The emergence of leadership and its relationship with the decision-making process

Wladimir A. Benalcazar

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1 Introduction

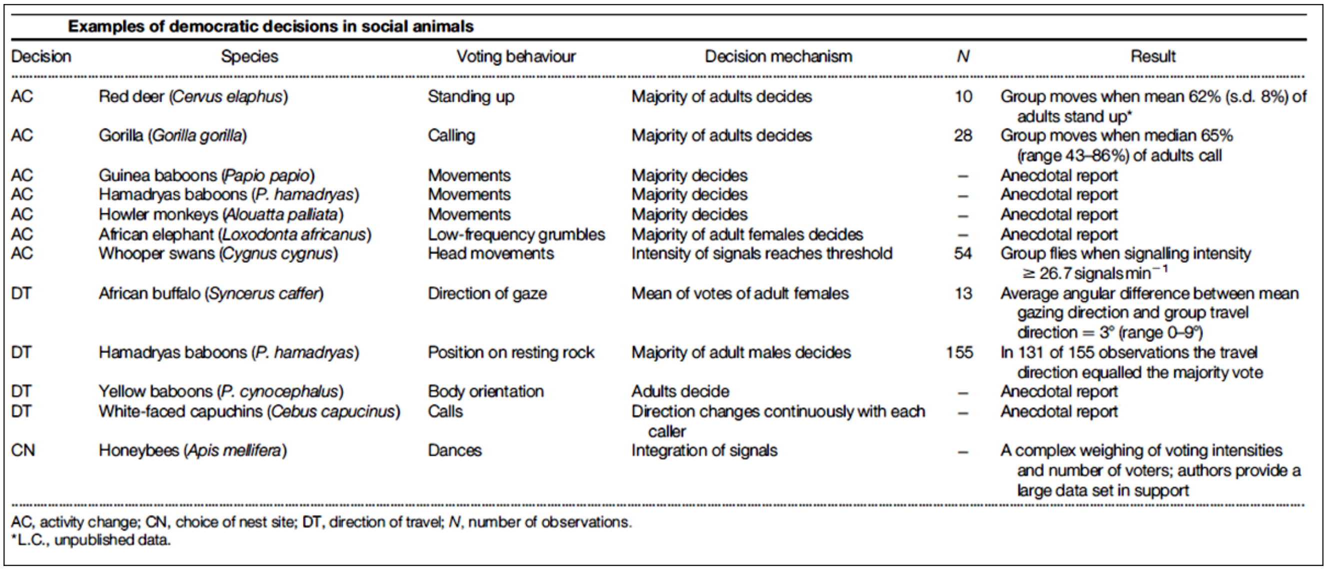
This project looks into the emergence of leadership under various types of organization. An initial guess would hypothesize that the nature of leadership is strongly related to the way information is distributed and flows in a population, as well as in the economic relationships between agents and between agents and the environment. For instance, whether agents decide to maximize their own benefit or the communal benefit, whether members benefit from synchronization of their activities, types of role differentiation, and mechanisms of resource reallocation could potentially regulate the emergence of leadership.

Analyses based on energy constraints for activities in animal groups have defined conditions under which democratic versus despotic decisions are made. Furthermore, models for the synchronization of activities have explained how the emergence of role differentiation and leadership could occur in certain animal groups, which have been corroborated by direct observations. There are cases, however, in which the networks of behavioral control observed in animals cannot be explained within the context of the existing theories, revealing the need for a more inclusive study of the essential factors that shape social and economic behavior. In more recent attempts to capture the complexity of the dynamics involved in these problems, computer simulations have also been used to better understand the role of leadership in systems exhibiting certain particularities, such as dynamic adaptation of their interaction networks, and delay in the flux of information within a system.

This paper starts by studying the problem of animal communal activities [1], such as migration [2] or foraging [3], in which members make joint decisions even when they cannot assess which individuals are best informed, or when there is conflicting information or interests between them. Later, it looks into a general framework for the onset of the emergence of leadership [4], valid for groups in which members can maximize their own benefit, have good access to information, and can direct resources towards generating information to later distribute it among the agents at extremely inexpensive costs, if necessary. Finally, this paper looks into how cooperation and leadership may be sustained in systems in which interaction networks evolve [5], and ends with a brief discussion about the survival of political leaders in different economic contexts [6].

2 Group decision-making in animals

Animals often make communal decisions, such as defining migration routes or foraging together. How they do so is still poorly understood [2]. Many authors have assumed despotism in animal groups, by which the communal decisions are defined by a single individual, the despot, because a system for voting is not obvious in non-human systems [1]. However, observations in animals have shown otherwise (fig. 1). To see how unlikely is for despotic decision making in animals to occur, let us consider the problem of synchronizing an activity within a group of n individuals, all of which start the activity at time $t = 0$. There is a distribution of preferred times to stop the activity $t_1, t_2, ...t_n$, one for each individual. For simplicity, let us make all times equally spaced. There is a cost to each individual, c_i, proportional to the difference between the preferred time and the actual time at which the activity stops $|t* - t_i|$, where $t*$ is the stop time. Notice that the costs are symmetric with respect to $t*$ (i.e. waiting for others to finish causes equal costs as finishing to early for the same time difference). In a democratic decision, $t* = t_{n/2}$, and the total cost to the group $\sum_{i=1}^{n} c_i$ is proportional to the area under the black lines in fig. 2, which is the optimal solution (i.e. it minimizes the cost), since any other stopping time, i.e., a time chosen by a depot, will incur in a larger area, such as the one under the red dashed lines. Therefore, if members are equally and correctly informed democracy is better than despotism, in the sense that it minimizes synchronization costs to the group. However, if synchronization costs are asymmetric, a biased democratic decision is less costly. This is used in legislative systems for decisions in which the potential cost of making decisions is higher than that of not making them, (i.e., those in which 2/3 of the electorate is needed to approve a law).



Examples of democratic decisions in social animals

Decision	Species	Voting behaviour	Decision mechanism	*N*	Result
AC	Red deer (*Cervus elaphus*)	Standing up	Majority of adults decides	10	Group moves when mean 62% (s.d. 8%) of adults stand up*
AC	Gorilla (*Gorilla gorilla*)	Calling	Majority of adults decides	28	Group moves when median 65% (range 43–86%) of adults call
AC	Guinea baboons (*Papio papio*)	Movements	Majority decides	–	Anecdotal report
AC	Hamadryas baboons (*P. hamadryas*)	Movements	Majority decides	–	Anecdotal report
AC	Howler monkeys (*Alouatta palliata*)	Movements	Majority decides	–	Anecdotal report
AC	African elephant (*Loxodonta africanus*)	Low-frequency grumbles	Majority of adult females decides	–	Anecdotal report
AC	Whooper swans (*Cygnus cygnus*)	Head movements	Intensity of signals reaches threshold	54	Group flies when signalling intensity ≥ 26.7 signals min^{-1}
DT	African buffalo (*Syncerus caffer*)	Direction of gaze	Mean of votes of adult females	13	Average angular difference between mean gazing direction and group travel direction = 3° (range 0–9°)
DT	Hamadryas baboons (*P. hamadryas*)	Position on resting rock	Majority of adult males decides	155	In 131 of 155 observations the travel direction equalled the majority vote
DT	Yellow baboons (*P. cynocephalus*)	Body orientation	Adults decide	–	Anecdotal report
DT	White-faced capuchins (*Cebus capucinus*)	Calls	Direction changes continuously with each caller	–	Anecdotal report
CN	Honeybees (*Apis mellifera*)	Dances	Integration of signals	–	A complex weighing of voting intensities and number of voters; authors provide a large data set in support

AC, activity change; CN, choice of nest site; DT, direction of travel; *N*, number of observations.
*L.C., unpublished data.

Figure 1: Examples of democratic decisions in social animals. Adapted from [1]

Since synchronization costs accumulate over different activities, despotic regimes would be highly disadvantageous for the group [1]. Additionally, despotic regimes are viable if the benefit in energy that the despot obtains is higher than the energy necessary to coerce (therefore existing a motivation to coerce). At the same time, the extra energy cost caused by the despotic decision on the oppressed members needs to be less than the energy necessary to resist (therefore discouraging resistance). These constraints make researchers think that despotic regimes should be rare [1].

However, an important differentiation needs to be taken into account. When the group is homogeneous, the stop times t_i are equally distributed over the entire population, and therefore, all individuals suffer equally from a despotic regime over time, but when the group is perfectly heterogeneous, the stop times can be thought of being fixed for each individual, so that there is always a minority that benefits from the despotic regime (fig. 2). Therefore, in heterogeneous groups, the minority that also benefits from despotism could ally with the despot forming an oligarchy.

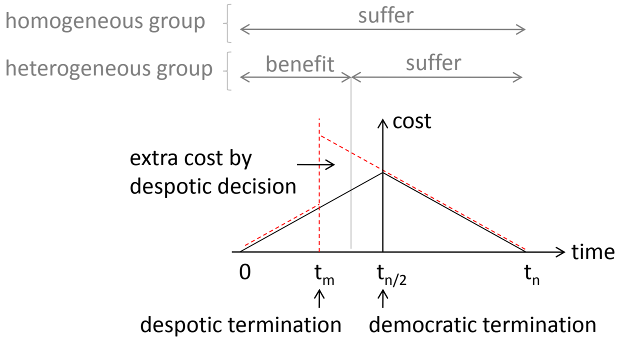


Figure 2: Energy costs for democratic and despotic decision making in synchronized activities. The area under the continuous black (dashed red) inclined lines represent the total cost to the group in the case of a democratic (despotic) decision.

In this simple model, it only pays group members to follow a single member's decision if the leader is experienced to the point that the leader's error is less than the median error of all other group members, which is likely to happen in small groups with poorly experienced members.

In many cases, however, individuals have uncertainties with respect to the quality of their own information compared to that of others, or even on whether other individuals have information to begin with [2]. Computer simulations have helped understand how information about the environment (e.g. location of resources or migration route) can flux from informed individuals to uninformed ones, or even how individuals can achieve consensus when informed groups with different preferences are present [2], thus creating an effective leadership that guides the entire group. It is likely for many species, that experienced group members play an important role in guiding the more inexperienced ones [2]. This occurs for activities which do not represent a social dilemma (i.e. those in which the group decision does not compromise individual preference), and therefore does not contradict the previous model, since in this case leadership does not imply a despotic regime.

Consider, for example, the problem of migration. A model can be built in which the direction of travel $\mathbf{d}_i$ of each member i of a group of n members is updated at each time by the formula:

$$\mathbf{d}_i(t + \Delta t) = \sum_{j \neq i} \frac{\mathbf{r}_j(t) - \mathbf{r}_i(t)}{|\mathbf{r}_j(t) - \mathbf{r}_i(t)|} \tag{1}$$

where $\mathbf{r}_i$ is the position of member i. This simulates the movement of individuals that try to maintain their own space and avoid collisions. A fraction p of the members is informed about the preferred direction $\mathbf{g}$, and balance the influence of this preferred direction with the social interaction term $\mathbf{d}_i$ by the use of a weighting term ω:

$$\mathbf{d}_i(t+\Delta t) = \frac{\hat{\mathbf{d}}_i(t+\Delta t)+\omega\mathbf{g}_i}{\left|\hat{\mathbf{d}}_i(t+\Delta t)+\omega\mathbf{g}_i\right|} \tag{2}$$

where $\hat{\mathbf{d}}_i = \mathbf{d}_i / \left|\mathbf{d}_i\right|$.

This model has shown that the accuracy of the group in following the preferred direction $\mathbf{g}$ increases asymptotically as the proportion of informed individuals increases. Additionally, it was found that the larger the size of the group, the smaller the fraction of informed individuals needed to guide. In migratory honey bees, for example, this is beneficial, because they form large groups, and only a small fraction of scouts is needed, which reduces investment costs in the community.

If two subsets of informed individuals with number of members n_1 and n_2 are considered, each subset with a preference in direction, the direction of motion of the group depends on the degree to which the preferences differ: when difference is small, the direction is the average of the two preferences; however, when the preferences differ drastically, there are two possible cases: 1) if $n_1 = n_2$, there is equal probability of randomly choosing any of the two directions (fig. 3A), and 2) if $n_1 > n_2$, the entire group chooses the direction preferred by subset 1, even if the difference is small (fig. 3B).

When a feedback loop is used by reinforcing or decreasing the value of ω depending on whether the group decision is getting closer or farther away from the preferred direction of the individuals, the general trends are not modified. However, the decision to choose one option over the other is made faster, and is reached not by average, but rather by consensus. It was also found that high values of ω for small portions of informed individuals caused the informed and the uninformed groups to fragment (fig. 3C). This may indicate that it takes a minimum critical mass to persuade the group. If there is only a small group of radicals (large conviction ω on preferred direction), they will become dissidents that will drift apart, without leading the population. This finding support the idea that the number of informants is more important than level of conviction. Finally, by different levels of conviction ω to the two subsets, not surprisingly it was found that stronger leaders (those more convinced of their knowledge) lead over weak leaders (fig. 3D).

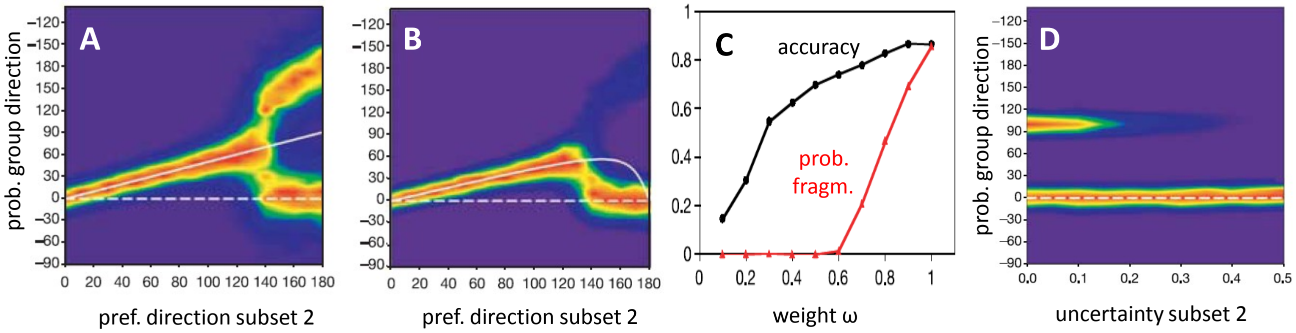


Figure 3: Collective selection of group direction when informed individuals differ in preference. A and B show probability distributions (normalized to the maximum) of group directions for groups containing 2 subsets with populations n_1, n_2 and directional preferences $s_1 = 0$ and $s_2 = 0 - 180$ degrees. A. $n_1 = n_2 = 5$, B. $n_1 = 6$,$n_2 = 5$. C. Accuracy of group motion in a preferred direction and probability of group fragmentation as a function of the parameter ω. N=50, p=0.1 (5 informed individuals). D. discrimination between two directions ($s_1 = 0$,$s_2 = 100$ degrees) as a function of information quality. Adapted from [2]

In this model, informed and naive individuals do not have to be able to recognize each other, and leadership can emerge as a function of information differences among members of a population [2], in a mechanism that is democratic in nature. The behavior predicted in this model has been found in pigeon homing, even for groups of pigeons as small as having only two members [7]. It has been found that elaborated forms of hierarchy emerge spontaneously in pigeon flocks, based on pairwise interactions of leader-follower pairs [8].

When pigeons are trained for a homing task, they become familiar with their own routes, which they repeat precisely over time. During a combined flight of a couple of trained pigeons, each of them had a conflict: that of preserving the social cohesion (i.e., fly together) or preserving one's established route. It was found that when the level of conflict is less than a threshold value, which happens when the difference in the preferred directions of the pigeons is small, the pigeons fly together along an average route, but when the level of conflict passes the threshold, they either split and flight independently or form pair of leader-follower, flying along the leader's route (fig. 4A-C).

It was found that the efficiency of homing for the pair increased as a consequence of averaging [7]. However, leading could not be correlated with higher efficiency, which may result from a lack of ability of the pigeons to estimate the efficiency of their routes (for example, see fig. 4C), or a consequence of some other benefit associated with following birds higher in the hierarchy [7]. In large migrations, the hierarchy may be modified based on knowledge of landmarks, motivation, or ability, causing a fluctuation in roles over time. This may be advantageous over a single leader scenario or egalitarian collective decision-making groups [8].

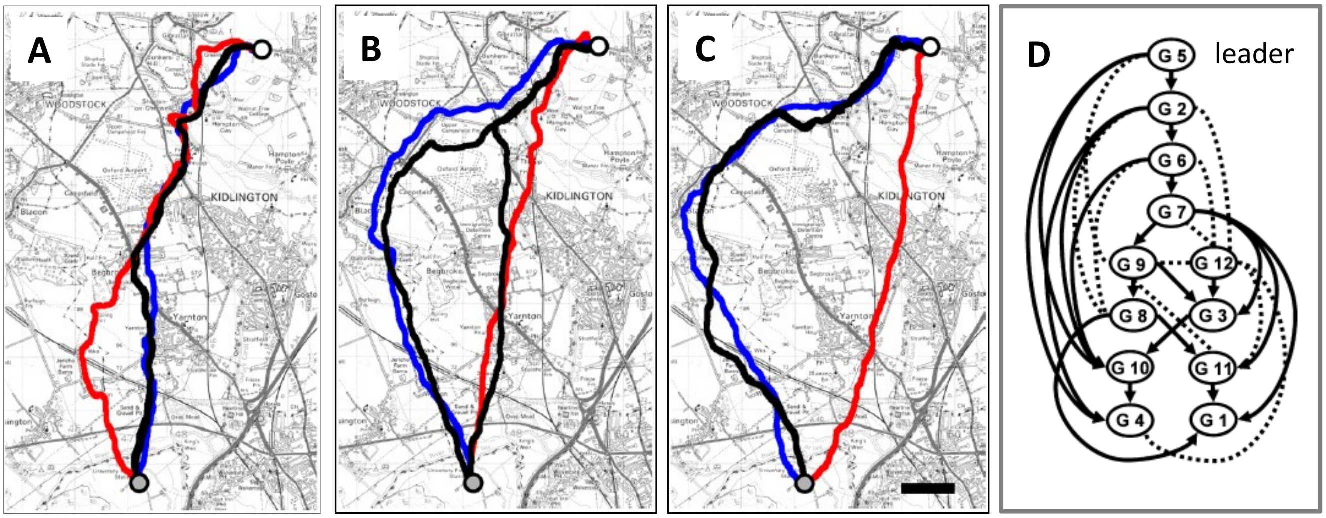


Figure 4: Examples of flights of pigeons pairs in homing tasks and pigeon hierarchy. In A,B, and C, red and blue lines indicate trajectories followed by two pigeons flying independently, and black lines indicate trajectories when released together. A. Trajectory is averaged up to a certain point, after which a pair leader-follower forms. B. Trajectory is averaged up to a certain point, after which pigeons split. C. Example that illustrates how leaders are not necesarily the most efficient. D. Hierarchy in pigeons. Ellipses indicate individual birds. Numbers indicate homing efficiency during flight. Solid arrows point from a winer of a pair to the looser. Dotted lines indicate pairs that split up. Note that there are no arrows forming cycles, which imply and entirely transitive dominance hierarchy. Adapted from [7]

As it was seen previously, consensus can sometimes require compromising the individuals' optimal decisions. It will now be shown in a simple model how the synchronization costs may shape the social organization of the system. Particularly, it may originate role differentiation and the emergence of leadership [3].

In this example, the problem we are concerned with is that of deciding when to forage and when to rest. While foraging satiates hunger, it comes at the expense of increasing the risk of predation. For simplicity, consider only two individuals. The external conditions set two possible scenarios: 1. Foraging together does not represent an advantage over doing it alone. In this case, no synchronization of activities between the two members occur, and both of them use the same policy: rest unless energy reserves drop below a threshold value. The states, defined as the level of resources, remain near threshold for both individuals. 2. If foraging in pairs gives an advantage, mainly by reducing the risk of predation, the policy is modified. This time it consists of foraging when energy drops below threshold or whenever the other individual forages. This is sufficient to synchronize their behaviors, out of which role differentiation emerges. In this second scenario, the states correspond to one individual having reserves well above threshold, and the other one having reserves closely fluctuating above it. Roles differentiate because the "lean" individual dictates the behavior: when his energy drops below a threshold, he will have to forage, and therefore the "fat" individual will have to forage, following the policy for this second scenario. Studies supporting this prediction can be found in foraging decisions in fish, in which leadership decisions may often be made by individuals with lower reserves [3].

In this second scenario, individuals can occasionally switch roles when, through a run of bad luck, the reserves of the fat member drop below those of the lean member. However, switching states, and therefore roles, takes orders of magnitude longer times than if no combined foraging advantage exists [3].

Notice that in this problem the outcome is not the result of a communal group decisions, rather, it emerges from the interaction between individuals under certain circumstances. Furthermore, this does not require pursuing elaborated strategies, it simply relies on the ability to observe and react to a change in the partner's behavior.

3 Phase transitions in political organization

In the previous sections, it was shown how group decision making, role differentiation, and leadership can emerge, even in relatively simple systems. In other bacterial, animal or human organizations, role differentiation can lead to very complex forms of division of labor and political organization. This happens whenever there are mechanisms to redistribute the proceeds of labor in systems that encourage specialization [4]. In particular, if an individual or group of individuals specialize in the generation of information, and the mechanisms for transferring that information are inexpensive, a substantial increase in productivity could occur (depending on certain parameters, as will be seen later on), suggesting that the existence of such systems would be favored over other less efficient systems.

In order to see how the structure of information affects political organization, let us consider the problem of exploration versus exploitation [4]. The system consists of N agents, each of which chooses one out of O actions to perform at each iteration. Of all O options, only one action is productive. Each agent must choose to divide his time in a fraction T spent on investigating what is the correct action (exploration), and a fraction $1-T$ performing the chosen action (exploitation). The accuracy $A(T)$ with which an agent chooses the correct productive action improves monotonically with the amount of time spent in exploring according to:

$$A(T) = 1/O + (1 - 1/O)T^{\alpha} \tag{3}$$

where α is the nonlinear benefit for investment in exploration. Notice that if no time is spent in exploring, the accuracy is that of an unbiased random choice, while certainty is reached only by spending all time exploring. The productivity of each agent is 0 for the wrong activity or 1 for the right activity. The average score $S(T)$ (i.e., level of production) obtained by the agent over time (many iterations) is therefore:

$$S(T) = (1 - T)A(T) \tag{4}$$

Now, consider the following possibilities in relation to the exchange of information:

(a) No information exchange, so that no agent in the system uses information from any other agent. In this case, if there is a linear reward to exploration $\alpha = 1$, the score is maximum at $T = 0$, i.e., no advantage exists in exploring, and the maximal score is obtained by guessing the right choice and spending all time in exploitation, which corresponds to a $T = 0$ *phase*. If the reward to exploration is nonlinear ($\alpha > 1$), a local maximum for $T > 0$ appears. This local maximum can pass the score at $T = 0$ and become a global maximum for certain values of O and α, causing a first order transition from the "guessing" phase to a "thinking" phase (fig. 5A). This phase is an *homogeneous disconnected phase*, because no division of labor emerges.

(b) Uniform information exchange, in which the agents assign an equal weight to the decisions of everyone in the network. This results in the final decision being made by those of the simple majority. The information exchange process in this *connected homogeneous phase* increases the accuracy of the agents in making the decisions, for this reason, this phase is always favored over the disconnected homogeneous phase (fig. 5B). Additionally, because the decision is the result of a collaborative effort in exploration, the decisions are less sensitive to fluctuations than in the disconnected phase.

(c) Weighted assignment of importance to information. If reputation in making the right decision differs between agents, the final decision is a weighted average that gives more importance to the decisions of individuals with better reputations. The ideal case of this *connected inhomogeneous phase* consists of one leader and $N - 1$ followers. However, a system with multiple leaders is less susceptible to fluctuations. For a sufficiently large number of individuals N, the homogeneous connected phase can outperform the single leader phase. Also, when the nonlinearity coefficient α is sufficiently large, a transition to the $T = 0$ phase occurs (fig. 5C). The resource production in this phase is proportional to the accuracy $A(T) < 1$ achieved by the leader. Since the leader has to assure resources for himself, he cannot optimize the decision by spending all his time exploring. To resolve this, resources can be redistributed to subsidize the decision makers, thus causing the specialization of agents. As a result, a minority of well-informed agents can exclusively specialize in exploration, while the rest specialize in exploitation following the leaders' decisions. That is, the workers subsidize the thinkers in favor of a higher total score. The emergence of a leader phase is a consequence of the low costs associated with the reproduction of information, so that achieving higher accuracy increases the productivity of all followers at an insignificant cost.

Notice that in this model the different possible structures of information networks are not a-priori conditions for the dynamics of the system, but rather they emerge from the size of the system,

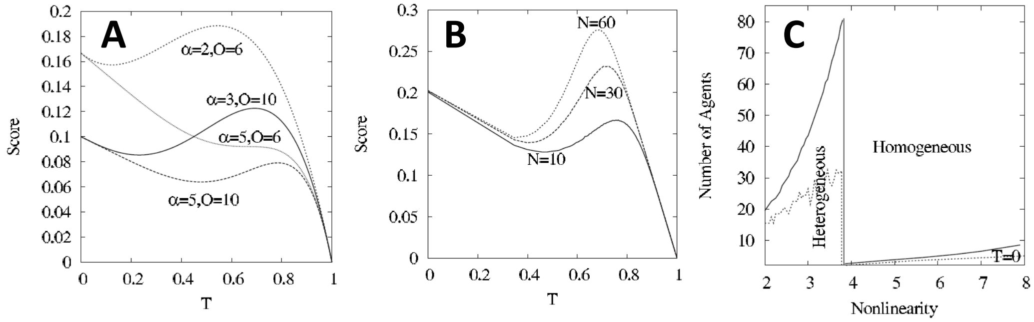


Figure 5: Phase transitions in political organization. A. score $S(T)$ as a function of the thinking time T for different values of the order of nonlinearity α in the accuracy function and the number of options O. B. score $S(T)$ as a function of the thinking time T for different values of the number of agents N. C. Phase diagram in the space of nonlinearity α and the number of agents N. Transitions between the heterogeneous, homogeneous and disconnected ($T = 0$) phases are of first order. Adapted from [4]

the nonlinearity in the function leading to the acquisition of correct information, and the selfish behavior of individuals that try to maximize their own production. The fact that the transitions between phases are of first order makes it possible for various phases to coexist over much of the parameter space when systems approach equilibrium dynamically [4], which may explain the diversity of current human political systems.

4 Meritocratic leadership and cooperation sustainability

In many social and economic environments, agents have preferences with respect to whom they interact with. Furthermore, those preferences evolve over time. Computer simulations have looked into how cooperation networks may evolve as well as what is the role of leadership in their sustainability [5].

Consider an organization in which selfish agents can adapt their interaction networks in the search to maximize their payoffs. Each agent plays a prisoner's dilemma (PD) game (fig. 6) with each of his neighbors (i.e., the members of his network), choosing to either defect (D) or collaborate (C). After playing all games, the agents collect an aggregate payoff, and imitate the strategy of the neighbor with the highest payoff. The feedback between network adaptation and payoff consists of allowing the unsatisfied defectors to dismiss the connections from which they do not profit, that is, all D-D connections, and replacing those connections randomly. Cooperators, on the other hand, are conformists, since they do not dismiss the C-D connections (from which the cooperator does not benefit). In this scenario, there is an opportunity cost to the cooperators for maintaining such connections, because the number of interactions per agent is kept constant over time (simulating limited resource environment), and therefore, a C-D connection is maintained at the expense of dismissing an C-C connection. The network adaptation follows the spirit of the PD game, which highlights the conflict between the interest of the individual and the interest of the group [5]: while individual interest is enhanced by allowing D agents to improve their pay off by escaping from D neighbors, the interest of the group is affected because D agents can survive attached to cooperators.

Results on this model show that the system typically reaches either a full-defective state or a highly cooperative steady state, this second one consisting of a majority of cooperators conforming

	C	D
C	σ,σ	$0,b$
D	$b,0$	δ,δ

Figure 6: Payoff matrix for a two-agent prisoner's dilemma interaction. C: cooperation, D: defection. The stability of systems in adaptive networks and the emergence of leadership is critical to the value of the incentive to defect b

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a hierarchical subnetworks, and a minority of defectors that exploits them. Since the basis for the network is the establishment of relations based on imitation of successful strategies, those at the top of the hierarchy are rich, successful cooperators. These "meritocratic leaders", sustain chains of cooperation, and their survival is crucial for the stability of the cooperative steady state, because they absorb perturbations caused by D agents.

The degree to which perturbations caused by the reallocation of D agents affects the network depends on the value of b. If the payoff of the wealthiest cooperator -the leader- exceeds that of the wealthiest defector by more than b, any link received by the leader will be of constructive type. That is, new defectors attached to the leader will imitate the strategy of the leader and not vice versa, increasing the network of cooperators. This will cause an increase in the payoff of the leader by $sigma$ in the next iteration, and the non-decreasing character of this payoff is an onset for the emergence of leadership in the dynamics of the evolution of the network.

When the previous condition does not hold, the cooperation network is unstable. High values of b increase the payoff of defectors, and therefore the probability that cooperators switch their strategy to defect. In particular, they can cause a series of changes in strategy from cooperation to defection that goes "uphill" in the hierarchical organization of the network, eventually reaching the C-leaders. Once leaders switch to acting as defectors, defecting can be propagated downhill to other chains of cooperations sustained by that leader. In real life systems, b can be lowered by punishing defectors, so as to assure social cohesion (e.g. punishment of corrupt practices in legal systems).

Simulations have verified the existence of both cooperation networks or all-D networks as steady states for the entire range $1 < b < 2$, with the final outcome depending on the initial conditions. However, for $b < 1.45$, a steady increase of cooperation was typically observed (fig. 7A). For $b > 1.45$, global oscillations occurred as the result of uphill perturbations and the rise of new C-leaders (fig. 7B). For comparison, in non adaptive networks cooperation is seen below a threshold for the value of b, and all-D networks are seen beyond that threshold. Therefore, adaptive networks promote more cooperation when compared to non adaptive ones.

An uneven distribution of wealth was observed among agents, with the average payoff of defectors being larger than that of cooperators (fig. 7C,D). Analogous to the dilemma present in the individual PD game, where defection is preferred by the selfish individual maximizing his payoff, a social dilemma holds, because the difference in the average payoffs for defectors and cooperators makes it tempting for selfish individuals to defect. In steady state, the structure of the network also changes with b. As b is increased, the network becomes more hierarchical and depends more on fewer local maxima with a very large payoff, making the network more vulnerable to perturbations (fig. 8). The key factor to sustain cooperation is to have several local maxima, with large payoffs, which are able to survive cascades. Slow adaptive networks (time scale of adaptation slow compared to

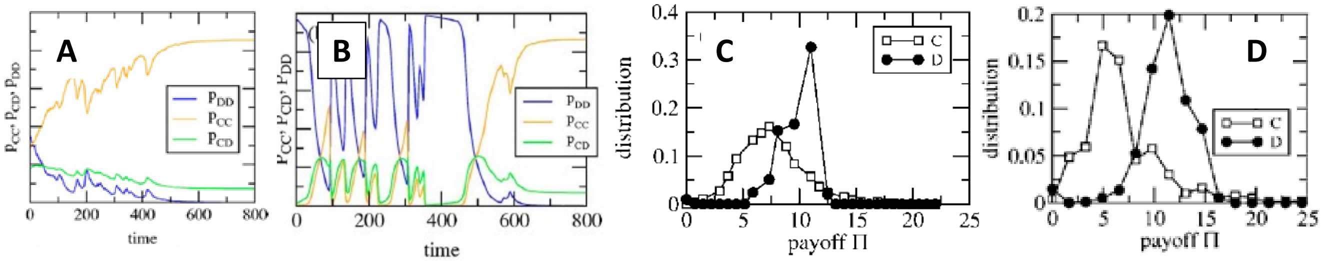

Figure 7: Time evolution of the probability to have a link between two C agents (P_{CC}), two D agents (P_{DD}) and a C and a D agents (P_{CD}) for A. $b = 1.45$, and B. $b = 1.75$. C. and D. show the distribution of payoffs for cooperators (empty squares) and defectors (filled circles) in steady state for C. $b = 1.45$ and D. $b = 1.75$. Adapted from [5]

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strategy update) are also more robust. In general, networks were robust to noise up to a threshold, after which a full-defective state was always reached.

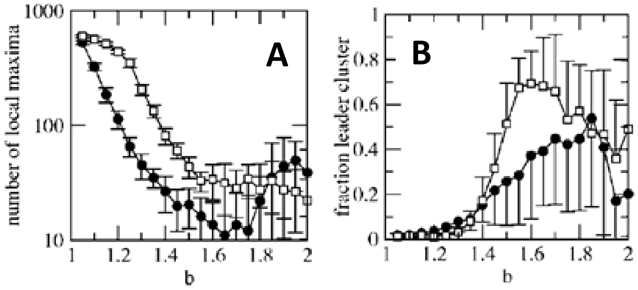

Figure 8: Leader's characteristics for $p = 0.01$ (empty squares) and $p = 1.0$ (filled circles). A. Number of C leaders in steady state. B. Fraction of agents that belong to the maximum C leader cluster. Adapted from [5]

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5 Public goods, private goods, and leader survival

When leadership is not based on the imitation of successful behavior (meritocratic leadership), as seen in the previous section, but rather it is an instance of formulation of communal decisions for a group, political relations take precedence over economic relations in the sustainability of the status-quo and leadership. In particular, when individuals have the ability to judge the quality of information and policies generated by a guiding supra structure, the guiding class is constantly under the threat of being replaced. To fight threats to its leadership, a study in ref. [6] suggests two options are available:

(a) Increase public goods: this increases the population welfare, which reduces the chance of revolutionary activities that question and threaten the leader. This action promotes better economic organization, which also benefits governments that receive income from taxes of its economic agents.

(b) Suppress public goods, especially those critical for coordination purposes: this suppresses political organization, but also economic organization, which results in less income for the government. Therefore, this option is feasible in labor-free economies, i.e., in those dependent on oil exports or aid assistance.

In addition to taking measures to minimize threats, the leader also needs to maintain the support of the leader's coalition. Measures towards this goal depend on the coalition size: if the coalition is small, the strategy is that of increasing private goods. This increases the loyalty of the coalition, because getting out of it would reduce benefits significantly. On the contrary, if the coalition is large, leaders will increase public goods, which increases the size of the coalition even more but without increasing loyalty. This second measure increases the ability to organize, which facilitates the conditions to threaten power.

Increasing public goods democratizes organizations, i.e. it empowers its members, which makes them less dependent and loyal to the leader (this threatens the leadership stability). At the same time it also increases the size of the coalition, which means, contradictions tend to fade. The result is that democratic groups tend to be more stable and alternate power, and the system is politically sustainable.

On the other hand, private goods decrease coalition size and increase its loyalty, i.e., oligarchies form. This, plus the fact that by reducing public coordination goods the ability to organize diminishes, defends the stability of the leader. However, the organization is polarized politically, with many unsatisfied agents that would like to overthrow the leader, because when coordination goods are suppressed, economic relations between the agents are affected too. The result is a polarized organization with a small oligarchy that supports a despotic leader, and a vast unsatisfied majority without political and economical means for development. Such a regime is sustainable under economies that depend on goods that do not come from labor.

6 Discussion and conclusion

Experimental findings in relation to decision making processes during pigeon homing failed to associate leadership with an improvement in the efficiency of the groups' performance [8]. This supports the idea that, unless leaders have very different and superior information, a decision made by one or a small number of leaders is less beneficial to the group than one made by the averaging of all members preferences [1]. Voting (averaging), however, seems to be widespread among animal groups, and may involve conscious mechanisms such as those described in fig. 1, or more subtle ones, such as trying to maintain a personal space during migrations [2]. It was interesting to find that the averaging rules found theoretically for decision making in groups of animals on the move, still hold in a probabilistic sense for pairs of individuals that differ in preferences, following the fitness logic: compromise for small differences in preferences, lead or follow for large [2, 7]. The fact that hierarchy in pigeon flocks is determined with no relationship to individual route efficiency [7] may indicate that instead of the problem being related to a conflict of information, it may relate to conflict of interests, i.e. leadership may be more of a political nature than of economic nature, a question not yet examined, to the best of my knowledge.

In a more general sense, simple models for synchronization of activities explained how individuals could be pushed by need to adopt leading roles [1, 3], and showed that a proper balance is required between the importance given to the activity and to social cohesion to avoid fragmentation of the group. A more systematic study of a minimum model could bring more insights into the emergence of leadership for values of some critical parameters, such as social cohesion. Such a treatment was found in a model for the emergence of leadership and political organization in information exchange networks [4], which showed that the structure of information is a key element that defines the types of political organization, and that if a method for resource reallocation exists in heterogeneous organizations, division of labor and leadership can emerge. This can be seen in colonies of insects, such as bees and ants, that function in a centralized economy that subsidizes individuals performing different tasks, even if they are not directly related to production.

An interesting study concluded through simulations that cooperation among a set of selfish agents is possible in an adaptive local neighborhood [5]. Furthermore, it showed the emergence of meritocratic leaders as agents that bring stability to systems by sustaining chains of cooperation. The model is based on the adaptation of networks according to levels of local satisfaction (i.e., by comparing success with neighbors). As the simulations were successful in reproducing many of the aspects of human societies, such as the positive correlation between the incentive to defect (i.e., poor social cohesion and impunity), inequality and political instability in underdeveloped nations, it would be interesting to see how leadership evolves when the constraint of measuring satisfaction in local terms is relaxed (e.g., is access to information changing the levels of satisfaction and therefore the nature of meritocratic leadership?, for instance, making it more biased towards global leadership as opposed to a more localized and hierarchical for of leadership?).

Finally, the survival of a political leader in the context of the economic constraints and political atmosphere was briefly discussed. As two main outcomes are envisioned in the study in ref [6], a more analytical study of a minimal model for the political forces that influence the leader may bring more insight into which parameters affect the future of a political and economic system from the point of view of the survival of a leader.

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