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Balancer effects in opinion dynamics

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ABSTRACT

We introduce a novel type of contrarian agent, the balancer, to the Galam model of opinion dynamics, which features group-majority update, in order to account for the existence of social skepticism over one-sidedness. We find that, along with majoritarian floaters and single-sided inflexibles, the inclusion of balancers, who normally act as floaters but oppose inflexibles in their presence, brings about the emergence of a critical point on parametric plane of the dynamical system. Around the critical point, three distinct phases of opinion dynamics separated by discontinuous changes are found.
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1. Introduction

The opinion dynamics is currently one of the most successful branches of sociophysics [1,2]. It abounds with easy-to-analyze dynamical models with intriguing insights for human social preferences, such as the dependence of the consensus-reaching time on the social network structure, the effect of social media, the logarithmic spatial correlations in election results [3–12]. In very simple settings and with simple assumptions, it seems to capture the essence of majority-opinion formation in real-world democratic societies [13,14]. The opinion dynamics is formulated in a language of agent-based numerical simulation, but often the equivalent deterministic dynamical system can be obtained, that can lead to the analytic solutions.

In the Galam model of opinion dynamics, a system with a fixed number of agents with binary-valued opinions goes through repeated local-majority updates and reshuffling. Two noteworthy findings of the Galam model are the possibility of the special type of minority dominance over majority [15], and the persistence of hung election with near fifty–fifty vote [16,17]. These findings have been brought about with the introduction of heterogeneous agents to the model: In addition to the *floater*, the "normal" agent type who follows the majority rule, there are two more agent types in the model, *inflexible*, and *contrarian*. Inflexibles are the agents who stick to one opinion whatever the opinions of other agents are. They can be thought of as representing vested interest, for example. Inflexibles give rise to the minority-dominance threshold at its population ratio $(3-2\sqrt{2})$ to the dynamics [15]. Contrarians are the agents who always act contrary to the local majority. They can be thought of as representing skeptical minds concerned with the appearance of unduly powerful majority. Contrarians are found to create the hung election after passing $1/6$ threshold for its ratio among total population [16,17].

One curious aspect of original Galam opinion dynamics is that the inflexibles and contrarians mixed together either result in the quick minority dominance of inflexibles, or quick appearance of hung election [18]. This is to be contrasted to the subtler, more varied phenomena in real-world dynamics of public opinion. Looking into the political histories of various societies littered with riots and revolutions, we often find that the skeptical few can act to instigate the opposition to the inflexibles, delaying their minority dominance, and occasionally, even cause "contrarian overkill" in which independent-minded few help the minority opposition to prevail over the majority supported by the solid vested interest [19]. These occurrences seem to await a proper modelling in the opinion dynamics.

In this work, we introduce a new agent type, which we call the "balancer", as an alternative modelling of contrarian preferences. This agent acts as a normal floater except when it meets inflexibles in its updating group, in which occasion it invariably acts in opposition to the preference of inflexibles. The conception of this agent has resulted from the basic observation, that people tend to value fairness in the sense that the society's decision should respect the overall majority. In a democratic society, we find the rise of people with reasoned skepticism and contrarian attitude, that seek to counter the unreasonably powerful few. The contrarians as

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appeared in the original Galam model, who oppose any majority opinion, are ill-suited to capture such attitude.

The key finding of this work is the uncovering of the critical point in the parameter space formed by population rates of inflexibles and balancers. Around the critical point in the parameter space, the system displays very rich dynamics such as the resilience to minority dominance of inflexibles, the persistent hung election and the balancer overkill.

2. Opinion dynamics with new element, the balancer

Consider a system made up of N agents, each of which takes one of two opinions S or O at discrete time t, each representing "support" or "opposition" for a certain issue of common interest to all agents. We assign a binary value $A_t(j)$ to j-th agent at time-step t, which takes the value 1 for the opinion S and 0 for O. The opinions of agents are updated deterministically with the discrete time-step advance $t \to t+1$. In the update process, the agents are divided into groups of uniform size r, and the update is assumed to take place group-locally, that is, the opinion of an agent at time $t+1$ depends only on the opinion of agents sharing the same group at time t. We limit r to an odd integer in this work. We also assume that N is an integer multiple of r, which ensures the uniformity of groups. The central quantity of our interest is the relative size of supporting and opposing agent populations. We define the supporting ratio at time-step t by

$$a_t = \frac{1}{N}\sum_j A_t(j). \tag{1}$$

Obviously, $a_t = 1$ signifies the total support where all agents have opinion S, and $a_t = 0$, the total opposition with all agents having opinion O.

The rule of the update is the majority vote with some twists, that come from the heterogeneous characteristics of agents. We assume that each agent belongs to one of the following *agent types*:

1) floater: This agent updates its opinion always following the majority rule. It chooses S or O according to the prevailing opinion of the group it belongs.
2) inflexible: The opinion of this agent is invariant through all time steps, irrespective to the opinions of others in the group. There can be both S-type inflexibles and O-type inflexibles, but in this work, we limit ourselves to the case of the system having only one of the two types. Since our dynamics is symmetric to S and O, the choice is arbitrary, and we only consider inflexibles with invariant opinion S, or equivalently, the binary value 1.
3) balancer: This agent updates its opinion just like the floaters when there are no inflexibles in the group it belongs, but always updates into the opinion that is opposite to the opinion of inflexibles. Namely, in the current setting, this agent follows the majority rule in the absence of inflexibles in the group, and takes the opposing opinion O (or equivalently, 0) in their presence.

The last agent type is the new element of the current work. This type represents a spirit of contrarianism, which acts against opinionated minority wielding excessive influence. This type of agents seems to be present in all healthy mature democracies [19]. This type is to be contrasted to the *contrarian* type introduced in original Galam model which is characterized by the unconditional opposition to the local majority [15]:

3′) contrarian: This agent updates into the state which is counter to the local majority: It takes the value O at time step $t+1$ if there are more agents with S than ones with O at time step t, and takes S at $t+1$ if there are more O than S at t.

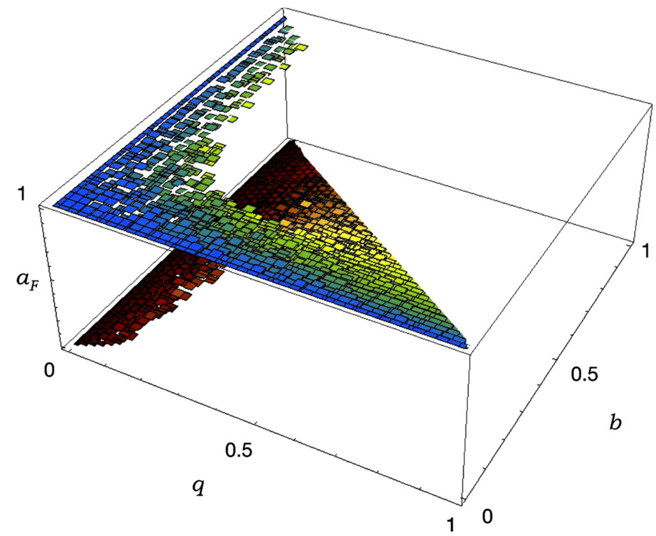

Fig. 1. The stable final value of S opinion ratio a_F of the system made up of floaters, inflexibles, and balancers, plotted as a function of inflexible ratio q and balancer ratio b: A three-dimensional view generated from numerical simulation. Number of agents are set to $N = 240$, and the size of the group, $r = 3$. At each value of q and b, 50 different random initial configurations are prepared with varying values of a_0. At each run, the system is evolved for long enough time T to obtain the s ratio a_T, which we identify to a_F. The actual value of T is chosen to be 200, which we have confirmed, by numerically changing T, to be large enough. Note the contrast between the peeled-off structure of the a_F surface in the area $0.3 \gtrsim q \gtrsim 0$ which represents the coexistence of two stable final values of a_F, and the mono-layered surface in the area $q \gtrsim 0.3$ which represents unique final a_F value.

We focus on the system consisting of 1) floaters, 2) inflexibles, and 3) balancers in this work, and briefly look at the conventional Galam system with 1) floaters, 2) inflexibles, and 3′) contrarians for contrasting and comparison.

After the update, all agents are reshuffled to form new groups for next update. We start from a configuration in which the ratio of agents with the opinion S among all agents is a_0. A single update of all agents gives the new supporting ratio a_1. The procedure is repeated until the supporting ratio a_t eventually reaches a stable number a_F. This procedure can be viewed either as a model of majority opinion formation in a consensus democracy, or as an idealized description of social decision based on voting in a hierarchical representative democracy [2].

3. Balancer moderation and overkill: numerical simulations

We consider a mixed system of floaters, S-type inflexibles, and balancers, whose proportion to the total agent population N is $(1-q-b)$, q, and b, respectively. We choose the simplest case of smallest nontrivial group size $r = 3$. In Fig. 1, we show the result of the numerical simulation with $N = 240$ and $r = 3$, in which the final supporting ratios a_F are plotted for varying values of the inflexible ratio q and the balancer ratio b. For a given q and b, fifty different initial configurations with supporting ratio ranging from $a_0 = q$ to $a_0 = 1$ are prepared to generate stable final configurations to calculate the values of a_F.

For a small inflexible ratio q starting from $q = 0$, there are two stable final values $a_F \approx q$ and $a_F \approx 1$. There is a sudden disappearance of one of these two at a certain value of the inflexible ratio around $q = 0.2 \sim 0.3$ as we increase q. Interestingly, the disappearing branch of a_F depends on the value of b, the ratio of balancers: For smaller proportion of balancers b, the system with sufficiently large proportion of inflexibles q always evolves to a final configu-

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