical approach again derives from the model itself, since a "good" technique is one that turns out to predict dominance relations as perceived and defined by researchers (e.g., Dickey, *et al* 2002b). Where no stable hierarchy is found, the statistical method and not the model itself is presumed to have failed.

In addition to this closed loop problem, superstition seems to play a role in the use of statistical analysis. Experimenters use statistics to assert that results obtained and conclusions drawn from observing a group of ten to forty animals have the same validity as a wide population study would. Even where the groups observed are larger, the animals are treated as static beings living in some permanent observable state. The statistical approach seems intended to sidestep instead of facing the complex problem of the individual learning histories of the organisms studied in order to draw broad conclusions from small group studies. However, the ability to learn is such a critical part of the manifestation of life in vertebrates that any study which tries to exclude the effects of this ability invalidates itself *a priori* as relevant to understanding the life of these organisms. A second superstition is that pulling data through a statistical program will, all by itself, solve the problem that the observer is inevitably interpreting what s/he sees (see below: The super-observer).

But it was, in the first place, not correct to apply a model developed watching wolves to the behavior of domestic dogs. Though it has become clear that domestic dogs share a common ancestor with the wolf, the genetic similarity is a weak basis for assuming that models derived from the studies of wolves are applicable to the behavior of domestic dogs or adequate to understand, explain or predict the behavior of the latter. It is clear that wolves and domestic dogs have occupied strongly differing natural habitats at least since the human agricultural revolution and probably long before that. Therefore, factors relevant to the survival of both individuals and the species themselves will strongly differ. In light of this, it seems reasonable to propose that the behavior of wolves and domestic dogs may differ as much as the behavior of chimpanzees and humans do. Furthermore, the relationship between genotype and phenotype is not well understood, let alone the role the genotype plays in determining discrete behaviors of an organism during the course of its life. Finally, selection operates on phenotypes, not on genotypes. Thus, we must at least for the moment assume that the observation of phenotypes and their behavioral ontology in the course of their lives in the particular environment they inhabit is critical in understanding any species. The dominance hierarchy model and many conclusions about wolf behavior have nevertheless been transferred to domestic dogs. At the same time, domestic dogs, like wolves, have rarely been studied in their natural habitat. In fact, the domestic dog's natural habitat is near or among humans and all the species humans live with, yet most studies take place in laboratories or in animal shelters, and none encompass the entire life-span of multiple animals in their natural habitat.

The transfer of the dominance hierarchy model as it has been derived from observations of wolves to domestic dogs, and attempts to preserve the model in the face of all contradictory evidence, have led to the model becoming an inelegant chaos in its new application, one full of contorted appendages and internal contradictions. To name a few:

- Dogs are, like other domestic animals, described as neotenic. The fact that wolf pups do not organize themselves around a leader is then difficult to reconcile with the assertion that domestic dogs do.
- It has, for example, been shown that domestic dogs exhibit different play behavior when interacting with humans as opposed to conspecifics (Rooney 2000), yet the assumption is still made throughout the literature that a domestic dog sees its human owner as some sort of dog which it will try to “dominate”. This ignores the fact that domestic dogs are able to organize their social groups to include other species despite vast differences between the species involved, and does not address the question of how they do that.
- The fact that most social conflict does not involve the presumably dominant animal, and that in fact a presumably dominant domestic dog often will defer to a presumably subordinate domestic dog in a conflict, has led to the hypothesis that “dominance” (also referred to as a “high rank” in the “dominance hierarchy”) brings some sort of zen tolerance with it. This ignores the dominance hierarchy model's own designation of the “dominant” animal as, by definition, the animal that can most use aggression with impunity and/or the animal that "wins" the most aggressive encounters. In an effort to solve this problem without abandoning the model, some researchers have shifted the definition of dominance to mean the animal most successful in resource holding. What is meant by "success" has never been satisfactorily defined, partly because what is meant by "resources" has been too narrowly limited and too observer dependent.
- Wolves spend most of their lives in stable family groups which normally do not incorporate outsiders (Mech 1995, 2000). Domestic dogs form loose, temporary groups (Beck 1973, 1975; Rubin 1982; Scott 1973) and/or interact fleetingly with each other during outings with a human caretaker. It seems ridiculous to talk about a linear dominance hierarchy in such a group of dogs, the composition of which may change from minute to minute as the dogs interact on a city field, since rank, which is a statistical construct, can only have meaning within in a group that stays together long enough for a statistical pattern to emerge.
- This construct has been reified. It assumed that when two dogs meet and execute the ritual greeting and “bluffing” ceremony, they are establishing "rank" with respect to one another. It is furthermore assumed that the animals themselves have some sort of consciousness of their respective ranks as such (Askew 1996; Overall 1997, 2002; Voith 1982; Voith & Borchelt 1982; Borchelt & Voith 1996; Fisher 1998, 1991; Neville 1993; Trumler 1972; Lorenz 1995), despite the fact that there is still much dispute regarding the possibility of cognitive content in animal consciousness. This assumption is probably another attempt to salvage the model, which, as it is applied to domestic dogs, can only be maintained if various assumptions are made about consciousness in the species and the contents of that consciousness.
- The treatment of domestic dogs with presumably dominant aggression problems is always based on the principles of respondent and operant conditioning (Askew 1996; Overall 1997, 2002; Voith 1982; Voith & Borchelt 1982; Borchelt & Voith 1996) and often includes the use of anxiolytic medication (Overall 1997, 2002; Borchelt & Voith 1996). Yet the causes of this aggression are still sought in presumably instinctive behavior as dictated by the dominance hierarchy model and the owner's failure to establish "dominance" over the dog (Askew 1996; Overall 1997, 2002; Voith 1982; Voith & Borchelt 1982; Borchelt & Voith 1996). The contradiction arises that high status is presumed to

create the self-assurance and tolerant calm needed to explain the lack of aggression in a "high ranking" animal, yet a dog whose aggressive behavior requires the use anxiolytics is also diagnosed as "dominant aggressive", i.e., that the animal perceives its “rank” as high with respect to humans.

- The dominance hierarchy model violates the rules of parsimony. No broad, comparative study has been done, for example, comparing the incidence of "dominant" aggression between domestic dogs raised and trained using positive reinforcement and those raised and trained using negative reinforcement and punishment techniques designed to elicit avoidance behavior. This should have been done before behavior was attributed to an internal, inherited need to operate within a “dominance hierarchy”, presuming the animal is thinking about "rank" in its interactions with humans, etc.
- Statistical analysis has shown that food guarding behavior in domestic dogs correlates with the development of "dominant" behavior toward humans (Overall 1997). Thus, it is assumed that food guarding is an early sign of a "dominant personality" in a dog (Overall 1997). In fact, this correlation is a result of operant conditioning. In guarding food, aggression may be reinforced by the other (human) animal's withdrawing to a greater distance. The reinforced behavior emancipates itself and, reinforced in other situations, becomes a generalized behavior. This is an example of the way in which statistical analysis can produce trivial information and serve to mask rather than reveal the mechanisms which are, in fact, operating. It is also an example of how a model, once adopted as a persistent belief, can act as a filter distorting perceptions to the point that observations lose all value and enter the realm of fantasy.

These are just a few examples of the problems that arise when an attempt is made to understand domestic canine behavior and social structure by applying the dominance hierarchy model to domestic dogs. In short, the model creates more conceptual and practical problems than it solves, forces its users into the realm of fantasy and projection, and has required the addition of inelegant appendages and various contortions of thought – yet the problems and contradictions remain. I assert that the only thing we can do with this model is discard it. Dogs are neither wolves nor male humans. If you want to know about dogs, you must observe dogs, not wolves. Not only that, but you must also study the animals in their natural habitat (near or among humans and all the species humans live with), and your study must encompass at least one entire life-span of multiple animals in their natural habitat. This paper is the result of exactly such a study.

In this paper I present a model based on non-linear dynamics and work on self-organizing autopoietic systems as these theories have been developed to deal with systems in which competition takes place. L. David Mech has already presented a model in which he describes wolves as role-oriented rather than dominance- or status-oriented (Mech 2000). I will contend that this model is also relevant to *canis familiaris.* Mech’s model describes, however, only one of several mechanisms for part production in a larger, autopoietic system, since domestic dogs, unlike wolves, live in two essentially different types of group during their lives: family groups and stranger groups. This autopoietic system and its parts gravitate toward stability and predictability, choosing at any given moment between multiple optima in the fitness landscape. The learning history of each animal is essential to the emergence and successful operation of the social system. This model is adequate to explain all observed interactions of *canis familiaris*, with conspecifics and with other species. I will also describe the mechanism by which discrete events on the ground generate a social structure and by which they lead to predictability in the social behavior and interactions of individual dogs within their social environment.

Theoretical framework

Complex self organizing systems and autopoiesis

In order to deal with the complex interaction of multiple variables at many levels or organization simultaneously, I refer to theories about complex self-organizing systems (Beckerman 1999; Lucas 2002 a&b), and to H.R. Maturana and V. Varela’s work on autopoietic systems (Maturana 1975; Maturana & Varela 1980; Varela 1981). A brief review follows here. Those who are not familiar with these scientific paradigms can click on the title of this section to get to a page in which extensive explanation is given.

When we look at a dog, what we are really observing is a creature that is a discrete and complex living system in itself, composed of many smaller systems (e.g., cells and their cellular organs, tissues, organs such as brain and heart). All of these smaller systems have an effect on the behavior of the whole that we are observing under the name “dog”. A dog’s perceptions and reactions will vary according to what we call its inner state, depending on all kinds of ever changing factors within its own internal system. The balance is always shifting, and a dog will be juggling many internal variables as it tries to maintain some kind of equilibrium inside itself as a system. At the same time, this system we call “dog” is situated in an external environment. Events in the external world can trigger changes inside the dog as a system. The dog will try to restore some kind of internal equilibrium, but as it does this it will have to take the outside world into account. External factors may limit the choices a dog has. Interaction with the external world is not a one way street: the dog’s behavior will, in many cases, trigger a change in the outside world: output returns to the dog as input. As a dog seeks internal balance, it will often simultaneously have to control how its output affects the external world and find ways not to disturb an equilibrium in parts of that external world. Thus, behavior is not a result of static traits, but of a complex interaction of internal and external variables and processes, and of several levels of organization changing and having to be managed all at the same time. In other words, in studying the organism called “dog”, we are focusing on only one level of organization in a multi-level system, while the dog deals with all those levels at once. All these levels of organization affect and are constantly being affected by all other levels (cellular<-> organic <-> dog <-> social system <-> habitat). While changes at one level neither cause nor specify the changes at another level, they constitute perturbation on other levels; the system may, at any level, seek a new attractor to accommodate the change. A description of any one level of a system (e.g., the dog) must try to find and include at least the *relevant* perturbations that originate at other levels (e.g., a social system) as the organism attempts to juggle optimization on various levels simultaneously.

In order to understand how this works, we must first clarify a number of theoretical terms as they are used in reference to complex self-organizing systems.

In this context, “fitness” has a different meaning than in the theory of evolution. “Fitness” refers only to criteria contained inside the system we are talking about. A fitness landscape is a distribution of optima the system can choose from: we call these optima “fitness hills”. These are positions in the system’s state space that result in best meeting criteria internal to the system (in this case, the dog), given the options available at a particular moment. Moving between these optima (or fitness hills) involves the balancing of many variables and is relevant to a current niche rather than to any imposed static function or criterion. There may be several more or less equally preferable optima available at any one time, again depending on the combination of conditions prevailing at that moment. The system itself constrains the options available and chooses between them referring only to internal factors; fitness is determined with respect to internal criteria. In complexity theory, fitness can include factors affecting the “quality of life” as perceived by the organism. Where an animal can’t optimize all factors at once since they affect each other, a compromise between factors may be the best route to the best *practically* possible solution: this is epistasis (Lucas 2002c).

“Selection” refers to the system choosing between equilibriums in reference to external factors. Selection may then operate on various self-organizing systems according to their emerging phenotypic states (Lucas 2002b). External selection pressure operates as a force on the system to perturb it to migrate to a different attractor, but it does not determine how the system, once perturbed, will behave, nor which attractor will be chosen. The system will move through its state space referring to internal rules and according to internal processes. Although a self-organizing system refers to internal processes and rules, the system may relate to its environment and must move within that environment. This is always the case with living organisms. This is called situated self-organization (Lucas 2002b). The internal structure of a system may become coupled to relevant features of that environment. This is structural coupling. In a system that is structurally coupled with its environment, perturbations can come from within the system or from outside the system. The environment becomes a factor in selecting which of the attractors available to the system will be chosen at a given moment, although the choices are still made according to internal rules and constraints. Structural coupling can operate at various levels. In systems in which the parts are living organisms, it can operate on the level of the organism as a system in itself. Structural coupling can also operate on the level of the behaving, whole organism; it can operate on the level of a larger system of which the parts are themselves living systems.

A self-organizing system consists of parts that may themselves be autopoietic systems. The parts are non-equivalent and may obey different laws. System parts can be interconnected in various ways. An interconnection means that system parts are positioned in space and time in such a way that a transfer of energy, matter or signals takes place. A signal is defined here as any change in or output from one part of a system that would allow other parts of the system to change their orientation or output in an interaction. Interactions between these parts refers to the influences parts have on each other due to their interconnections. This influence can trigger a change in one or both parts’ internal state, and a signal or perturbation can percolate in some way to other parts. Interactions between the system’s parts must be net positive sum to be sustainable (Lucas 2002b).

A final note: the author uses the term “binary” to indicate a pair of interacting organisms, whether the interaction is fleeting or results in a two-part system that continues to exist over a long period of time. The term is common in the literature concerning self-organizing systems. The word “dyad” is specifically rejected due to the unavoidably observer-dependent definition of what a “significant” sociological relationship would be.

Learning

Each dog has an internal fitness landscape, a sort of map of all the possible system states, some of which provide more opportunity for success than others with respect to various parameters and system functions. This fitness landscape shows the rating of each option in terms of some attribute or achievement that pertains to the system's optimal condition according to its own internal criteria. Higher hills represent preferred states and lower hills the less preferred states. An organism or any other system will migrate between fitness hills, trying to optimize its position on this fitness landscape. In this paper we are dealing with organisms capable of learning. This means that on the level of the organism, the fitness landscape and the migration across it will be affected by the dog's history. This history will play a role in the animal's mapping of the heights of various fitness hills, and in determining the choice whether or not to attempt an adaptive walk to a higher peak, the tactics an animal will use to achieve this migration, and the routes it may choose from. If it does decide to migrate, a dog must have a plan. A plan is any attempt to predetermine the trajectory of an adaptive walk across the fitness landscape. This involves predictions about the animal's own actions, about the actions of others in the system, as well as how these actions will affect the landscape and the system as a whole. Lack of precise knowledge of starting conditions, input and/or other agents in the system can be responsible for lack of precision in predictions. New information may effect the plan and the trajectory, as well as changing the fitness landscape. Beliefs (in behavioristic terms: learned associations, conclusions about prevailing contingencies, superstitious learning) can also effect strategy. (Beckerman 1991, *passim*) Thus, a dog’s movement within its state space is a result of learning as an ongoing production process.

In a complex self-maintaining systems at points of instability and at points far from equilibrium, new forms of order are generated, which lead to higher levels of organization and increased diversity (Capra, 1996). The system moves away from chaos and towards one (or more) attractor(s). The processes which lead complex systems to and from various stable states, or provide for maintenance of self-maintaining systems and their parts, are called production processes. These can be purely mechanical, chemical or physical, involving the movement of matter, energy or information, or can, in the case of living organisms include mental processes such as self-generated thoughts, perception, learning and cognition. Learning is a critical production process in the autopoietic system “dog”. A domestic dog is a complex, self-organizing, structurally plastic system. Learning is a production process by which the structure of the animal as a system changes through time (e.g., changes in brain structure and the organization of electrical patterns within in the brain, in available internal representations of the environment, in metabolism, in behavior of both subsystems within the dog and of the dog as a whole system). This affects both the animal’s ability to maintain itself as a living system and its ability to conceive plans that enable it to participate in the organization at the next level, the social system. A number of learning processes are well understood. Before we engage in superstitious behavior and posit some mysterious internal property (e.g., “dominance”) of the animal as a cause of behavior, we should make a rigorous attempt to understand what learning process and contingencies could result in behavior we observe. In fact, these learning processes are adequate to explain and predict many changes that take place over time in an organism as a system and in its relation to its environment. Learning is also included in the model presented in this paper as a crucial production process in the larger social systems domestic dogs occupy. It is through learning that these systems are generated and structured. This inclusion of learning allows us to model dogs’ behavior and the organization of their social systems without making any presumptions about genetic determination of their discrete behaviors, about the content of their consciousness or about how dogs learn beyond those processes that behaviorists have unraveled, yet without excluding the possibility of cognitive processes which may in time be proven to take place.

Although the various aspects of consciousness and cognition in animals are still being researched, it is sufficient here to include only discoveries made by Pavlov, Skinner and Sidman and some of the insights further experimental research has provided based on their work (Skinner 1938, 1953, 1969; Sidman 1989). In particular the following behavioral phenomena have been mistakenly interpreted as “dominant” and/or “submissive” behavior in domestic dogs: spontaneous recovery, the extinction burst, extinction aggression (Azrin *et al* 1966; Kelly & Hake 1970; Hutchinson *et al* 1968), learned aggression (Baisinger & Roberts 1972; Powell *et al* 1972), avoidance behavior (Sidman 1989), behavior produced by a variable reinforcement schedule (Skinner 1938), behavioral depression (Sidman 1989), and superstitious behavior (Skinner 1938, 1953, 1969; Sidman 1989). Though an internal change may operate as a perturbation that triggers movement of the dog as a system within its state space, it is learning that will determine which behavioral choices the dogs perceives as available, its valuation of the various choices and outcomes, and the strategies the dog perceives as available for moving along a certain trajectory. In other words, it is learning that determines which path a particular dog moves upon as it seeks a new internal equilibrium in response to a perturbation. Not only do the concepts of “dominance” and “submission” assume that the contents of a dog’s consciousness are similar to the contents of human consciousness, they are also unparsimonious and inelegant, and are entirely superfluous in explaining the behavior of the domestic dog. Respondent and operant conditioning are sufficient to explain the behavioral responses on the organizational level of the system called “dog”, and to explain the emergence and maintenance of a larger canine social system.

Competition

At the level of the social group, we are dealing with discrete living systems that are parts in one or more larger systems consisting of one or more other animals. Not only will each individual animal's actions change its own fitness landscape, but it will also affect the fitness landscapes of other agents in any larger system it is part of. This means that competition between animals may occur, since no two dogs can have the same ball or eat the same bit of food simultaneously. In a competitive situation, stability can be described as a state where each agent is better off just sitting on its present attractor so long as the other does, or others do, the same (Kauffman 1996; Beckerman 1999). In this case, stability also means resistance to change. Each agent will prefer to stay where it is, neither improving its position nor allowing it to deteriorate. Each agent may, if necessary, somehow defend or try to preserve its position on its own fitness landscape in the face of perturbation. But the animals are also participants in a single larger system together, and they are all structurally plastic. If the agents in a system selfishly optimize their position on the fitness landscape with little regard for other units, their lack of coordination will result in a wildly fluctuating, uncoordinated fitness landscape for the group as a whole (Beckerman 1999). This means that organisms that are part of a system may choose stability of the system they occupy or some other form of epistasis above the maximization of their own positions. Many factors may operate as variables in the determination of an animal’s fitness landscape and in determining its choices as to whether, and if so, how, to migrate across the landscape. Competition on one level of organization may be limited by the organization of the system on another level, as agents seek optimization on more than one level at once. Thus, competition is not as important in determining the system’s structure as is generally assumed. Epistasis may be chosen and achieved within a frame of reference that includes variables from several levels of organization of the system that an animal occupies, as well as from its own states as a system. The choices may seem paradoxical or illogical to an observer, but that is only because a super-observer does not exist.

The super-observer

As Whitaker points out, "the precise form(s) and function(s) by which systems are distinguished are unavoidably imposed by whatever observer is addressing them" (Whitaker 1996, p 5). A mammal engages the environment via disturbances in its nervous system. It is limited to the internal representations of the literal external environment, which result from these disturbances. These internal representations of the external environment are called descriptions (Maturana 1970). The organism in which these descriptions reside, and which operates within the realm of these descriptions, is the observer (Whitaker 1996). All observers operate within a cognitive domain. That is, a domain that circumscribes "…all the descriptions which [the observer] can possibly make" (Varela 1979, p 46). Observation is fundamentally based on making distinctions. That is, "the pointing to a unity by performing an operation which defines its boundaries and separates it from a background" (Maturana 1975, p 325). This enables the observer to behave as if he were "external to (distinct from) the circumstances in which he finds himself" (Maturana 1975, p 315). However, the observer operates only within the domain of his/her closed nervous system, and is not actually external to the circumstances in which s/he finds her/himself (Whitaker 1996): her/his nervous system is one of those circumstances, as is the attractor upon which that nervous system sits at the instant of observation. This nervous system is partly physically determined, and partly determined by the learning history the observer as an organism has undergone. Thus, observations are always relative to the person and history of the observer. Finally, where descriptions of experience are negotiated or shared among multiple observers, observations are qualified by the interactions of the observers, their persons, their personal histories and their histories of interaction (Whitaker 1996; Kuhn 1962). What we call knowledge is "inseparable from our bodies, our language, and our social history" (Varela *et al* 1991, p 149).

The super-observer, one who does stand apart from the circumstances in which s/he finds her/himself, whose descriptions are something other than internal representations, and whose observations are not dependent on her/his personal and social history and context, does not exist. All (scientific) statements are observer-dependent. This phenomenon is studied by the historians and anthropologists of science as they observe the scientific observer, but scientists themselves have been too unaware that they, too, are animals whose behavior must be studied, and that they are subjects operating within a cognitive and social domain upon which the very questions they ask, their observations and their conclusions are dependent. The use of statistics is not adequate to solve this problem. In addition, though science is practiced with the aim of eliminating as much superstitious learning as it can from its models and belief systems, it is inevitable that some superstition always remains – though the content can shift with time. This has all had a huge effect on the way animal societies are studied, the models, which have been proposed, and the conclusions, which have been drawn throughout history.

Linguistic and other consensual domains

An animal is, as a living system, constantly behaving. It is interacting with its environment at all times. Adequate behavior is that behavior which enables an interaction to take place without disintegration of the system's unity (Maturana & Varela 1980). On the level of the organism, this means behavior which enables the animal to interact with its environment without undergoing grave bodily damage. On the next level, adequate behavior is behavior that will not lead to disintegration of the system occupied with one or more other animals. Adequate behavior is, on this level, not determined by the choice of a single animal, but of more than one, all of whom are learning and behaving as parts of each other's environments. In order to interact adequately, the animals involved must do this within a consensual domain.

A consensual domain is a range of interlocked, intercalated and mutually triggering sequences of possible states with respect to each other, determined through the ontogenic interactions between structurally plastic state-determined systems (Maturana 1975), which can arise when two or more living organisms interact. The animals generate, through time, "…a history of recurrent interactions leading to the structural congruence between two (or more) systems" (*ibid.*, 1975, p75), in a "…historical process leading to the spatio-temporal coincidence between the changes of states."(*ibid.,* p321).

One of the areas of consensus that dogs develop in interactions is a linguistic domain. That is, "…a consensual domain of communicative interactions in which the behaviorally coupled organisms orient each other with modes of behavior whose internal determination has become specified during their coupled ontogenies" (Maturana & Varela 1980, p 120). In this paper, a signal refers to these communicative modes of behavior. Signals in a domestic dog include a positioning of the ears, tail, lips, eyes, head, or body, vocalizations, regulation of distance from other animals, manner of approach, and any other sounds, movements or gestures which allow other animals to orient themselves to interact with the subject in an adequate way. After they are born, domestic dogs go through a learning process in their interactions with conspecifics, through which a basic consensual domain is achieved with respect to the significations assigned to various physical signals the species is capable of emitting. This system of signaling is loosely called "body language", and constitutes a linguistic domain. The linguistic domain is part of a larger consensual domain, which is necessary for adequate interaction to take place.

Mood and emotion

Signals give an indication of the respective, changing internal states of agents, enabling them to mutually orient and seek to generate adequate behavior in an interaction. The model presented in this paper requires a re-definition of some of the signals used by domestic dogs, since the old terms really only describe human emotions. But this will be of no use unless we replace the old terms with well-defined new terms. In order to define the meaning of various signals accurately, we will first consider what we mean by "mood" and "emotion". Where an association results in physiological changes when a stimulus is presented, the changes can be such things as levels of salivation, secretion of gastric juices, a change in hormone levels, muscle tension, rate of the heartbeat. The changes in an internal response are often referred to as "mood" or "emotion". These "moods" and "emotions" can only be deduced, by measuring, for example, stress or sexual hormone levels, by observing responses such as flight or approach, or by observing signaling responses in species which have signals available. The names we give these responses are analogies we make with our own responses. It is common in the literature describing canine social systems to refer, for example, to fearful aggression vs. dominant aggression, or a submissive approach vs. a dominant approach. We are not then speaking of the behavioral expressions, but using analogies of our own feelings to describe the internal state we presume to underlie the behavior. Because of the inexactness of terms referring to moods and emotions, I will use (and precisely define) only two of them here: fear and anxiety. Fear as used in this paper refers to a classically conditioned internal response in an animal to a stimulus, where behavior includes signals that the animal is perceiving or anticipating a threat to its physical integrity as a system and that the behavioral response with the highest probability is flight. If flight is not possible, an animal may attack (defined below). Anxiety will refer to an internal response to or in anticipation of an aversive (Skinner 1938, 1969), though not necessarily integrity-threatening, event, to which flight is not necessarily the response with the highest probability. When anxious, the dog can show stress signals such as panting or displacement behavior, it can resort to snapping or inhibited or uninhibited biting, it can emit sounds, and so forth.

Aggression

Scientists have had huge trouble defining what they mean by aggression in animals. This is largely because scientists have projected how they, themselves, would feel in a given context rather than describing a behavioral event. This has resulted in the definition of aggression shifting as contexts and observers shift. Sometimes mere approach is called aggression, sometimes it's not, depending on how the observer thinks the approached animal must feel. In such a case, the observer is not describing a behavioral event in the animals, but rather describing his/her own rules and emotions about social space. Sometimes a grab that does not damage the other animal's skin is called aggression, sometimes it's not, again dependent on observer bias. There is argument about what we will and won't call a bite. Sometimes the killing of prey is considered aggression, sometimes it's not. Where a term does not fall within a consensual linguistic domain shared by those who are attempting to communicate with each other, discussion using the term is pointless. Despite the illusion that all are discussing a single phenomenon, in fact each participant is remarking on a different (internally defined) phenomenon than each of the others. Such a discussion may feel satisfying to each participant, but in reality no participant really has any idea what the other is taking about as they all refer to their differing internal descriptions. Unless this term is clearly defined, we will never gain clarity about the role aggression plays in the lives and social organizations of any animals.

In this paper, aggression by a domestic dog is defined, quite simply, as the delivery of an uninhibited bit to another organism, with the exception of the uninhibited biting that takes place as a part of the activity of eating. Where a human is the aggressor, aggression refers to actions (as opposed to omissions) by the human that could damage a dog's integrity as a functioning living system (e.g., hitting, kicking, jerking on a choke chain, delivering electric shocks, hanging a dog by the neck, and many of the other things people do to dogs). Attack refers to initiation of aggression by an organism towards something in its surroundings.

Resources

A similar problem has turned up in the definition of what a resource is, as scientists tried to save the dominance hierarchy model by claiming the "dominant" animal was the one who could hold and control the most resources. Inevitably, these resources ended up being defined as things male humans value most: food, sleeping spots, sex, and some went so far as to claim that even an abstract status within the group was a resource that would be defended. Obviously, this is all mistaken. It is irrelevant to attempt to quantify which animal is capable of keeping the most of one or more resources a human author values and think you are learning anything about the animals or how their social system works. There was an attempt made in other quarters to define resources as related to survival and evolutionary chances, but for some reason this again led back to food, sleeping spots, sex and status. As we will see later, observer bias also led scientists to overlook many of the resources dogs are in fact trying to conserve.

I will use the definition of resource as it is given in an ordinary dictionary: "**1a** : a source of supply or support : an available means – usu. Used in pl. **b :** a natural source of wealth or revenue – usu. Used in pl. **c :** computable wealth – usu. Used in pl. **d :** a source of information or expertise **2 :** something to which one has recourse in difficulty : EXPEDIENT **3 :** a possibility of relief or recovery **4 :** a means of spending one's leisure time **5 :** an ability to meet and handle a situation : RESOURCEFULNESS" (Mish, *et al*, 1983). Because dogs can't count money, "source of wealth" means, in this context, anything that increases the quality of a dog's life as perceived by the dog itself. During this study, *the dogs* were allowed to indicate what falls into any of the categories the dictionary mentions, so resource-holding is recognized as a subjective activity whose subjectivity does not have to be discounted. No attempt is made to define resources that would supposedly be valid for the whole species, because it turned out that among dogs the definition and valuation of a resource varied from one individual to another, and in each individual according to time and circumstances, just as subjective as it is from one human to another, and just as dependent on many individual factors.

The signification of signals

As will be shown below, dogs are also capable of adjusting the signification they attribute to various signals so that a smaller consensual domain is achieved with a single other dog in a binary interaction, separate from the consensual domain in which the entire species or group operates. For example, a dog can learn that a certain tail position means something very specific and different in this one other dog, but not in any other dog. Through a mutual process of learning during interactions with members of other species, domestic dogs are also capable of generating a consensual linguistic domain with those non-conspecifics. This domain again exists outside the domain that is achieved with conspecifics and, perhaps, yet other species. However, with humans, there is often failure to achieve a consensual domain.

This failure is at least in part caused by the cognitive domain in which humans operate, and the low plasticity of this domain's structure. Once a human has adopted a particular model by which it organizes its perceptions, it may take a long time for this model to change (Kuhn 1962). This model, in turn, may limit the descriptions which it is possible for the human organism to make. This can be due to a filtering effect – the human fails to perceive that which does not fall within the model structuring her/his cognition (e.g., Phillips 1993). It can also be due to the threat of loss of system integrity if the structure of cognition is changed, that is, another model adopted. When an observer moves out of the consensual domain s/he shares with other humans, group membership or even the very existence of the observer can be threatened (Kuhn 1962).

The dominance hierarchy model has become widely popular both among laymen with one or more dogs in the household and among scientists studying canine behavior. One of the areas of study is the linguistic domain. Human observers have attempted to attribute signification to the signals domestic dogs use in their social interactions. The significations "dominant" and "submissive", are derived from the dominance hierarchy model and have been assigned to certain ear, tail, eye and bodily positions, and this consensus has led to a limitation of the ability to perceive any other possible signification for these gestures. That is, the model structures the cognitive domain of human observers such that this cognitive domain does not (for the moment) include any other possible descriptions of these signals. In this regard, human cognition is possibly less plastic than that of a dog with all its neurological and cognitive limitations, since the dog is not subject to some of the complex group pressures humans operate under, and may be more able to incorporate new descriptions than a human at a particular point in history.

I assert that the dominance hierarchy model and its concepts of "dominance" and "submission" are examples of superstition as defined by Skinner. Rather than curing the problem, extensive dependence on statistics has operated as a typical feedback loop, actually resulting in an increase in superstitious learning in many areas of study. This dependence is also an expression of the limitations of the shared, historically shaped cognitive domain within which scientists operate.

In attempting to describe the linguistic domain of domestic dogs, it is therefore necessary to abandon the use of the terms "dominant" and "submissive", since these terms keep our perceptions locked inside the cognitive domain defined by a single model. These terms *in themselves* tie us to a pre-existing human consensus, thus themselves structuring our perceptions and preventing us from considering or, considering, being able to discover another model of domestic dog behavior and group organization. This, in turn, prevents us from arriving at some other consensual domain among ourselves. It is therefore impossible to develop a new model while continuing to use these terms. Furthermore, pharmacological evidence suggests that the underlying system states related to these signals are not what humans have so far thought them to be (Borchelt & Voith 1996; Simpson & Simpson 1996). This implies that some other signification of these gestures may help us more accurately describe the consensual domain within which the animals interact and to find a consensual domain with the animals as we interact with domestic dogs ourselves.

The following gestures are generally described as "dominant" in domestic dogs: ignoring the other, erect ears, staring, holding the tail higher than horizontal, retracting the lips to show incisors and fangs, standing on straight legs so that the body shows a high posture, placing the head or a forepaw on the shoulders of another animal, mounting another animal in a non-sexual context (Askew 1997; Borchelt & Voith 1996; Dunbar & Bohnenkamp 1986; Fisher 1998; Gaus 1995; Morris 1994; Overall 1997, 2002; Schenkel 1967 – to name only a few). While most researchers have included standing over in the list of dominant gestures, one researcher does not consider this a dominant gesture (Mech 2002). Other gestures are generally described as "submissive": ears held low on the skull and folded back in the neck, averted gaze and/or head, holding the tail lower than horizontal, bending the legs so that the body assumes a lower posture, licking at the corners of the other animal's mouth, licking at the air during an approach, lifting a forepaw in a tapping motion at a distance, lifting a hind leg to expose the groin, lying on the back, urinating without assuming the normal urinating posture (Askew 1997; Borchelt & Voith 1996; Dunbar & Bohnenkamp 1986; Fisher 1998; Gaus 1995; Morris 1994; Overall 1997, 2002; Schenkel 1967 – again, among many others). Some authors have referred to these gestures as "pacification" or "appeasement" gestures (Abrantes 1997). While this is seems to imply a departure from the dominance hierarchy model and an abandonment of the concepts of “dominance” and “submission”, this terminology does not go far enough. A state of war is implied in which aggression is always imminent and must be pacified or appeased in order to interact at all. Retracting the lips in a sort of smile to show the incisors, fangs and molars is generally described as a gesture motivated by fear, though one researcher maintains that this gesture is motivated by "submission" (Abrantes 1997). When two domestic dogs meet each other for the first time, their gesturing at each other is generally described as an attempt to establish respective “ranks”. Ritual fighting can take place, but in the end one animal is described as reverting to "submissive" gestures, at which point “rank” is supposedly established between the two. This categorization of and assignment of signification to the various gestures does not do justice to the complexity of the interactions nor to the animals as plastic systems. Finally, it has apparently led to the ascription of faulty significations to many signals (e.g., the "dominant" aggression which in fact can be treated with the help of anxiolytic medication [Overall 1997, 2002]).

In this paper, another system of signification will be used. The concepts of dominance and submission are abandoned as irrelevant and unverifiable. Instead, gestures will be categorized as indicating a threat or the absence of a threat to another animal. Further discussion will follow later in this paper, but for now it will suffice to define the new, more accurate significations.

Threat gestures

A threat is any signal indicating that the gesturing animal's internal state is such that it perceives or anticipates a perturbation to its position on a fitness hill or to the larger system. A threatening dog is not being “dominant”. It can be indicating that it feels threatened by or anxious about the anticipated perturbation of its position in its fitness landscape, that it wants more information before conceiving a plan as defined above, and/or that it wants the other to back off (i.e., maintain or increase physical distance) until enough information is exchanged so that its internal state returns to (or migrates to) an equilibrium.

The following gestures will be referred to in this paper as threat gestures:

- staring
- growling
- wrinkling or lifting an upper lip (sometimes for a split second)
- retracting the lips so that teeth are bared
- standing on straight legs so that the body shows a high posture
- lifting the tail to a position higher than horizontal
- freezing up
- approach in a straight line (direct approach) unless non-threat signals are given during approach
- barking in a low tone
- opening the jaws wide, teeth exposed, while moving the jaws around the face/neck of the other
- the delivery of an inhibited bite

Non-threat gestures

A non-threat gesture is any signal by which the signaling animal indicates its explicit intention not to perturb the fitness hill the receiving animal is sitting on. Some of these signals are referred to as “dominant” and others as “submissive” in the old theory.

The following gestures will be referred to in this paper as non-threat gestures:

- ignoring the other

- ears held low on the skull and folded back in the neck
- ears turned (erect) so that the openings point sideways/outwards
- averted gaze and/or head, or otherwise avoiding direct eye contact
- bending the legs so that the body assumes a lower posture
- licking at the corners of the other animal's mouth
- holding the tail in a position lower than horizontal
- licking at the air during an approach
- lifting a forepaw in a tapping motion at a distance
- sitting
- freezing up
- lifting a hind leg to expose the groin
- approach in a curved line (indirect approach)
- maintaining or increasing distance from the other
- not pursuing/approaching when the other increases the distance
- orienting the side or back of the body towards the other
- emitting high tones (yelping, squealing, barking in a high tone)
- lying on the back
- urinating without assuming a normal urinating posture
- gestures which are recognized as creating the consensual domain of play in an interaction
- displacement behaviors (e.g., yawning, scratching, sniffing the ground)

Turid Rugaas (1997) was the first to recognize many of these non-threat gestures as “calming signals” rather than any expression of “rank”, and was thus also the first to explicitly acknowledge threat signals as expressions of anxiety. In this paper, I expand on her work and show how these signals fit into a complex self-organizing system and how they are used to achieve stability on multiple levels of organization.

Methodology

When dealing with complex self-organizing systems, we are dealing with systems in which an enormous number of variables operate, and where feedback loops mean the results of the system's output return to it in the form of input, so that the system's operation itself ends up supplying variables which affect the determination of the system's future behavior. The whole is more than the sum of the parts, and the sum of the variables taken altogether in their interaction is more than and qualitatively different from the sum of each of their effects separately. In fact, each variable is, in isolation, meaningless since the relevance of a variable is derived from its interaction with all the other variables. We are therefore not studying separate variables, but the interaction of all the variables simultaneously.

One of the characteristics of a self-organizing system is the fact that it can choose between various attractors in its state space. A complex self-organizing system is, therefore, deterministic, but it is not necessarily predictable. The general direction the system will take is determined by the driving function, but the path it may take to any one of various fitness hills is broad with many side roads or forks (bifurcations), and the system may switch midway to a path toward another attractor. Thus, we cannot predict the system's trajectory through state space. In the of study self-organization, it is necessary to observe a system operating. In the case of artificial intelligence, artificial life, cellular automata, genetic algorithms, neural networks, and such, the researchers create a set of rules, set the system in motion, note any stable patterns that emerge, and then repeat the sequence many times. Generalizations with some statistical probability can eventually be attempted (Lucas 2002b, *passim*). With living organisms, however, we do not know the rules in advance and must begin by observing an operating system without any assumptions as to which rules will turn out to apply. The aim of research is to discover general properties that apply to topologically equivalent systems. Once these rules are discovered, they can be tested by repeatedly starting a system at some point in state space and observing whether they adequately describe the evolution of the system through time. These are the methods used in this study.

We are not super-observers. In observing a system, any criteria we use in plotting the height of hills in the fitness landscape are our own criteria and the map which results is our own map. When the system parts are living organisms, they will be mapping their fitness hills according to their own internal criteria, which may remain invisible to us. Domestic dogs are complex organisms subject to many kinds of input, able to produce many kinds of feedback-generating output, and capable of learning. It is therefore impossible for an observer to determine all the criteria the animal itself is using in attributing heights to the various fitness hills in the landscape. We cannot say that a hill occupied by the use of threat signals is higher than some other hill unless we specify that this is a criteria we have imposed ourselves which may be irrelevant for the animal(s) involved. We cannot determine that possession of some resource will always lead to a heightening of a fitness hill, nor that the relinquishing of a resource has led to a lowering of the height of a fitness hill, since factors as the learning history, valuation of system membership, and such internal metabolic states as hunger or sickness may influence an animal's valuation of a resource at any given moment or in a given interaction. We can, to some extent, predict that a condition such as famine might lead to a higher valuation of food and result in changes in interactions involving the access to or possession of food. However, in such cases we are observing an example of what is called an Error Catastrophe: too high a rate of innovation is not controllable by selection and leads to information loss, chaos and breakdown of the system (Lucas 2002b). This will not tell us how the system operates, but how it disintegrates. The author did not, therefore, attempt to rank fitness hills in any sort of hierarchy.

If we want to understand social organization, we must study an organism in it natural habitat. Such a study must encompass the entire life span of at least one organism. The author argues that the observations made in such a context will have more validity and be better related to the behavioral realities than many studies that have been done or are being done in laboratory or academic settings, for many of the same reasons that studies of wolves have recently been criticized (Mech, 2002). Though a laboratory or academic setting succeeds in reducing the variables involved when very specific aspects of behavior are being studied, they are unable to provide a context for studying the full range of natural behavior or for discovering the principles which govern the social organization of domestic dogs.

The model presented here is derived from information gained during a longitudinal study of a group of domestic dogs living in their natural habitat: a) in groups of two or more and b) among humans. The study began in 1994, and is still in progress. I refer to the group studied as “the home dogs”. Though the membership of the group changed over time, the defining factor was that the dogs shared a home and were never separated for more than a few hours once they’d joined the group. These dogs live in my home, in an urban setting. The dogs in the home group were observed 24 hours a day, seven days a week, which meant the evolution of their behavior could be followed without missing events that triggered changes. The group has been built up by a process of accident. Human preferences or expectations did not play a role in selection of types or sizes of dogs. This accidentalness also provides a more accurate microcosm of the natural habitat domestic dogs live in than would a group based on human selection, since dogs interact during their lives with many conspecifics that were not selected by the human they live with. Because a defining characteristic of an autopoietic system is that it produces its own functioning system parts, reproduction and the raising of offspring must be understood if we are to understand the functioning of a system composed of living organisms. To deduce system principles, we must observe the system functioning as a whole for at least the time span of an entire life cycle of at least one system part. The system formed by the home dogs has, at the time of writing, been observed for a period of twelve years (probably more than three quarters of the life span of the oldest animal present in the permanent group), and has included several rounds of introduction of offspring, However, domestic dogs are not limited to the groups in which they are born and raised. When two dogs meet, they are usually capable of quickly arriving at a point where they can interact while both maintain their own system integrity. They are also capable of doing this with other species. This means that other species can participate in the system. Part of the data for this study comes from watching the permanent group of dogs absorb new members into their group and watching them interact with strangers of various species inside and outside of the home. This allowed observation of how the larger social group moves across its landscape in the face of a perturbation, as well as the establishment and evolution of new binaries between hundreds of dogs (and tens of other animals) that had never met.

A second part of the data for this study comes from data arrived at through participant observation engaged in with domestic dogs in an animal shelter. In this case the author chose to work with animals showing fear or aggression toward humans. This was partly to test the proposed system rules by repeatedly starting systems at or near chaos and testing whether the proposed rules predicted the evolution of these systems. The underlying proposition was also that much could be learned about system principles by entering an interaction in chaos and participating in moving the interaction into a non-chaotic region of state space, so that I could amend my model if need be. That is, that by repeatedly undergoing production processes and allowing myself to be shaped into an adequately functioning system part, I would discover some of the principles governing the system's organization, determination of structure, and movement through state space. Besides, participant observation was unavoidable as the only way to solve the problem of the super-observer. You can’t send a dog into an interaction and know he is following the rules you propose. You obviously can’t solve this problem by giving a dog a set of instructions to follow in an interaction with another dog, asking the dog to test your rules for you. The only way to be sure my proposed rules were being tested was to enter the interactions myself and behave according to those rules. This also provided an arena for testing the signification I had hypothetically assigned to dogs' signals: responding to a dog's signal as if it meant what I proposed it meant, signaling back (within the human limitations) with signals from my own dictionary of significations, watching the dog's response to see whether its internal state as indicated by its own signaling changed as I predicted it would. My work in the shelter was, thus, a testing both of my proposed model and of the new significations I propose for dogs' signals. Did we generate, through time, Maturana's "…history of recurrent interactions leading to the structural congruence between [our] systems" (Maturana, 1975, p75), in a "…historical process leading to the spatio-temporal coincidence between the changes of [our] states."(*ibid.,* p321), as I predicted we would? Could the dog and I construct a stable binary social system in which were able to display adequate behavior while sharing a physical space and a social landscape?

The first dog present in the permanent group was a Basenji crossing, male, born in 1979, abandoned to me by a neighbor in 1984. This study started In 1994 when I found a male puppy on the street, a Scottish Collie/Labrador mix (hereafter mCL). This puppy was approximately eight weeks old when I introduced him to the Basenji. He had been bought at a market in Antwerp at the age of seven weeks, spent a week in a household with two adults and two children (both male, eight and 11 years old), then was dumped onto the street when Dad got tired of cleaning up pee. mCL had been alone on the sidewalk for about five minutes when I came along. When mCL reached the age of 30 months, in May 1997, a ten-week-old male Border Collie (hereafter mBC) puppy was acquired from a farmer who was planning to drown him. MBC had spent his first eight weeks alone in a small shed with his mother and siblings, and his eighth to tenth week alone with the mother. He saw humans when food was brought, when people came to choose a pup, or when neighborhood children stopped by to look at the pups. The mother was a well-socialized working dog. When mBC reached the age of 31 months in the autumn of 1999, two new puppies were added to the group, a female German Shepherd (hereafter fGS) and a female Labrador (hereafter fLab), both eight weeks at the time of introduction to the group. These pups were referred to the author by the local SPCA. In May, 2001 a castrated male Jack Russell (hereafter mJR), five years old, was added to the group when another person moved into the house. This dog had been acquired in a shelter at the age of a year. In June, 2002, a female Canadian shepherd (hereafter fCan) was added to the group. This dog was 18 months old. Her original owner had bought her from a breeder (conditions unknown) at seven weeks old. She had lived until her 18th month with this man, his wife and three small children (two male, three and five years old, one female, seven years old). All of them were often severely beaten by the man, the dog from her eighth week of life. FCan had spent much time in dog parks. She was extremely fearful of human males, but she had no trouble interacting with dogs or other animals. I had fCan sterilized as soon as she joined my household. In August, 2002, an already sterilized female Friese stabij (fStab) was added to the group. She had lived eleven years with a woman, until she was re-homed due to the birth of a handicapped child. FStab had had the life of an ordinary household dog, living with humans, spending time in dog parks.

This permanent group of dogs interacts with visitors, both canine and human, in their home. This includes both puppies and adult dogs of both sexes, and children and adult humans of both sexes. Visitor dogs sometimes stay a few hours, most come two to four days every week (thus allowing repeated observation of the resumption of interrupted relationships), and sometimes they stay for several weeks. The dogs are fed in one space, about half the time with one or more visitor dogs present, which are also fed. In addition, the group interacts in city parks with randomly encountered dogs of all ages and both sexes. When traveling to a city park, the entire home group is present, including any visitor dogs that are staying with us. At no time did the researcher interfere in the interactions between the dogs in the home. In parks, most interactions were left to the dogs. The first exception was in cases where the owner of a non-group dog panicked during an interaction between the dogs. In six cases, a dog was observed to be delivering uninhibited bites to a second dog. The interaction was stopped by human intervention, as it would be unethical to allow a dog to be damaged in the name of research. This did provide an opportunity to observe the later reactions of dogs to a conspecific that had exhibited aggressive behavior. The third exception was when intervention was necessary to save the life of a dog from an attack by one of the breeds humans have developed for the purpose of killing other animals and dogs, or to avoid such an attack from even starting.

For ethical reasons, I prevented the adult females in the group from reproducing. The evolution of Interactions with (and between) puppies younger than seven weeks were observed only twice. Both periods of intermittently observing neonates during their first seven weeks took place in the shelter, when carelessness had led to the birth of litters there. This is a gap in the present study. However, as research continues the gap may be filled, or perhaps other observers will be able to present data, which will compensate this hiatus and correct any flaws it may have led to.

The testing of rules in systems starting at chaos was done in an animal shelter in The Hague, two days a week, from May 1997 through June 2000. This shelter places approximately 800 dogs per year, giving the author a chance to observe a wide population of city dogs. It is important that this population was not socialized by the author or her own dogs, since this provided a chance to test the proposed model against observations of a population of variously raised and socialized dogs, without further knowledge of their past experiences and in a context where the dogs were dealing with strangers of all species they encountered. I entered binary interactions with each of 53 dogs. These dogs were not randomly chosen; focus was on dogs with extreme fear problems or aggressive behavior toward humans. An attempt was made to arrive at a consensual domain with each animal, such that the participants could, finally, interact on an open field without flight, threat or aggression occurring. The proposed rules were tested to see whether they would move the binary through state space to a stable attractor, with each participant undisturbed on a fitness hill while also constituting part of each other's fitness hill. To further test the rules, guard against omissions and exclude purely personal biases, a research assistant also participated in forming binary relationships with some of these dogs using the same set of instructions. In the shelter, I also had the chance to observe the reactions of dogs to personnel who continued to believe in and behave according to the old dominance model, including the interpretation of the dogs' signals. It was interesting to watch personnel respond to threat signals with their own threat signals, and to watch relations quickly deteriorate (i.e., move further toward chaos, often to the point where personnel became afraid that attempts to remove a dog from its cage would result in aggression as defined in this paper). This provided a chance to validate my own model. I was able to contrast the results of its application in interactions with many specific dogs to the results of applying the old model in interactions with the same dogs.

One group of dogs was excluded from this study: the fighting breeds (the pit bull, the American and English Staffordshire bull terriers, the English bull terrier, the akita inu, the tosa inu, the American bull dog, the Presa Canaria, and all the other breeds that humans have artificially selected for killing behavior). There are anomalies in the behavior of the fighting breeds which make it too dangerous to allow them to interact with other dogs merely for the purpose of observation. An exploration or explanation of these anomalies is beyond the scope of this paper. This does, however, constitute the one exception to the aforementioned randomness of the interactions between observed dogs, and must be mentioned here.

Summary of Results

Aggression: Dog to dog

Dog-to-dog aggression turned out to be extremely rare. In twelve years, I observed six cases in parks in which a dog delivered one or more uninhibited bites to another dog. (Remember here that bred by humans based specifically on artificial selection for aggressive behavior are excluded from this study.) Aggression was never in the context of a dispute about a resource. Attacks occurred each time outside the context of any ongoing interaction, coming as it were out of nowhere, not embedded in any social context. A seventh dog had been brought to the shelter with an owner-reported history of killing other dogs. In the shelter, this dog was kept isolated from other dogs, so this behavior was not actually observed.

When aggression did occur, dogs reacted to it as abnormal behavior. Attacked dogs showed fear (if possible, flight behavior with all attending fear signals), uttered screams, did not attempt to bite back but rather whipped head and body around trying to avoid or fend off bites and (it seemed) attempting to get a look at their attacker (i.e., visually orient), looked for an opening to flee. After an attack was stopped by human intervention, the attacked dog would stand there trembling, often barking in a high tone at the dog that had attacked it – highly emotional, whatever those emotions may be, but we can presume full of adrenaline in any case, yet not attempting to re-engage physically. The experience must be called traumatic, because an immediate change in behavior in later social interactions was always observed. Some dogs became fearful even of familiar conspecifics; some of all unknown conspecifics, others of dogs that shared some feature (size, color, breed) with the attacking dog. They all showed highly increased anxiety when they saw their attacker later (at a distance), growling, bristling, lifting the tail. They showed avoidance behavior, increasing distance or attempting to leave the site altogether while the attacker was still far away. The reactions remained very emotional (i.e., they made clear that the inner state of the dog was highly perturbed at seeing a stimulus associated with aggression). These changes sometimes lasted for years. The heavy emotional reactions of the dogs, the fact that an attack always resulted in long lasting fear or anxiety, the fact that it damaged a dog's ability to engage in social interactions, and the fact that the attacker was avoided, that all led to the following conclusion.

Aggression is not relevant to the social organization of the domestic dog. Dogs do not use aggression in organizing either binary or larger social systems. Aggression leads to the complete disintegration of interactions. Furthermore, it damages the attacked dog as a functioning part of any social system. Thus, the first and most basic, important rule governing relations in the domestic dog's binary interactions and in the emergence of social systems is: aggression will not be used.

Aggression: Dog to human

Dog to human aggression turned out also to be rare. Dog to human aggression was observed only in the shelter. In two of these cases, owner-reported original conditioning was sufficient to explain the response. A third case involved an adult Doberman, male, who had been in the shelter for a time without showing any sort of fear or threats toward humans. On the contrary, he was friendly, sought human companionship, allowed himself to be touched all over his body, and was generally considered by staff to be an ideal companion animal. The dog was eventually re-homed, but he was brought back after six weeks. Upon return, he showed marked fear behavior when an unfamiliar human approached his kennel (e.g., he fled to the outdoor run, maximizing distance to whatever human stood before his cage). Humans he had know before the re-homing were able to take the dog out of the kennel to walk him. The attack occurred when a female staff member took the dog out of his kennel, leashed him, then (standing to the left of the dog) abruptly bent over the dog's back to grasp and examine a wound on the dog's right front foot. The Doberman did not attack the staff member who was bending over him and handling his wounded foot. Rather, he attached a second caretaker who was standing in front of him three yards away. This woman was directly in the dog's line of vision, and she later reported that she had been looking him directly in the eyes while the other woman tried to examine his foot. We were unable to work extensively with these three dogs because they were executed within four weeks of attacking a human. However, and in particular as illustrated by the case of the Doberman, learning remains sufficient to explain the attack behavior without reference to mysterious internal traits in any of these dogs.

With fearful dogs and threatening dogs, we followed a procedure of focused respondent conditioning and at the same time developing consensual domains with each dog. We succeeded in establishing stable binary systems with each and every dog that initially showed fear or threat behavior. The dogs all showed signs that our presence heightened their fitness hills long before we reached the stage of taking them out of their cages onto a field. Here, the importance of learning as a production process was clearly demonstrated. Once we had established a linguistic domain with these dogs, the dogs were able to generalize this domain to other humans who used the same signals. In the end, various shelter volunteers were able to enter into stable binaries with these dogs, some of whom shelter personnel hadn't dared take out of their cages for as long as a year. Aggression did not occur with any of the participants who cooperated in establishing consensual domains with these dogs.

Threat behavior did not decrease, and sometimes aggression did occur, toward shelter personnel who continued to believe in and behave according to the idea that you must "dominate" a dog (they did not do this to fearful dogs). These humans were not willing to try using other signals. All of them expressed indignation at the idea of "submitting" to these dogs. What was the use of establishing peaceful interactions if these were not the result of winning a power struggle? Here we were again witnessing the low plasticity of the human cognitive domain. These humans were defending various investments and resisting having to make new ones. They had invested much time in learning the dominance hierarchy theory. There was psychological investment in the image of the self as already having expertise, and reluctance to let go of this ego image. Learning new ideas would have meant leaving a negotiated and shared consensual domain, thus also possible loss of position within a peer group. In addition, we were watching persistent projection of the rules governing human systems onto the dogs' system. Not only are all relations power struggles, but one can only count a "win" where one has prevailed by dominating rather than by compromising. None of these humans ever removed these dogs from their cages, so personnel's hypothesis that these dogs would attack them was not tested. Aggression consisted of dogs biting any object, including hands, that were inserted into the cage by these people (e.g., to feed the dogs). It remains unclear whether these were really just high level threats (reflecting a high level of anxiety about what these humans would do next), or whether these dogs (or some of them) were really determined to drive the human out of the shared physical space (and thus out the dogs' fitness landscapes altogether) by the use of aggression.

This contrast in the dogs' behavior with each set of humans shows that the success of my model and the failure of the old one is not due to something in the dog. It also shows that my proposition is correct that relationships are binary, always established between two participants and applicable only to them. Though the linguistic domain becomes available to others once it is learned and established, each of these others must use it to establish his/her own binary system with a dog.

Aggression towards humans was so rare that it must be considered an anomaly. Aggression is clearly not relevant to organization in the systems dogs form with humans – at least not from the dogs' side of the interactions. Rather, it is related to the loss of the consensual domains that are necessary to maintain a system containing one or more human agents. This confirmed the rule stated above: aggression will not be used. Where aggression does occur, it is not used in organizing a system, but is an indication of total system breakdown.

Resources

Learning was clearly of great importance in determining what a dog considered a resource. Interest in toys was entirely dependent on learning history. Other resources were also defined by the dog's learning history. I will cite one example at length here to give clarity about the method of analysis, and to emphasize how important it is not to be sloppy in such analysis. One of the dogs in the home group had been severely beaten by a previous owner. She initially responded with fear (flight behavior) to any sign that human attention was directed toward her (e.g., looking directly at her). I responded by ignoring her and not decreasing distance. Eventually fCan began to approach carefully, emitting all kinds of emphatic non-threat signals. I responded by also emitting non-threat signals. Fcan was, in fact, testing whether I would obey the rule that aggression will not be used: she was learning about me in a process of mutual orientation as described above. Within eight weeks fCan began to seek frequent interaction with me, not only giving an orienting response to receive a food reward, but also soliciting attention and stroking. This behavior allows us to conclude that attention and stroking were now operating as reinforcers. We must, thus, conclude that fCan now perceived attention and stroking as increasing the quality of her life. She *learned* to experience human attention as a resource, whereas it had first been a sign of danger. FCan had also learned that certain signals of hers would be followed by certain signals from me, some of which predicted the appearance of these reinforcers – a new linguistic domain was established. Once these consensual domains been opened up, fCan was able to transfer it to other humans. She became interested in investigating whether she could safely establish social interactions with new humans. This indicates that there was a second resource involved. fCan got plenty of stroking from me, so there was no reason to seek more of this in and of itself. The more so since seeking this resource from another human meant voluntarily undergoing a strong perturbation of her inner state (a high level of anxiety) and – in her eyes – the risk of being attacked. I conclude that fCan actively sought to repeat experiences of non-violent interactions with humans because each new peaceful interaction led to decreased anxiety that a human meant, by definition, an extreme perturbation of the shared fitness landscape at the least, and a danger to herself as a functioning living system at the worst. Because fCan was willing initiate interactions in which she had to overcome fear and risk attack to test this stability, we must conclude she perceived stability in the social landscape as a resource in itself. fCan was attempting to find our how frequently this resource was available by actively seeking repetition of the experience she'd had first with me. If other humans turned out to share the linguistic domain (responding to non-threat signals with non-threat themselves), and if humans could be generally regarded as following the non-aggression rule, a great increase in the quality of fCan's life would be reached. She would be able to move within a state space in which violent perturbations by humans did not occur on the binary level, and internal perturbations were decreased by her own changed perceptions of humans. Thus, generalized reduction of fear, increase of inner stability and increased stability in the general social landscape were clearly all resources fCan was willing to face fear to gain. This was, however, a binary process. The responses of the other dogs or myself to a new person had no influence whatsoever on fCan's responses. Each new human had to establish its own predictability with, and thus value as a resource to, this dog. The other dogs in the home group had different learning histories. They considered all human attention to be a resource and no human to be a threat to stability on any level. (The analysis followed in all cases is the same as that used with fCan: the other dogs behaved as if human attention was a reinforcer for all kinds of soliciting behavior; from their behavior we can conclude that human attention was perceived as increasing the quality of their lives and that the non-aggression was assumed to operate; approach was not careful, non-threat signals were subtle; the dogs behaved as if the consensual domains necessary for social interaction could be taken for granted as pre-existent.)

But learning does not only determine what a dog considers a resource. Learning was also important to behavior around resources. Dogs whose owners constantly took things away from them showed intense threat behavior if approached by a human while the dog had what it regarded as a resource in its possession. Dogs whose owners did not constantly take things away from them did not show this behavior around humans and resources. A dog's behavior toward other dogs was dependent on both experience with other dogs in general and knowledge of whatever dog was approaching. Dogs were able to learn to predict the behavior of another individuals as individuals and to adjust their behavior accordingly, with responses varying according to experience of a particular individual in the past. In interactions around resources between dogs who did not know each other, the resource-holding dog would often emit high level threat signals. Threat signals always decreased, finally, in response to non-threat signals emitted by a dog not holding a resource. After several interactions in which a particular dog had consistently emitted non-threat signals, threat behavior by the other dog ceased to occur at all toward this particular dog in the presence of resources. For example, some of the home dogs initially (in the first days after joining the group) showed threat behavior toward the other dogs while treats were being handed out. These dogs all quickly learned that some other dog receiving a treat was a reliable indicator that a treat for her/himself would follow. Threat behavior ceased and was replaced by strong orienting responses toward the human at the sight of another dog receiving a food treat. This was clearly dependent on knowledge of the human and the other dogs present. Sometimes new dogs who did not threaten nevertheless triggered threat behavior in the home dogs, until the home dogs had, one by one, each testing the new dog individually, learned enough about the new dog's behavior around food (i.e., until behavior around food treats was added to the consensual domain). When a new visitor dog joined the home group, there would initially be much approach-threat-retreat behavior around food in general. This ceased as the new dog learned about the others' fitness hills (food was a resource whose removal would decrease the height of the eating dog's fitness hill) and as the home dogs learned that the new dog would respond appropriately to a threat (maintaining or increasing distance). This was clearly a binary process. The new dog respecting one dog's distance requirements did not influence the behavior of any other dog. A new dog had to interact with and establish consensual domains with each of the home dogs separately.

Dogs also learned which individual would emit threat signals in the presence of which resources. One of the home dogs (fGS) consistently guarded balls from the others, emitting threat signals if approached while in possession of a ball. The other dogs quickly ceased approaching her when she had a ball and emitted pronounced non-threat signals if they had to walk around her to get to some other part of the physical space. On the other hand, the border collie (mBC) consistently played a game of actively giving a ball to another dog (dropping the ball he had, then picking up the ball the other dog inevitably dropped in order to catch mBC's dropped ball). The other dogs freely approached mBC when he had a ball in his mouth, rather than avoiding him or emitting other pronounced non-threat signals. A single newcomer was able to learn to predict both mBC's and fGS's behavior, playing trade with mBS but maintaining distance if fGS had a ball. This also demonstrates two other points. First of all that dogs learn, by interacting and experiencing the other's behavior, how another dog's fitness hill "looks" – which resources are important to the height of that hill, which behavior will be perceived as an anticipated or real perturbation of the attractor the first dog is sitting on. Secondly, this was an interesting demonstration of how the establishment of binary systems works. When fGS threatened while holding a ball, all the dogs that were close to her would increase distance – the threat signal percolated through many binary connections in the larger system at the same time, and all the dogs responded with a non-threat signal. However, fGS herself responded only to the signals emitted by the dog she was looking at. Interactions had to take place one on one, with eye contact and a direct exchange of signals, if a stable attractor was to be reached, and only this particular binary moved to the stable attractor. In other words, the other dogs present might interpret a signal as directed at themselves and signal back, but the threatening dog could only respond to the signals of one other dog at a time, namely the dog it was looking at.

However, as important as learning is, it is not the only variable that plays a role with respect to resources. The internal state of an individual dog (aside from changes in the organism triggered by learning) was a second factor in determining what was considered a resource and behavior around those resources. For example, after one of the home dogs was put on a restricted diet, he began to show anxiety about holding onto edible objects. There was a marked increase in threat behavior around anything that could be eaten. When I had to have two males castrated due to testicular tumors, both stopped behaving as if a female dog in heat was a resource. They ceased to show interest (e.g., approach, orienting responses, play invitations) and also completely stopped threatening other dogs in the presence of a female dog in heat as they had done before.

Both a dog's own behavior *as* a resource-holder and its behavior with respect *toward* a resource-holder are a result of learning. Other changes in a dog's inner state can act as a perturbation, triggering changes in both perceptions of resources and behavior around resources. However, continued learning will determine new behavior as a dog chooses trajectories in its state space, juggling variables from several levels of organization at once.

The signification of signals

I noticed early on that dogs with a history of success in establishing peaceful interactions with other dogs were the least likely to use threat gestures. There was also absolutely no correlation between some presumed position in the permanent group and the use of threat vs. non-threat signals. I will again give an extended example here, to illustrate how analysis must be done and the clarity that must be maintained. mLC was older and much larger than mBC, had assumed a parenting role toward mBC, and was the dog longest in the home. Nevertheless, mLC never threatened mBC around any resource – not ever, not even food, and not even after they were both on restricted diets, and no matter how closely mBC approached. Outdoors, neither mLC nor mBC threatened often in interactions. It made no difference whether the other dog was big or small, female or male, known or unknown. This changed after mBC was attacked by a pit bull. After that experience, mBC began to greet large, unknown dogs with a high tail, growling, staring, walking stiffly on extended legs, and sometimes delivering an inhibited bite to the side of the other dog's neck during the orienting process. Unknowing observers (stuck in their rigid cognitive domains) perceived mBC's threat behavior as a need to "dominate" in social interactions, making his "rank" utterly clear to some other dog. When I explained that it was anxiety generated by an attack, these observers remained stuck in their rigid cognitive domains, stating that anxiety had resulted in an increased need to show "rank" right at the beginning of an interaction. It remains unclear how being attacked would suddenly make a dog "dominant" or bestow higher "rank". But if this somehow were the case, and since increased "dominance" is a permanent trait residing inside the dog, it must have been evident in other interactions as well. Here, the advantage of observing the dogs 24 hours a day, seven days a week became apparent. There was no change in mBC's behavior within the home group. There was no increase of threat behavior toward other dogs in the home group, not around resources or in any other circumstances, nor toward other familiar dogs, nor toward smaller dogs. Though many readers will still see this as a result of the 'zen' state of mind "rank" bestows, it is better to remain parsimonious in our explanations. It was clear that mBC's threats were a response only to a certain class of dogs. Because they were limited to this one category, we must conclude that his threat signals were generalization of a learned response to similar stimuli. mBC's threats were the result of anxiety generated by having been the object of aggression, and this anxiety response was generalized to a whole certain class of dog. His threats were an indication of loss of consensual domain – it was no longer a part of mBC's inner state to assume *a priori* that the non-aggression rule would be obeyed when confronted by a dog that was similar to the one that had attacked him. If mBC had been fearful, he would have fled. Because he was anxious, he attempted to restore inner stability by soliciting proof that the other dog would obey the non-aggression rule. The delivery of an inhibited bite has to be seen as a result of his highly perturbed and anxious inner state. Such a bite is, however, also output that will return as input. The other dog's response shows how it will respond to such a signal. A dog that responds with a non-threat signal, or with an inhibited bite back, is showing that it will not use aggression even when instability is great. Once this predictability of non-aggressive response had been established, mBC could share a physical space with the other dog without experiencing this perturbed inner state or fearing loss of the resource "physical safety". This conclusion was supported furthermore by the fact that, once mutual orientation had taken place and the other dog did turn out to obey the non-aggression rule, mBC's threat behavior toward that dog ceased, including around resources and in all other circumstances. The further evolution of the binary did not show anything that could be construed as "dominance" or any kind of "ranking" between the dogs.

Another example is the two female Yorkshire terriers who were socially parented by the home dogs. These dogs each weighed a few ounces when interactions began, and grew into eight pound adults. They grew up with dogs who all weighed nine to ten times as much as they did, but neither of them ever experienced failure in establishing safe interactions. They had extensive experience with the feedback non-threat signals generated as returning input from other dogs. The behavior of the adult home dogs towards them was no different than with larger puppies. As they grew, the Yorkies were not treated more harshly, nor snapped at more often than larger adolescents, nor any of the other behavior that would supposedly teach them some low "rank" due to their size. They also weren't treated more gently than other puppies. As adults, these two approach large new dogs freely, emitting non-threat signals all the way but neither hesitating nor showing fear. It would be a human projection to call this "active submission." This presumes knowledge of the contents of the other dog's consciousness, that it values some "rank" and will refrain from using aggression if only the other dog signals it "knows" it has a "lower rank" (which also presumes the little dog knows what "rank" the big dog thinks it has before so much as making contact). In fact, there is a more parsimonious explanation. The Yorkies had no experience that would cause them to doubt the universal existence of the consensual domain regarding the non-aggression rule. I.e., they had undergone conditioning processes such that they did not anticipate a perturbation of any system on any level from any other dog in the form of aggression. These conditioning processes had also led them to an inner state in which they anticipated the same input as a result of their output at all times: as far as they knew, the linguistic domain was universal, and the use of non-threat signals would always result in the safe establishment of a stable binary system with another dog. A dog so small would, once close to a dog so large, have no way to save its own life if the large dog attacked. Therefore, learned anticipation of being able to control the interaction (i.e., great self-confidence) is the only circumstance imaginable under which a tiny dog would approach a huge, unknown, new dog at all. Put simply, these Yorkies' use of non-threat signals was an indication not of "submission" , but of great confidence in their ability to predict responses and to control interactions, leading interactions along a short and safe trajectory to an attractor in any binary system's state space.

A third example is that of the new dog that comes onto a field and is suddenly surrounded by the entire home group plus whatever other acquaintances are present. Such a dog is surrounded by a group large enough to tear it to pieces in two minutes. The idea that a dog would, surrounded in this way, try to assert "dominance" or some "rank" with respect to the whole group all at once presumes great carelessness in the dog about its continuing integrity as a living system, the more so if one assumes that all the dogs in the group will also have some "rank" they want to maintain. Nevertheless, many of these dogs emitted threat signals while surrounded. The threat signals did not trigger aggression. The other dogs generally sniffed a little, then moved off. After watching this happen many times, the conclusion was inevitable that the threat signals were a sign of anxiety while surrounded by the group, and that the group members recognized this, responding with the non-threat signal of increasing distance. Furthermore, the dog that had threatened at the beginning of interactions did not turn out to have any special access to resources, nor privileges, as interactions on the field full of playing dogs progressed. In general, dogs threatened only in situations where predictability about what the other would do had not been established, or where predictability was disturbed by some unexpected action. Size (i.e., physical prowess) had nothing to do with it.

Thus, the posturing and physical gestures dogs use (i.e., the signals they emit) did, indeed, turn out to have a different meaning than is generally assumed. At first, knowledge of the history of a dog was necessary to interpret the signals correctly. Later, seeing the signals was enough to guess about the history of a dog. Every time I had an opportunity to check my guesses with a dog's human companion, my guesses were confirmed. It is lack of predictability about what the other will do in a given situation, unexpected behavior of the other in a binary, or traumatic or frightening experiences during the learning history of a dog that lead to an increased use of threat signals. Dogs with a history of peaceful and predictable social interactions don't threaten. Dogs with a known history of successful social interaction were, on the contrary, consistently ready to emit non-threat signals. Both threat and fear signals consistently diminished and eventually disappeared in interactions as dogs became more experienced with each other as individuals, or as they gained more experience in social interaction in general. Non-threat signals indicate a "confident" inner state – i.e., lack of anxiety about the other dog's responses. It is the dog signaling non-threat that has learned that it can that predict and control an interaction by using non-threat signals After all, signaling is a process in which the dog's output returns to it as input. Before returning as input, the signal is led through the other dog's brain, influencing its inner state in some way, and returning as a signal about that inner state (which may be changed by reception of the signal). The dog that signals non-threat has an inner state such that it does not expect aggression and that it does expect returning input to be a signal indicating a decrease in anxiety in the second dog. Because of its learning history, the non-threatening dog expects that the binary interaction can, by its output of non-threat signals, be led to a cooperative, stable attractor in the binary's state space. The dog signaling non-threat is, put simply, the more confident of the two dogs. In the end, it is clear that threat signals are an indication of anxiety about what the other might do. It is the non-threatening dog who takes control of the interaction, reassuring the other and leading the binary along a trajectory toward an attractor.

Observations also showed that the signification of signals has to be learned. This will be discussed later. In my conclusion below, I will discuss how the signals are used to generate predictability (consensual domains) and to lead systems to stable attractors.

The use of signals

It looks as if many of the signals dogs use are not conscious attempts to communicate. Many of the positions a dog assumes, how it holds its tail and ears, seem to be spontaneous responses to inner changes in the dog. A dog's body expresses its inner state whether another can see the dog or not, and without the dog controlling its postures in an other-directed way. This is no wonder, since a dog knows what it sounds like, but it has no idea what it looks like. When a dog is sniffing a blade of grass, its body is relaxed, tail hanging, its body expressing its relaxed inner state without the dog being aware it is revealing anything important to an observer. When a dog smells or hears another dog, but without seeing it, its inner state changes and its body expresses this, even thought the other dog hasn't been sighted and can't see the signaler. A tail goes up, ears go up, hairs might bristle, the dog stiffens its legs and freezes to listen or perhaps, excited and worried, increases its pace in an orienting response (trying to orient to visually locate the other dog). A fearful dog might already tuck its tail, lay its ears back and start scanning the surroundings with lowered head. Although a dog has learned that other dogs will probably react in a certain way to certain behaviors it emits, it engages in many of these behaviors regardless of whether the other is present. In particular, dogs seem to assume the postures that express anxiety and fear simply as a spontaneous response to changes in their inner state, no matter who is or isn't within visual range. When an anxious dog starts to relax its raised tail during an interaction, this doesn't seem to be a conscious other-directed signal, but a non-directed reaction to a change in the dog's inner state (diminished anxiety, perhaps falling adrenaline levels, thus some relaxation of tension in the muscles). Approach also seems to be inner directed. Though it reveals an inner state such that the approaching dog wants to interact with the other, the approaching dog is fulfilling a need of its own by doing so rather than signaling, with approach, a more specified inner state or plan.

Dogs do seem to use vocalization (barking, growling, screaming, squeaking) with the specific intent of communicating something about their inner state to others. Some signals, such as lifting a lip or retracting the lips to show the teeth, are emitted only when another is very close or when there is direct eye contact. These seem to be consciously other-directed signals, intended specifically to generate feedback from the other the dog is looking at. The same is true of many of the non-threat signals. They seem to be output directly aimed at generating the specific returning input that the signaling dog has been conditioned to anticipate in response to these behaviors. During other-directed signaling, a dog seeks eye contact. It is this eye contact that reveals a feedback-seeking, other-directed signal as opposed to a non-directed indication of a change in the dog's own inner state.

As they mutually orient in "interlocked, intercalated and mutually triggering sequences of possible states with respect to each other, determined through the ontogenic interactions between structurally plastic state-determined systems (Maturana 1975), which can arise when two or more living organisms interact," the dogs generate, through time, "…a history of recurrent interactions leading to the structural congruence between two (or more) systems" (*ibid.*, 1975, p75), in a "…historical process leading to the spatio-temporal coincidence between the changes of states."(*ibid.,* p321). The mutually triggered sequences of inner states are sometimes revealed unconsciously, sometimes through specifically other-directed signals. Unconsciously emitted signals nevertheless are signals, providing information about the dog's inner state, generating feedback by triggering changes in the other's inner state, which then trigger changes in the first dog's inner state. The dog has its tail high because all of its muscles are tense. The other dog has been conditioned to anticipate defensive reactions when it sees this stance, and it reacts by laying its ears back or looking away. The first dog's tail drops a little just simply because its inner state about what the second dog will do becomes less anxious. The second dog sees this change, which triggers a change in its own inner state. For example, it now anticipates a less defensive reaction. The interaction is a little safer than it was a second ago. The second dog might now feel safe turning its head away to sniff the first dog's genital area. This triggers a change in the first dog, which is no longer facing the part of the first dog that contains teeth. In addition, the longer they stand there without attacking each other, the more the first dog's anxiety about the non-aggression rule will subside, just simply due to time passing and an attack still not having occurred. Sniffing genitals has created a tiny bit more distance, the first dog's body relaxes just a bit more, the second dog might now feel safe turning its back to walk away or making a play gesture. As the less anxious dog signals, it is pulling the inner state of the other dog toward congruence with its own inner state: low anxiety, perhaps a willingness to begin recreational interactions. The two dogs work toward a spatio-temporal coincidence between the changes of state: both dogs in the same place and at the same time with low anxiety levels, perhaps experiencing each other's company (in the end) as a resource added to each of their respective fitness hills.

The same thing happens when signals (conscious and unconscious) are used in resolving conflicts between two dogs that know each other. A dog wants to keep a ball, growls at another dog that gets too close. This triggers a change in the second dog, which usually increases distance a little. This triggers a change in the first dog – its anxiety level drops, it relaxes, it stops growling and makes a play gesture. The dogs have, through signaling, brought the binary to an attractor. There is congruence of inner states: both dogs have conserved the resource they preferred (respectively the ball and the company of the first dog), they are in agreement about how much distance will be maintained, and both are now ready to play.

We won't always see dogs go through a long exchange of signals when they first meet. Sometimes a dog will seem to join a group without really being noticed by (some of) the others. In fact, all this means is that their inner states already have the necessary congruence and coincidentality. They have seen each other, make no mistake – but what they observed apparently did not act as a perturbation of any inner states, thus no need to actively seek return to some attractor, since no one was bumped off one.

Conflict resolution

A conflict is defined here as a dispute about a resource. Resources can be all kinds of things. To a fourteen year old dog with arthritis who is lying on her cushion on the floor, freedom from pain is a resource – e.g., not being bumped by a careless adolescent dog as he passes. This is why she threatens the young dog if he gets too close, expressing her anxiety that her freedom from pain might be diminished if the clumsy juvenile doesn't stay at least a yard away. To a frightened dog, distance from the other is a resource, so it will threaten, revealing to the other the importance of holding of this resource. To fGS, the ball was the resource, to mBC the trading game was. In twelve years' time thousands of conflicts between dogs were observed. These were almost always fleeting, and they were always settled by the exchange of signals. Aggression did not occur. In all cases, conflicts clearly served as a learning process. In conflicts, dogs find out which resources the other values and how much physical space the other needs in order not to feel anxiety about the possession of that resource – i.e., they learn the contours of each other's fitness hills.

Conflict resolution means that dogs shift their positions in their own fitness landscapes in order to arrive at a point where imminent instability in the social landscape is avoided or stability is restored. To achieve this, both dogs are making choices. The old dog growls, indicating that she is sitting on an attractor (a fitness hill) she would like to stay on. She doesn't have many choices available that will preserve an equivalent fitness for her (i.e., the combination of resting her tired old bones and freedom from pain; moving to another spot would be painful, so any movement off the attractor she's on would mean a loss in fitness). The young dog moves off. He doesn't have to play right here, he can play somewhere else just as well, and moving doesn't hurt. He shifts to a different one of many optima he has to choose from, perfectly willing to make a trade. The trade (one spot in the physical space for another) might be a slight loss (he was just searching for crumbs under the parrot cage) – but he does it anyway. By doing this, he conserves two resources of his own: stability in the social landscape and the relationship with the old dog. His shift keeps him on a higher hill than the one arguing with the old dog would put him on (even though he'd have the parrot's crumbs on that one). In another case, fCan goes for a stick and so does a park dog she met a half an hour ago. They arrive there simultaneously, upon which fCan jumps all over the park dog, delivering lots of inhibited bites and growling. The park dog, who weighs 20 pound more than fCan increases distance, abandons the stick to fCan, and then runs with her around the field as she carries the stick. He now knows that the stick is an important resource to fCan. He moves to a spot in his own fitness landscape that does not include the stick but does include a continuing relationship with fCan. Apparently he values the continuing relationship with her more than he values the stick. If we say that she has "dominated" him, we are focusing only on the material resource the human sees, and the invisible resources. Then we make the wrong sum. The park dog's behavior demonstrates that *in his own estimation*, the hill with fCan's company but without the stick is higher than the hill with the stick but without fCan as a playmate. This is not positing all kinds of content in a dog's consciousness, nor projecting. This is a way of saying that the visitor dog's inner state is such that he perceives interacting with fCan as adding more to his quality of life than possession of this particular stick. Rather than "submitting", he had made a perfectly selfish choice. This perception of relative values is a result of various conditioning processes (and, of course, of fCan's behavior in the binary). As it is, fCan's company is apparently a stronger reinforcer for this park dog than the stick – but a different life history, or a different history of interactions with fCan, might have led to a different perception of his optima, and to a different choice.

These are just examples. In general, the same two dogs rarely had the same conflict twice, and the longer any two dogs interacted, the fewer conflicts they had at all. The decrease in conflict is a result of learning about the lay of each other's fitness landscapes. Dogs learn by experience when and in the presence of what and under which circumstances another dog will threaten (express anxiety), which comes down to understanding what another dog's fitness hill is composed of, how the other dog values various resources relative to each other, and which shifts the other dog is willing to make in its fitness landscape. Here we again meet learning as a production process, a process that leads a social system through its state space toward an attractor.

What we also see here is the third consensual domain dogs establish in interactions: fitness hills. The third rule governing the organization of groups of domestic dogs is that they will generally try to minimize perturbations to each other's positions on a preferred attractor. Once a dog has learned what another dog's preferences are, it will avoid bumping that other dog far off the position it is sitting on in its own fitness landscape. Sometimes one dog will have fewer optima available than the other. This can be a due variables on any level of organization: in the dog as a system composed of many smaller systems and parts, in the social system the dog is standing in at that moment, perhaps things in the ecosystem at that instant. The dog that has more optima available will then shift to accommodate the other dog. If this involves a physical shift in the physical space, it will control its moves so as to simultaneously avoid perturbing the larger social system by getting too close to or bumping into some other dog. As it moves, the dog is balancing its own inner state, the binary it is active in, and the larger social system simultaneously. The dog will seek compromises that keep all of these systems as stable as possible. Anyone who watches a field full of interacting dogs will see this going on. This is where the observer thinks it is seeing paradoxical choices – but it is not. The observer is just failing to see the resources the accommodating dog is choosing to conserve as it makes a choice that leads, in its own eyes, to equivalent fitness. In fact, when a dog relinquishes a resource to another dog, we must conclude that this choice led to greater fitness than the other choice (holding the visible resource) would have. Interactions must be positive sum to be sustainable.

Stability of the social landscape is, indeed, a resource dogs value highly. Relationship with the other is also a resource a dog may try to conserve. Conflict resolution is clearly aimed at finding compromises that will preserve the binary system and move it toward a stable attractor within its state space, following the shortest feasible trajectory that does not involve aggression. A "feasible" trajectory is determined by factors internal to the participating dogs as discrete smaller systems, agents, within the larger social system.

Meeting novel organisms

The first – the very first – part of the consensual domain dogs have to establish with the other when they first meet is that aggression will not be used. No interaction can take place until both parties are assured that their physical integrity as a living system is safe. Thousands of meetings were observed between dogs who had never seen each other before. In the six cases where attack occurred, there was no signaling preceding the attack, and the attack prevented all other interaction, thus also preventing the formation of a social system. Dogs that use aggression cannot (and therefore are not) be included in any of the social systems domestic dogs form. The material discussed below excludes these six cases.

Dogs consistently began emitting signals as soon as they were within sight of each other, and (as pointed out in the preceding section) sometimes long before that (having smelled or heard the other). They already begin to mutually orient before making close contact, sometimes from more than a hundred yards' distance. Meetings at close hand involved smelling each other and emission of signals back and forth. In only few cases did the mutual orientation involve what humans call a fight. In fact, a "fight" turned out to be merely an escalation of threat signals: these threat escalations never led to aggression. Threat levels decreased consistently as any pair of dogs gained experience of each other, including the experience of having "fought".

When a novel dog came into close proximity of the home group members, all five of the home dogs consistently rushed over to investigate the new dog. Although the new dog's signals were, obviously, perceived by all five of the other dogs simultaneously, the new dog seemed able to concentrate on only one of the home dogs at a time. A typical progression was as follows. The new dog stood still for a short interval while the whole group investigated her/him at once (visually and with the nose). Several or all of the group members would then walk away. At this point, the new dog would approach the home dogs one by one for an individual exchange of signals. Not all the home dogs were always approached. Novel dogs seemed to seek out the home dog or dogs with which the most tension was apparent (to the human observer) in the first interaction. Puppies consistently sought out the adult who did the most grumbling and snapping at them. Adults sought interaction with the dog or dogs (one by one) who displayed the most threat gestures during the initial interaction. These were one on one interactions, in which the approaching dog at least sought eye contact. The other dogs remained at a distance, seemingly totally uninterested, while these paired interactions went on. Even when it came to a "fight", the other dogs usually remained at a distance, although they directed their gaze at the "fighting" pair. On four occasions in twelve years, a "fight" between males seemed to trigger approach by the other group males, who then bumped the home dog involved, tugged on his skin, or ran around barking. This never led to the two arguing dogs breaking eye contact for more than a millisecond. As described above, threat signals decreased as any two dogs gained experience of each other. New dogs clearly attempted to interact with each and every one of the dogs in the group, one at a time, until all tension was gone. They seemed to do this in a descending order according to how much tension there had been in a first interaction. Once the establishment of consensual domains between all the dogs had taken place, it was impossible for an outsider to state which of the dogs belonged to the home group and which was a park acquaintance.

Here I add an important note. The fact that dogs seek out the other with whom stability is farthest away is indicative that the driving function of the dog's social system is to achieve maximum stability on all levels of organization, with a maximum number of agents sitting unperturbed on fitness hills. The system does not, like the wolf's social system, strive to limit the numbers of agents participating. The non-aggression rule operates on the level of the individual dog to guarantee safety in interactions, but on the level of the social system it operates to allow maximization of the number of agents the system can include. Thus, a dog will work actively and often on a binary relationship that is farthest from an attractor, until stability is found.

Besides dogs showing aggression, there was another group that was avoided by other dogs. Sometimes a dog would continue to approach another dog and emit threat signals anew at every meeting, not reducing these threat signals despite multiple interactions. In fact, the threat signals often escalated, apparently reinforced by the mere fact that the approached dog did not attack. The approached dog would, after a number of encounters, show anxious behavior at the sight of this dog – barking, grumbling, growling, and at the same time maintaining or increasing distance. I conclude that the options perceived in the always threatening dog's state space were very limited. It had apparently never experienced reinforcement of non-threat signals, and so did not see this as a possible trajectory in the state space of a binary relationship. It continued to experience anxiety at the sight of other dogs, and it was unable to recognize and use non-threat signals, and thus it was not able to move from the attractor it sat on to an attractor that included non-anxious interactions. This prevented establishment of the consensual domain regarding aggression. It was clear that the continually threatening dog became an unwelcome perturbation to other dogs. They clearly felt anxious in the presence of another dog with whom their non-threat signals did not lead to clear consensus about not using aggression nor to greater stability in the binary system. This is again indicative of the driving function of the social system. A dog that did not permit stability to be achieved was not able to participate in the system for long. Eventually, other dogs would avoid it.

Meetings with novel humans progressed according to what one would expect given the learning history of each dog. Where the learning history was unknown, generating a new one (participant-observation in the shelter) proved sufficient to arrive at adequate behavior in interactions with a dog and to form a binary social system with any dog. The extent of human mastery of the canine signaling system, and human willingness to emit non-threat signals turned out to be an important factor in arriving at adequate behavior within a human-dog binary. Human belief in the idea of dominance hierarchies also turned out to be a factor that could prevent the two organisms from arriving at adequate behavior in an interaction.

I watched many of dogs meet and establish binary social systems with other species, such as cats, rabbits, mice, a rat and a parrot. It is, most of all, the non-aggression rule, the fact that dogs are always seeking compromises that enables them to include so many other species in their systems. It is learning that enables them to find compromises. The dogs learned to understand the signals of some other species as predictors of behavior, and thus to understand them as signals about the animal's inner state in a process of mutual orientation. The home dogs could clearly predict whether a cat or a rabbit was planning to approach, for example. The mammalian species clearly learned to understand the dogs' signals, cutting off approach at an appropriate moment. For example The, rabbit learned not to approach any dog while it was eating, although it wasn't always aware of what was or wasn't a food object to a dog. It avoided the dogs, in any case, whenever they were at their food bowls. A lot of what I observed is not relevant to this paper. What is relevant is that the formation of binary social systems with other non-human animal species also took place according to the model presented in this paper, starting with mutual orientation in which learning was a crucial production process, establishing consensual domains, delineating fitness hills that were not to be perturbed, and attempts to keep the social system on a stable attractor. Also relevant is that no dog ever seemed to enter a binary relationship with, say a fly or a fish. What this means is discussed below.

Participant observation

Participant observation in the animal shelter, during which the author took part in the formation of a non-competitive binary with many single dogs, confirms all my hypotheses. Dogs designated as dangerously dominant-aggressive by staff, dogs which postured in their cages in ways that pack theory requires us to see as “dominant” posturing and threat, responded well to an approach designed to remove anxiety and offer predictability regarding the participant observer's actions while increasing the height of the dog's fitness hill, which had been totally flattened (save the retention of bodily integrity) by transference to a shelter. The heighteners included novel food and social contact as reinforcement of non-aggressive responses, and relief of boredom in the form of novel food, social contact and eventual release from the cage for training sessions on a field or a walk in the woods. Since our model assumes that a dog's perception of its fitness hill is determined by primary physical needs, but also by learning experiences and conditioning, there is no conflict here. Thus, rather than changing any dog's "perception of its rank", participant observers merely provided for a stable, cooperative binary system in which it was clear the participant observer would not threaten the system's stability or the dog's fitness hill. Rather, the observers heightened the animal's fitness landscape and became part of its fitness hill. In the shelter, the participant-observer formed a fitness landscape with each dog, which consisted of only one two-way tube and two fitness hills. Each system achieved stability relatively rapidly, and aggression never occurred. Each dog maintained a boundary it would not let the researcher pass, or only after extensive desensitization exercises, but this had nothing to do with any perception of “ranks”. Rather, it was dependent on the dog's security on its fitness hill and the perception of the researcher's predictability in not perturbing it. The only times threat gestures took place were when the researcher approached the dog in some way when the dog had not yet learned to predict what the human would do. There was not one occasion where a dog attempted to "correct" any human behavior that it did not perceive as directly related to itself and its fitness boundaries. In such cases, the animal was not exerting control over human behavior beyond preventing an perceived impending decrease in the quality of its life at that instant. Though this generally involved posturing commonly referred to as “dominant”, the animal was in fact expressing anxiety as to what the observer’s actions would mean for the stability of its fitness hill. It was offering information about both its internal state and the boundaries of the fitness hill, that’s all. By not attacking, it was giving me the chance to respond appropriately. This shows that the dog was still trying to conserve the resource “relationship”. Human emission of non-threat signals constituted not “submission”, but the transmission of information which made the interaction predictable to the dog, indicated respect for larger system rules, and enabled the system to return to stability. The threat inevitably subsided, and after a period of desensitization (information transmission), approach was possible to the area of the fitness hill the dog had previously defended. The problem of flattening the dog's fitness hill by returning it to its cage until the next training session, which some dogs did react to with threat gestures, was solved by sufficiently reinforcing the return to the cage and remaining to provide reinforcing interactions from the other side of the bars for a short period after the door was closed. Once return to the cage was no longer a signal that total flattening of the dog’s fitness hill was imminent, threat behavior ceased. The dogs entered the cages and immediately oriented for the continuation of interactions through the bars, which they had now learned to anticipate. It should be obvious how presumptions of rank and of a need to establish a hierarchy in which the human is "dominant", as well as the use of so-called "dominance postures" would make interactions with such dogs dangerous or impossible, and tend to worsen the dog's responses to humans. Indeed, responses to shelter personnel demonstrated this fact.

Discussion:
A New Model of the Social Organization of *Canis familiaris*:
Self-organizing autopoiesis

The system

Domestic dogs are generally able and, unlike wolves, willing to interact without aggression with any other dog they meet. Thus, dogs can be viewed as inhabiting a system of which all the dogs that might meet each other, that is, all the dogs alive at any moment, are potential parts. Domestic dogs are also capable of interacting with members of other species as parts of the system the dogs inhabit. The system is nevertheless bounded: it is limited to organisms (parts) which are capable of achieving a consensual domain with a member of the species *canis familiaris*. That seems to mean organisms: a) which emit signals a domestic dog can perceive and learn to use in a process of mutual orientation and the production of adequate behavior; b) which themselves are capable of perceiving the signals a dog emits and of learning to use those in a process of mutual orientation and the production of adequate behavior; and, c) whose system function and position in physical space means that they can or must participate in the domestic dogs' system. The driving function of both binary and larger systems is to achieve epistasis without aggression; that is, to move along the shortest possible trajectory to a system attractor on which each animal is sitting on a fitness hill while others stay on theirs. The larger social system strives to maximize rather than minimize the number of agents present. Thus, the highest peaks in the fitness landscape of this system are those where the maximum number of animals sit undisturbed on a fitness hill, where each animal stays without disturbing others on theirs. There is no hierarchy. The relative height of the individual dogs' various fitness hills cannot be measured by an observer and is irrelevant anyway. A dog is not comparing its fitness hill to the position of some other dog, but to the other positions it, itself, can choose from within its own fitness landscape.

To begin with, I will discuss the system as consisting of interactions between domestic dogs. A discussion of those with other species will follow.

Interactions within the system are binary: two individuals form a connection, which does not influence any connection either of them has with any other dog. That is, the two interacting dogs mutually influence each other's part state through signaling and behavior, whereby any relation either participant has with some third organism are not input. Each dog's part state has, prior to such a binary interaction, been influenced by other organisms and events (e.g., learning history, momentary adrenaline level), but an interaction nevertheless involves the two dogs as parts constituted, signaling and behaving as discrete wholes toward each other at the moment of interaction. This binary exchange of output and input eventually results in a consensual domain consisting of various sub-domains, and in which further interactions take place. The content of the domains of consensus that are reached is limited to the two participating organisms.

Of course, not all dogs have interacted with all other system parts on the planet. A worldwide system exists only in potential, while in concrete reality many smaller systems emerge where dogs actually interact. Thus, inside the larger system, we have smaller emergent systems. The smallest system is on the level of an individual dog and its binary relations. This system can be drawn as a set of binary interconnections between any dog and all other dogs with which it is interacting or has interacted. Each of these other dogs is a part in the social system the subject dog inhabits, but they are only connected to the subject. Their connection to the subject does not mean a connection to any of the other dogs the subject has a binary connection with. Such connections can only be established by any of these dogs interacting itself, as a subject, with any of the other dogs. A binary connection can disintegrate or be maintained without affecting the other binary connections. These connections are two-way tubes by which signals move back and forth, enabling the animals to mutually orient themselves and their behavior to each other. Two-way signaling takes place only through one tube at a time. Thus, a domain of consensus is achieved separately with each of the individuals the dog interacts with. However, one-way signaling can occur over many of a dog's connections at once, as others observe it interacting with the animal with which two-way signaling is active. I call this passive signaling, since the animal concerned is sending and receiving signals actively – in conscious anticipation of generating feedback specifically from this source – only through the tube in which two-way signaling is going on. Others receive, as it were, the ripples caused by a stone thrown at the animal on the other end of the active two-way signaling tube. These ripples can result in a change of a receiver’s part state and of its behavior; but the signaling dog will not respond to these changes until it switches to two-way signaling along another tube. It does this by switching eye contact, which it can only have with one other dog at a time. In other words, a dog can only focus on one binary connection at a time.

Each dog can have many binary connections with other individuals. The connections can be active or inactive. Dogs and other organisms meet on a field in a city park, interact, then leave each other, and may not see each other for a period of time. However, when (if) they meet again, they recognize each other and the binary relationship is resumed. The consensual domain established in earlier interaction is assumed to remain valid rather than having to be entirely reestablished, though the content of this domain can be changed each time there is an interaction. There may be a brief testing of any changes when interactions are resumed.

When more than two dogs are present in the same physical space, a new level of organization is generated. In a group of dogs, for example, on a field in a city park, the individual systems overlap. This must be drawn as a web of binary interconnections, with each dog connected along one line to each other dog separately. These systems must be viewed as complex, since they contain a few or many agents at different times and the number of stable states available to each agent and to the system as a whole is constantly varying. Each dog shares a binary consensual domain with each other dog in the group. The group thus includes any dog that has a binary connection with each and all of the other dogs that are present in the physical space. The boundary of this system is porous. Other dogs can enter the system by establishing a connection and a consensual domain with each and all other dogs in the system (the human observer doesn't always see this happen, but it remains a fact that it does). The system's boundary is, however, distinguishable: when a dog appears in the physical space within which the others are interacting, dogs that do not already have a connection to the new dog may approach it and attempt to establish an individual domains of consensus with the new dog. Alternatively, the dogs may establish a consensual domain without approaching each other (since not approaching is a non-threat signal). Once this has been done, group interactions are resumed and include the new dog, which becomes part of the system as soon as a binary connection and at least minimal domains of consensus have been established with each other dog present.

The establishment of a domain of consensus always includes three things (three sub-domains).

When two dogs meet for the first time and begin to exchange signals, they are not establishing some supposed rank with respect to each other. Rather, they are testing first of all the linguistic domain: whether the other recognizes and responds to signals according to the same signification the signaler assigns to those signals, and if not, what his own signification of those signals is (i.e., what behavior it thinks the signal predicts). This is a process of observing a signal and the behavior that goes with it or immediately follows it, as well as the other's responses to each dog's own signals. It is important to remember here that inhibited bites are not aggression but social signals. So even where a first interaction comes to what humans call a "fight", the dogs are still in fact signaling rather than aiming to damage each other's individual system integrity. It does not matter which dog first reduces the level of threat or gives a non-threat signal. This may well originate in the fact that, for example, the first dog to reduce threat has had enough experiences of non-threat signals being recognized and reinforced to increase the probability of non-threat signals being emitted. Thus, this is not "submission", but the result of respondent and operant conditioning. Because of its learning history, the inner state of the dog returns more quickly to a less anxious condition, which triggers the emission of a non-threat signal. Initiation of non-threat can also, for example, be because the first dog to reduce threat recognizes fear or anxiety in the other. This will trigger a calming of his inner state. The dog may also have learned in the past that it must, in the presence of fear or anxiety, be the first to show it's own willingness to reduce threats in order to produce the reinforcement which movement toward a cooperative or complementary binary supplies. But this aside, a threat reduction in an interaction serves, first of all, as a test of the other dog's ability to understand the signal. This is feedback-generating output; if the other dog interprets correctly what the signal indicates about the first dog's inner state, its own inner state changes in the way the first dog anticipates. If the other then responds with a threat reduction, it shows it has understood what the signal revealed about the first dog's inner state. The second dog also emits signals of its own which the first dog must understand, returning feedback as the second dog anticipates. If feedback is unexpected, the dogs are capable of compensating and assigning a new signification to this particular dog's signals. This is not a mysterious or highly cognitive process – it is simply discerning the contingencies operating in this particular situation. Eventually, the dogs establish a linguistic domain in which there is consensus regarding the signification assigned to various gestures – what the signals are revealing about each others' inner states and what behavior they predict.

The second thing dogs are, simultaneously, testing is each dog's conformity to the fundamental rule governing the organization of the larger social system: aggression will not be used. In the initial meeting, the dogs test each other's conformity to this rule, each testing the other's ability and willingness to work toward stability through social signaling, without resorting to aggression. For all clarity, this can include the delivery of inhibited bites, which, when it occurs, a source of important information to the bitten animal about the biting individual. First of all, it becomes clear whether this other dog has learned to control and inhibit its bite. Secondly, it proves that even in an escalating situation the other animal will continue to inhibit its bite. Thus, even high-level threats such as inhibited bites are benign: the threatening animal is displaying the fact that it can and will inhibit its bite, and by displaying this willingness is still soliciting the other, through signaling, to avoid aggression and come to consensus. Again, which dog first gives a non-threat signal will depend on the internal system state of each dog and has nothing to do with "rank" or "submission". In fact, the first dog to give a non-threat signal is this situation is likely just the quickest to be satisfied that it is safe in the other dog's presence, even when anxiety is high. Thus, even in what looks to the human observer like a "fight", the dogs are using signals to be sure there is consensus about obedience to the most basic rule governing interactions.

These two areas of consensus – establishment of a linguistic domain and consensus regarding the basic system rule (no aggression) – seem, together, to constitute the smallest consensual domain that must be achieved before other interactions can take place. Once this consensual domain has been established, both dogs move about in the physical space, and the third area of investigation is opened.

The organization of the social system determines that the system will migrate as quickly as possible (via the shortest possible trajectory in state space) and *without aggression* to an attractor where the largest possible number of agents sit on their fitness hills and leave others on theirs. This means the basic principle governing relations is compromise about resources and carefulness about social space. This has concrete consequences for how interactions progress on the binary level of organization. A threat will occur only when, and as signal that, a dog perceives or anticipates a perturbation to its fitness hill by the other. It also means that in interactions the preferred reaction to a non-threat signal is reduction or cessation of threat. But to leave each other on fitness hills, a dog has to have some knowledge of other dogs' perceptions of their fitness landscapes. So the third thing that dogs find out about each other is the topography of each other's respective individual fitness landscape – where the other perceives the slope of the hill s/he sits on as beginning (how much physical distance does it want), what elements constitute the hill (what will it want to keep), and what will be perceived as a disturbance of it. This lack of knowledge about each other may find its expression in increased tension (visible in various stress signals) in each other's presence at first, and in occasional (brief) threat-matches during play or interaction. The dogs move around a field, playing with each other or with others or a human. They discover each other's fitness hills as approach beyond a certain distance results in a threat, if an object is in possession is guarded with threats, and so on. The reaction of the threatened dog will act as feedback, perhaps triggering a change the first dog's behavior toward this dog (e.g., it might tolerate closer approach without threatening next time, or it might signal that it wants even more distance). The dog that threatens is expressing perception of an impending perturbation to its fitness hill. In this sense, the dog emitting a threat signal is indicating anxiety about what the other will do rather than control over the interaction. The animal emitting non-threat signals is in fact controlling the interaction, taking the initiative to lead the binary to an attractor according to the larger system rules. Threats, thus, are linguistic signals that express anxiety and serve to stimulate the formation of a consensual domain regarding fitness hills. They do not indicate intent to damage or "dominate" the other. This exchange of signals generates a third domain of consensus between each two dogs: each dog eventually knows where the other dog's fitness hill lies, how not to disturb it, and to what extent they are each willing to leave the other on its fitness hill with the particular elements that constitute that hill. The dogs, in their binary interactions, arrive at a point where they are able to display adequate behavior toward each other and cause a minimum of perturbations to each other's fitness hills and to the larger system.

When a new dog enters the system through the system's porous boundaries, we may see a perturbation to the system. This can be on the level of the individual dog, whose inner state is perturbed by the sight of the newcomer, and stability of the larger system may also be threatened. The new dog might not be an adequately produced and functioning system part, it may not share the linguistic domain, there may have to be a shift in fitness hills and changes in the fitness landscape of each dog and the whole system as adaptive walks across the fitness landscape are made to accommodate a new system part while returning the system (on all levels) to stability. One or more group members may rush over to test and establish consensual domains with the new system part, which consensus restores system stability. The incidence of threat signals may be heightened for a time between various dogs, but these conflicts should be seen as skirmishes around the boundaries of fitness hills rather than disputes about rank. Once all participating dogs have arrived at consensus with the newcomer regarding where the fitness hills are, what constitutes them, and leaving each other there, stability returns and threats return to the minimal level that is normal among dogs.

This does not mean that "ranks" or a "dominance hierarchy" have been established. As pointed out above, being the first to signal non-threat does not mean that the other has "won" an "aggressive" encounter. Secondly, the respective height of a dog's personal fitness hill exists only in the perceptions of the dog that occupies it, so the hills cannot be rated by an observer according to height. The same applies even where a resource is relinquished because "resource-holding" cannot be rated by an observer, either. A domestic dog's valuation of a given resource will depend on its internal state at a given moment and on its learning history. A dog may or may not value balls, some value balls more than food, some don't particularly respond to females in heat, each has a different learning history and internal state with respect to every resource present in the physical space. Furthermore, relationship itself is part of a domestic dog's fitness hill, as is stability in the social landscape: these, too, are resources. A dog may prefer to give up a certain resource because it values maintenance of and stability in the binary more than it values possession of the contested object as part of its fitness hill, thus shifting its position on its fitness landscape so that continuing participation in the binary rather than possession of the object is chosen.

This may look to a human observer like a loss. However, the net gain in an interaction due to maintenance of relationship and periods of stability may be greater than the loss due to making some other shift. In interactions, and in conflicts regarding its fitness hill, a dog will be weighing all of many factors according to its own internal state and learning history. Various combinations of various factors may all produce the same optimum fitness: there is more than one compromise available. A dog may decide to move to what appears to a human observer to be a lower fitness hill. However, we cannot see the dog's map of its landscape, and cannot, outside of extreme situations, know whether the dog finds this hill lower or merely one of several available and perhaps equal optima. Therefore, we must assume that each dog is not attempting simply to maximize the height of its fitness hill, but rather that each is trying to settle upon one of many optima, each of which is constituted by many factors simultaneously. Any height assigned to these optima by an observer is arbitrary, being inevitably based on the observer's own internal state, learning history and subjective valuation of the weight of the various factors s/he is capable of seeing at all. The observer can, like any dog in the system, draw a number of general conclusions regarding a particular participant's fitness hill (e.g., a dog is reinforced by play with a ball or will defend food objects with high-level threats), and a human observer can make guesses about a history of learning that led to this behavior, but that is all, and it does not mean we know the relative height of a particular fitness hill. When the system has settled on an attractor, that is, when threats have come to a minimum and stability has returned, the observer can only conclude that each dog is sitting undisturbed on a fitness hill it considers one of its available optima. This does not mean that *all* needs are met, but that dogs seek compromises between various possible inner states as they seek stability on many levels at once. A dog may trade off some inner stability in order to maintain or restore stability on the level of the binary or the larger social landscape. This means that, weighing various available possibilities according to its own inner state (including its expectations and knowledge of any relevant others in the social landscape), each dog has made choices that, juggling many variables on many levels, lead both it and the system it is part of to one of many available attractors. What we see within the binary is in fact co-evolution of the participants' respective landscapes and positions rather than competition for position in a hierarchy.

In a group of dogs interacting in some physical space, we have a system composed of many binaries. The binary is the only level of organization the dog actively influences, unlike genes with some higher level that switches them on and off, nor like a human colonel with many troops under his control. Because dogs don't have to (and can't) regulate multiple relationships simultaneously, and because they do this one on one, each dog's behavior is a relatively easily compensable perturbation to the dog it is interacting with. With dogs it already knows, all a dog has to do is maintain the consensual physical distance while it moves around the physical space. Dogs are very good at playing wild games without bumping into others. A dog can, therefore, concentrate on dealing only with whatever perturbation a new dog has caused without having to deal with input from and generate output for many other agents at the same time. The fact that dogs regulate relationships one on one and not collectively is the very thing that enables the larger system to return to stability in the face of a perturbation so easily and quickly on all levels.

Despite having various anatomical structures similar to canine predators, domestic dogs are not predators, they are scavengers. Unlike wolves, they do not hunt large prey and there is no advantage for a domestic dog to being in a group as far as food acquisition goes. Thus, one might ask why dogs bother, why each dog doesn't try to be alone in a mono-stable system in which it is the only participant aside from intervals related to sexual reproduction. There are dogs that do that. The fighting breeds are apparently unable to cope for long with a bifurcating system (one where possible system states increase to larger than one), and eventually attempt to return to the mono-stable state by killing the conspecific with which interaction is taking place. Any dog that has not undergone adequate production processes may be unable to take part in a binary or a system composed of many binaries. Such dogs often freeze in a fear posture or flee at the sight of a conspecific, or try to chase other dog away and sometimes will attack and try to kill them. For these dogs, even sexual reproduction can be impossible. Dogs that are systematically punished by their human owners for threat signals towards conspecifics may experience conspecifics as conditioned punishers and attempt to attack them at sight. This brings us to the discussion of the production processes involved in the production of adequately functioning system parts. Here we will also find the answer to why dogs bother to interact.

Since domestic dogs are a species that engages in sexual reproduction, conception and birth are the first steps in the production of a system part. However, a dog is born as a functioning physiological system, but not as a functioning part of any other system. A puppy has only the *potential* to become a part in some larger system. It has the anatomical structures necessary to take part in a linguistic domain, but the signification assigned to various signals must be learned. It has a brain capable of learning, and sensory organs that enable it to perceive a certain part of its environment, but it must learn adequate behavior with respect to this environment.

When a dog is born, we must presume – where the mother does not immediately kill it – that it is initially part of the mother's fitness hill. She is fulfilling one of her functions in an autopoietic system, in which, by definition, all parts participate in the production of functioning system parts. The mother and any siblings are the first conspecifics a puppy is exposed to. Various apparently inherited behavior patterns are reinforced: crawling combined with the searching movement of the head back and forth, which will disappear after a short time if it is not reinforced by the discovery of a nipple or the warmth of the mother's body or a pile of sleeping siblings, a period in which the smell of conspecifics also becomes a conditioned reinforcer; the emission of a high toned distress signal when separated from the warmth of the mother and siblings, which for a certain period leads to retrieval by the mother, a period in which the emission of high toned vocalizations is learned as a behavior that is reinforced; lying on the back being licked by the mother as she cleans the urinary and anal areas, a period in which lying in this position is learned as a behavior that is reinforced. A puppy is discovering the basic principle that behavior leads to a reaction in the environment. It is also undergoing respondent conditioning, in which the presence of conspecifics is associated with the meeting of basic physiological needs. In addition, even before it can see and hear, a puppy is already learning certain elements of the signaling system as certain behaviors (e.g. lying on the back) lead to a pleasant experience (the mother's licking), though it cannot yet use these elements as signals. The foundations are laid for participation in an autopoietic system involving signaling and group membership. This is the period in which puppy undergoes respondent conditioning, which will lead it (or at least enable it) to find interactions with conspecifics reinforcing for the rest of its life.

As the puppy grows, its eyes and ears open, and it is confronted with new input from the environment. This means that it is confronted with new behavioral puzzles: what the significance of various input is and how to react to this input. When a response has already been reinforced, its probability increases over that of behavior that has not been reinforced (Skinner 1938). Thus, puppies can be expected to approach siblings and mother, and to frequently display such behavior as high vocalizations and lying on the back – behaviors that already have a history of reinforcement. As they develop physically, puppies are also able to begin displaying a broader repertoire of behavior toward the mother and siblings, and to discover the contingencies that govern the reinforcement of various behaviors (Skinner 1969). This is a period where a pup might discover that aggression is reinforced. However, the system requires that aggression not occur and that the rule of leaving the other on its fitness hill be obeyed. This means that we must interpret the mother's behavior in this context. When she reacts to a puppy with a frightening display of threat, she is not "dominating" it. Rather, she is conditioning it on a respondent level to find certain elements of its own behavior aversive, and on an operant level that certain elements of its own behavior will lead to an aversive event. In the face of such a threat, the puppy will try a behavior that has already been reinforced (e.g., lying on its back, high-toned vocalizations, licking the other's mouth corners) or may discover a new behavior that is reinforced by the cessation of threat (e.g., tucking its tail, increasing distance). It learns to interpret various levels of threat, e.g., to predict that certain signals will be followed by the delivery of inhibited bites, and it beings to develop avoidance behavior (the emission of non-threat signals). The mother is thus the first to help the puppy assign signification to various physical signals. At the same time, she teaches them certain system rules and rules that must be obeyed in binary relations. In interactions with siblings, a puppy learns various play signals that are, like other behavior, at first only present as potential or random behavior until they are reinforced in practice. It discovers the principle of individuality: that not all conspecifics react exactly the same way to a certain behavior. It also learns that the behavior of a particular individual can, with time, be predicted with some degree of certainty. Domains of consensus can be achieved. All of this takes place at a moment when the brain is laying down its fundamental neurological connections. The aversion for behavior of its own that could lead to a frightening outburst from the other and the experience that non-threat signals stop such an outburst will end up deeply anchored as a fundamental part of the puppy’s later responses in social interactions. The fundamental preference for non-threat signals and the fundamental willingness to seek compromise are both a result of these early interactions with the mother (and a few weeks later with other adult dogs). They are not innate or mysterious, but are the result of well understood conditioning processes.

By the time a puppy interacts with an adult dog other than the mother, it has a set of behaviors at its disposal that have been reinforced, others that have been punished, a number of reinforced avoidance behaviors, and some understanding of the signification assigned to various signals. In interacting with other adults, the puppy must undergo a learning process which includes generalization (e.g., the fact that other adult dogs use and respond to similar signals as mother and siblings) and discrimination (e.g., the fact that other dogs are individuals which will threaten under varying circumstances). It continues to undergo respondent and operant conditioning processes, generalizing the lesson that aggression is scary and aversive, as is any of its own behavior that might trigger aggression, and thus that threat signals are best responded to with non-threat signals. In the period before the milk teeth are replaced by the adult teeth, the puppy learns great exactness in inhibiting its bite. Again, this is learned empirically, and conditioned on both a respondent and an operant level by the responses of conspecifics. A functioning system part is being created.

In an autopoietic system, all system parts participate in the production of new system parts. That domestic dogs live in a system larger than the family unit wolves live in (Mech 2002) is demonstrated by the fact that a puppy seems to become a part of the fitness hill of any socialized adults it interacts with. In fact, few domestic dogs grow up in a family unit. Most are dependent for further "parenting" (i.e., production as functioning system parts) by conspecifics on meeting unknown and unrelated adults after they have left the mother and been placed in a human home, where they often may be the only dog. Almost all adult dogs seem to find interaction with a puppy reinforcing. This is partly because domestic dogs have all undergone the initial conditioning in their first seven weeks to find interaction with conspecifics in a stable binary reinforcing. Part of it may be that it is particularly reinforcing to interact with a conspecific which is so clearly no threat at all to any adult's fitness hill, whether or not it is yet socially competent. In any case, observations show that there is the usual first step of establishing a consensual domain, after which many adult dogs will actively seek play with the puppy. Adults often lie on the ground so that the pup can reach their heads for mouth-to-mouth play-"fighting". They often lie on their backs in such a way that the pup can climb onto their bellies and play-grab their throats. This probably constitutes the recurrence of old behavior in the presence of a the original conditioned signal (a puppy); the adult reverts to behavior it engaged in with its siblings in its own puppy days, behavior that was frequently and strongly reinforced.

Thus, adult dogs do not enter a competitive binary with a pup, but seem concerned with teaching it the skills it will need to be able to participate successfully later in a complex system. Threats to pups seem not so much focused on changing or maintaining the height of a fitness hill, which a pup cannot threaten in any case, but on getting the "right" social response in the form of non-threat gestures from the pup. Further, these threats show a greater intensity than those seen with adult dogs. A pup will may be pinned under the body of an adult as the adult snaps its teeth in the air around the throat of the pup and growls, sometimes the adult will pin the pup down and place its jaws around the pup's neck or belly, all in a sudden outburst of seemingly overwhelming violence. Human bystanders often think the dog is killing the pup. Rather than interpreting this as some sort of psychotic need to "dominate" a pup, it seems that the adults, preparing offspring to participate in a complex system and to strive for stability of the system rather than pure maximization of its own hill, condition pups to be sensitive to signals and system rules, to strongly prefer non-threat gesturing, and to fear the consequences of triggering or using aggression or even of delivering a not sufficiently inhibited bite. Thus adults are being produced to whom the very idea of using aggression, which would hinder the system's ability not only to gravitate to an attractor but to continue existing at all, is highly aversive.

Adult dogs also adopt this parenting-instructor role toward adolescents, though the level of threat in a conflict is substantially toned down: the sudden, overwhelming outburst of all kinds of extremely elevated threat behavior that is shown to puppies was never observed toward an adolescent. The adults either ignore careless behavior and allow the adolescent to join in play, or there is an increase in barking and air-snapping toward the adolescent, which eventually settles down without direct conflict or posturing. Rarely, a young adolescent will be knocked over and pinned with a neck grab or "stood over" by one of the adult dogs. Even more rarely, an adult will stand with the forepaws on an older adolescent's withers, threatening the back of the neck with bared teeth, a gesture that was never observed between adult dogs. Adolescent signaling is also different than that of domestic dogs of other ages. Adolescents do not threaten adults, and they often use play stances and sudden flight to indicate non-threat, rather than the displays puppies or adult dogs use. It is typical for an adolescent to suddenly throw itself into the middle of a group, putting on a play face (Abrantes 1997), without the carefully non-threatening approach or the threat and non-threat posturing an adult dog uses, trying with great energy to participate in play without introducing itself, as it were. This behavior proved to be a reliable indicator of age, particularly in male dogs. The few adolescents (of both sexes) who used puppy gestures such lying on the back, licking the mouth corners of the adults, urinating, when meeting non-parenting adults continued to use these signals into adult life when approaching unknown adult conspecifics. This is not an expression of mysterious internal traits, but more likely the result of conditioning processes that these particular dogs underwent in their very early interactions with other dogs.

Once dogs have regularly assumed the parenting role toward a conspecific, the dogs seem to maintain the parent-offspring role towards each other permanently. The threat and non-threat displays they employ toward each other remain different from the displays one sees between dogs that met or meet as adults, throughout the rest of their interactions. Dogs will often continue to correct the social behavior of adults they have instructed from youth, using signals they otherwise use only with infants and adolescents and do not use with other adult dogs, such as pinning with a neck-grab and amplified threat signals for seemingly small or even impending infractions of politeness (i.e., respect for boundaries of a fitness hill), or a stare to correct some impending infraction of social space. Conversely, an adult dog will use gestures toward its instructors that it does not use toward other adult dogs, such as profusely licking the corners of the instructor dogs' mouths at times of greeting and during play, or releasing urine during the greeting (females), or rolling on the back with a hind leg lifted during a greeting (males and females).

My observations show, in other words, that the autopoietic function of producing system parts must be a driving function in the behavior of domestic dogs in cases where adults have begun to interact with another dog before it reached the end of its adolescence. Domestic dogs assume the responsibility for instructing the young, through conditioning processes, in the art of participating in a complex system and allowing it to gravitate toward an attractor. Adults are willing to continue this instruction throughout the younger dog's adult life. They are not establishing power hierarchies, but assisting a younger dog in finding out which behavior will, and which will not, constitute adequate behavior in a social system with other dogs.

But this is not the end of the production process. It appears that adult dogs who are first encountered as adults are expected to know the rules without instruction, and are merely tested at the porous group border to check that this is the case. That is, adult dogs are assumed to be finished and functioning parts not in need of further production. However, dogs live with and are dependent on humans, and not all are adequately socialized in their youth (Scott & Fuller 1974). Thus, an adult dog sometimes turns out to be a malfunctioning or unfinished system part. In cases where the unfinished adult dog does not display aggression, it undergoes a repair or finishing process in its interactions with other adult dogs. Although there are dogs that have learned that bullying a frightened conspecific is in some way reinforcing, most dogs respond to a frightened conspecific by ignoring it, even when it is displaying threat signals. An adult dog that is clumsy in avoiding the lower slopes of another's fitness hill will be threatened, but not attacked, until it has generalized this non-perturbation system rule. In the field of behavior therapy, humans recognize that the best treatment for a dog that has trouble interacting with other dogs is to expose it to as many other dogs as possible, as frequently as possible, on a field in a park somewhere, without interfering in their interactions (Askew 1996; Bohnenkamp1994; Donaldson 1996). This constitutes an implicit recognition, even by authors who still speak of "dominance" and "submission", and who are unacquainted with complex systems theory, that dogs inhabit a self-producing system in which parts undergo a production process at the hands of other parts, and that this process includes part repair where necessary throughout the dog's adult life. This can also occur in the form of play. Play is interaction within a consensual domain which is created prior to the interaction by gesturing among the participants indicating that all bites will be symbolic and controlled as long as the consensual domain is maintained. Within this domain, no fitness hill is in question. Rather it is a domain within which the linguistic domain can be reaffirmed and various other behaviors practiced without consequences for fitness landscapes at any level of organization, except in so far as play itself is a resource that heightens the landscape as a whole for the participants.

As a final note regarding the production process, it must be said that a dog that malfunctions to the extent that it attacks others cannot and will not be repaired. Attack makes it impossible for the dog to which the attack is directed to execute any sort of conditioning or repair process. Creation of any consensual domain is made impossible. The receiving animal may be so damaged as a system in itself that it disintegrates as a system: it may die. If not killed, it may cease at that moment to be able to function due to serious injuries. Or it may flee, which means all interaction – and thus any repair process interaction might include – is terminated. All of these results (death, injury or flight) may work as reinforcers to the malfunctioning dog's aggression response, thus heightening the probability of attack occurring in following interactions with conspecifics. On the other hand, attack might be met by counter-attack, in which the first dog is killed, seriously injured or forced to flee. In all of these cases, the malfunctioning dog either ceases to exist as a system or is subjected to a respondent conditioning process which strengthens the perception of conspecific as aversive. On an operant level, the sight of a conspecific is affirmed as a signal of impending punishment. Thus, aggression cuts off all processes by which the malfunctioning dog could be repaired as a system part. A domestic dog that shows aggression cannot be part of either any sub-system or of the larger, worldwide system that other dogs inhabit. Here, we meet not only the limitations of the production process, but also the boundary of both system and sub-systems. Canine systems include only those organisms that obey the rule that aggression will not occur.

Observation shows that the system inhabited by domestic dogs can include other species. Members of those species undergo production processes similar to those described above, with the exception, of course of the infantile period with the canine mother. Thus, members of other species can be shaped into functioning system parts through the mutual and reciprocal learning of signals and the establishment of consensual domains regarding the non-aggression rule and the location and non-perturbation of fitness hills. In our permanent group, the rabbit present quickly learned to keep distance when the dogs were eating and to approach slowly and carefully when it wanted to lie next to a sleeping dog. The dogs seemed to learn to interpret the rabbit's grunting sounds as a signal indicating an intention to approach, and responded with either threat, non-threat or play gestures. The rabbit quickly developed the response of increasing distance in the face of a threat, approaching at non-threat, and freezing when play gestures were emitted. mBC learned that when the rabbit approached, froze, and lay its ears back with its head against the floor, the appropriate response was to lick the rabbit's head and body. The same process was observed with the cats in the home, though the content of the linguistic domain was slightly different. The free-living house rat was also incorporated into the system. Cats met outside were chased until they stood still, at which point the dogs seemed to interpret a cat's threat gestures (tail low, ears flat) (Leyhausen 1979) as appropriate non-threat signals, and increased distance (walked away from the cat). A cat that had been chased and cornered three or four times, and had each time shown this "appropriate" "non-threat" posture, was subsequently ignored. Rabbits met outside the home were intensively investigated, then left alone. This is not to say that all dogs will respond this way to these species. It merely proves that dogs *can* include other species in their social systems, dependent on production processes that both the particular dogs and the members of the other species undergo or have undergone.

Humans

Observations done during this study showed that the species with which this process most often fails is the human species. There are many reasons for this, though anything more than the following short sketch is beyond the scope of this paper.

In part, this failure is due to the apparent structural rigidity of humans as signaling systems. We are verbally oriented. Although our non-verbal signaling constitutes about 70% of all meaningful signals exchanged in an interaction, this takes place on an unconscious level. Humans are not used to observing and controlling the non-verbal signals they give. In addition, humans seem unable, or perhaps are simply unwilling, to learn the signaling systems used by other species. A third factor is that our own systems rules are different. Aggression is not forbidden by them, but rather is an integral part of how human societies organize themselves, in particular where males are concerned. (I am not talking about the way we like to see ourselves, but about the way we behave in reality, as shown by all kinds of statistics and the general state of the world.) We seem unable to perceive the rules applying in other systems. Humans interpret threats from other species as signals that aggression is impending, failing to perceive that a non-threat signal is merely being solicited, and we (in particular males) tend to apply our own system rule that we must meet this perceived aggression by being the first to attack (human females are more likely to appease or flee). Our history is full of the annihilation of other organisms because, unable to step out of our own system's descriptions and rules, we perceive impending aggression from them.

This response is presently strengthened in all human systems that are influenced by the body of beliefs referred to in those systems as "science". Here, as in various religions that affect human responses to animals, so-called persistence of beliefs plays a role. The inheritance of Descartes strengthens the failure to perceive animals as systems whose signals could have meaning, as it also strengthens the failure to perceive any animals as individuals with whom interaction is a mutual and reciprocal learning process. The dominance hierarchy model, which since the early twentieth century is also subject to persistence as a belief in both scientific and lay circles, gives the "scientific" stamp of approval to the application of our own system rules in our observations of and interactions with, among other species, domestic dogs. It leads us to interpret the signals and behavior of dogs according to the contents of our own human consensual domain, thus preventing us from perceiving the domain of consensus within which dogs in fact interact. This model also hinders humans in their ability (or willingness) to reach a domain of consensus with a dog they interact with. Giving off a non-threat signal to a dog is stamped "submissive", and the model warns that this will be met with "dominant" behavior from the dog. The model further ignores all the insights behaviorism yielded as early as 1938. Although this knowledge seems now to be slowly percolating through to some biologists and veterinarians who work with dogs (Abrantes 1997; Askew 1997; Bohnenkamp 1994; Donaldson 1996; Overall 1997; Voith 1982; Voith & Borchelt 1996), many persist in their belief in and use of the dominance hierarchy model. This persistence of belief in the face of contrary evidence is illustrated, for example, by one author who, after not only having talked extensively about conditioning processes, also remarks on the fact that tri-cyclic antidepressants (which are all anxiety inhibitors) are useful as support in the treatment of “dominant” aggression – only to then continue on at length about getting the dog to perceive its “rank” in the family “dominance hierarchy” differently, without missing so much as a beat (Overall 1997, 2002).

This rigidity of the human belief system, and thus of humans as behaving systems, dooms them to be non-repairable system parts when they interact with dogs. In many cases, the structural flexibility of dogs as behaving systems allows a stable, non-aggressive binary relationship to be established despite human behavior. But in many cases, the inflexibility of human behavior leads to interactions involving aggression. In first instance, the human is the attacker. Much puppy behavior, such as play biting or urinating in the house, or failure to respond to an inadequately conditioned signal (i.e., a command) is interpreted as some sort of “dominance” or attack, and is met with attack (hitting, kicking, throwing things at the dog, jerking on a choke chain) by the human. In older dogs, not only such threats as growling or lifting a lip, but also failure to respond to an inadequately conditioned signal, as well as extinction aggression and intense or persistent behavior generated by intermittent reinforcement are also generally interpreted as "dominant" and met with attack or punishment by the human involved. Humans often continue to threaten and/or attack when a dog gives non-threat signals. Then, when a dog has exhausted its repertoire of non-threat signals to no avail, resulting defensive aggression by the dog is labeled as failure to "submit". Participant observation in the shelter proved that where a human obeys the canine system rules, tries to construct a consensual domain rather than to achieve “dominance” , and consciously applies respondent and operant conditioning, aggression from a dog does not occur.

Again, and perhaps because of processes described by Kuhn (Kuhn 1962) and due to financing and other competitive structures, which lead to a lack of interdisciplinary study in many "scientific" disciplines, there is a general failure to take into account the conditioning processes which are going on during these aggressive interactions. Humans may become conditioned punishers, leading a dog to show more frequent threat or attack behavior (Azrin, *et* al 1966; Azrin *et al* 1968; Powell *et al* 1972; Sidman 1989). Since a human is easily damaged by a domestic dog's weapons, aggression by the dog is often – though perhaps only negatively – reinforced. Inhibited or uninhibited bites that were originally preceded or accompanied by fear signals may eventually be preceded or accompanied by signals that are, mistakenly, generally labeled "dominant": high ears and tail, high posture, etc. In fact, the dog has not "become" or "turned out to be" "dominant". Rather, it has undergone an operant conditioning process that has elevated the probability of biting as a response in circumstances not necessarily involving fear. The "high" or "dominant" posture merely indicates that the dog does not feel fear, but only anxiety – because the dog now possesses learned self-assurance that biting will be reinforced. It is anxious about what the human will do but, unlike the fearful dog, it feels confident it can cause the human to back off. When this process has led emancipation of the behavior and to a wide generalization of biting in response to many signals and in many situations, it is incorrect to attribute this to some presumed internal, innate characteristic of the dog, or to conclude that dogs organize their social systems by the use of “dominance” and/or aggression.

A final effect of the human persistence of belief in the dominance hierarchy model is that humans may never learn the principle of leaving the other on its fitness hill. We want a one-way street with animals that live by the rule that interactions are two-way streets and that all participants will compromise. With us, dogs are generally supposed to let humans take food and objects away, to chase them from sleeping spots, to commit various sorts of violence, and so on, without the dog indicating by a threat that it is anxious about an anticipated perturbation of his fitness hill, or that a fitness hill is being perturbed, or that system integrity is being threatened. They are not allowed to ask us to consider their inner state or to reach a compromise. Any signal from the dog that it anticipates a perturbation or a threat to its integrity as a system is interpreted as “dominance”. Even when the dog resists by simply not moving, or doesn’t move because it doesn’t understand what we want, we attribute this to it thinking it “outranks” us. We believe that any and all of this behavior must be met with some sort of threat or aggression, or at the very least a training program designed to “lower the dog’s idea of its rank”, and our aim is to get the dog to always allow perturbation of its fitness hill at all times and under all circumstances. Thus the human's persistent belief system prevents the human from discovering the basic real system rule, and leads her/him to ignore and disobey it persistently, which again may lead to an escalation of threats ending in aggression and/or disintegration of the system in which the human participates (often by execution of the dog which has bitten). Furthermore, the human is, rather than participating in the production of functioning system parts which is required of all members of autopoietic systems, attempting (inadvertently or not) to damage or destroy functioning system parts through the process of conditioning it is subjecting the dogs to.

Thus, what may happen in the interaction between a human and a dog is that the human turns out to be resistant to the production processes which produce, finish or repair system parts. As a result, the human involved cannot be integrated into the system which one or more dogs inhabit, and must be either attacked or altogether avoided. Aggression, including aggression toward humans, is not a result of the principles governing the organization of canine systems, but the result of a breakdown of the system where an irreparable part is involved. The irreparable part is, be it by fatal attack, threats leading to the irreparable part's flight or flight from the irreparable part, placed outside the system's boundaries.

Analyzed in terms of the model proposed here, human cognition is possibly less plastic than that of a dog with all its neurological and cognitive limitations, since the dog is not subject to some of the complex group pressures humans operate under, and a dog may be more able to incorporate new descriptions than a human at any particular point in human history. Where a domestic dog, within its own cognitive domain and the consensual domain it shares with conspecifics, in fact attributes another signification to these signals that humans describe as "dominant", and a human is unable (or unwilling) to adjust its own signification of these gestures, there is failure to generate a consensual linguistic domain between the dog and the human. This leads to various problems. Arising from this failure, both organisms are unable to find and display adequate behavior, that is, behavior that allows them to interact without disintegration of system unity. That the system is affected at various levels is demonstrated by the fact that, for example, domestic dogs often bite humans, and that domestic dogs are often killed for having bitten humans. The integrity of the bitten human as a system is damaged, the dog is terminated as a system, and, where the human does not keep the dog that bit it, the binary system they occupied as parts ceases to exist. A second problem is that attempts by humans to modify a domestic dog's behavior will be less successful as long as the consensual linguistic domain has not been achieved, since behavior modification involves (among other things) the ability to understand the signification the animal itself is assigning to various signals: that even seemingly self-assured threats indicate not “dominance”, but anxiety concerning the perturbation of a fitness hill and/or system integrity. Finally, the failure to achieve a consensual linguistic domain affects the ability of the scientific observers to reduce the superstitious content of her/his system of beliefs. It is assumed here that attempts to find descriptions for the organization and structure of animals or groups of animals are attempts to discover properties internal to the observed system(s) rather than to impose descriptions which in fact refer to the organization and structure of the system(s) the observer is or occupies. Therefore, a failure on the part of humans to discover the signification the animal attributes to various signals limits the capability of researchers to discern and describe the organization and structure of the observed system, as well as the ability to understand how behavior of single organisms is generated within that system.

The theory that domestic dogs inhabit a dominance hierarchy is no longer tenable. A "linear dominance hierarchy" is a snapshot of a dynamic system, confusing this snapshot of observer-defined relative fitness hills at a given instant with the organizing principles of the system. In fact, the system allows many different snapshots as it moves through state space, and the criteria determining the relative height of fitness hills are largely invisible to the observer. The interactions of parts are not predetermined ("rank" does not exist except as a human statistical construct), and many "hierarchies" can result. These hierarchies are human artifacts and irrelevant to system organization. But even the old theory's description of structure ("hierarchies") is based on measuring phenomena which have seemed relevant to male human observers, failing to take many biases on the part of the observer into account. Not only does this observation confuse social signaling with aggression, but it also has included sloppy definition of the terms it uses (aggression, resources, wins). Even the species studied has been sloppily defined, seeing domestic dogs as a sort of tamed wolf, predators in our living rooms. That is all very romantic and perhaps good for the human ego, but dogs are not wolves. They are scavengers, not predators, and their natural habitat is human society, not the untamed forest. They do not live in packs, but in ephemeral, highly porous and loosely organized groups, whose membership is constantly changing and can include other species. The system’s organization allows for easy compensation of perturbations and easy absorption of new parts. Parts move easily within the physical space, and they shift easily and quickly between personal optima. The structure of the dogs’ system is highly plastic. In short, the old theory confuses structure (the momentary arrangement of specific parts within a system) with organization (the principles governing the dynamics of the system), and is inadequate even in its description of structure because it looks only for an instant and without even knowing which animal it is really looking at. Discarding the dominance hierarchy theory enables us to solve the conflict between the model we use and the actual behavior we observe in groups of domestic dogs.

Summary and conclusions

The model presented here, of dogs as occupants of a complex autopoietic system, provides an accurate and conceptually elegant way to represent canine social systems and understand system organization and structure, as well as better understanding discrete interactions within the system. Looking at dogs this way solves a number of serious problems presented by the older model, which represents the social organization as a dominance hierarchy. It provides us with a means of studying and describing the animals' and the system's behavior which does not conflict with the behavior observed, and, no less important since we are dogs' natural habitat, it allows us to interact more adequately with domestic dogs we live with.

The model itself is not new, but applying it to dogs is. In addition, by doing so, this study was able to discover three simple principles governing the organization of their groups and accounting for behavior on all levels of organization. The first principle is: no aggression. The second is: we will find a common language and try to establish a complementary or cooperative binary. The third rule is: once we know about each other's fitness positions, we will make compromise so as to minimize perturbing those. As dogs interact, they are juggling variables from and seeking stability (epistasis) on multiple levels of organization. The dog's signals serve to establish a consensual domain within which two dogs can interact safely and adequately; as they signal, the binary moves along a trajectory in its state space, seeking an attractor. The dog that emits non-threat signals is, in fact, leading both the other dog and the binary toward a stable spot in their respective state spaces. As a dog interacts with another dog in a binary, it is still keeping an eye on the larger social landscape and watching out not to accidentally perturb any of the others present. If a dog bumps another dog while playing, it must shift eye contact and exchange signals directly with the bumped dog before it can focus on the other binary again. It can't do both at the same time. Each dog has an individual fitness landscape that it moves in. This fitness landscape contains the many subjectively defined optima that dog may choose from. There is also a fitness landscape each larger system may move upon. Optima for the larger system are defined by the maximization of stability in the social landscape without the use of aggression. Each dog occupies a fitness hill in its own landscape, and the dogs are constantly exchanging signals regarding these fitness hills in order to avoid perturbations. Dogs are quite wiling to make trade-offs in order to preserve stability of whichever social system they are participating in. Their choices are not paradoxical: both social peace and continued relations with other dogs are valued resources. The system's border at the third level of organization (groups larger than two) is porous. Each time another dog passes through this border, all inner states and fitness landscapes may be perturbed, information is exchanged, inner states find new equilibriums, and shifts among individual optima may take place to accommodate the new system participant. Unlike a war or a capitalist market situation, where parties try to completely flatten other actors' hills and maximize the height of their own, in this canine system participants migrate to the closest attractor available, striving to restore the stability and predictability generated by consensus rather than to heighten individual hills at the cost of the other(s). In fact, the very presence of the other(s) constitutes in itself a heightening of a dog's fitness hill if only the dog has undergone normal production processes. If it hasn't, it can still be repaired – it can learn. This is, however, dependent on the dog obeying the first, basic system rule. Aggression is abnormal behavior, which, by its nature, prevents a dog from being able to become a part of any canine social system. Aggression, when it does occur, indicates system disintegration. The system as a whole tends not toward a hierarchical structure, but towards a structure in which each dog sits unchallenged on a fitness hill whose height is immeasurable and irrelevant.

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