Polarization and non-positive social influence: A Hopfield Model of Emergent Structure

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Abstract

In this study, we classify three types of social influence from the perspective of social identity, and investigate to what extent that the non-positive social influences affect group opinion polarization based on the Hopfield neural network model. Through simulation, we observe that opinion in a group would self-organize into two polarization pattern, under the condition of no imposing external intervention, which is entirely different from the result of drift to an extreme polarization dominant state with single homogenous influence. This result suggests non-positive social influence can promote group bi-polarization opinions, which may account in part for the widely observed well-matched voting phenomenon in the real world.

Keywords: Opinion Dynamics, Social Influence, Hopfield Network Model, Polarization

1 General Instructions

Opinion dynamics is one of the important aspects of crowd's behaviors. Under the complex social and economic conditions such as mutual influence among members, the external interference, towards a specific object or event , human collective opinion displays different patterns, e.g. consensus, polarization, and diversity. Opinion dynamic is widely studied in management science[1], social psychology[2][3][4], economics[5], socio-physics[6][7], system science[8] and computer science[9] etc. Recently, with the booming of Internet and advances in information technologies, the topic is maturing into the spotlight for social psychology, risk management, computer science, marketing and social apponomics.

In this article, in order to investigate to what extend that the non-positive social influence can affect group opinion formation, we make a clear classification about three types of social influence as positive, neutral and negative based on social identity theory, furthermore, we study the relation of polarization and non-positive influence through Hopfield network model simulation.

The rest of the paper is organized as follows: in Section II, according to social identity, we discuss three kinds of social influence implications and make a clear classification . In Section III, we add three types of social influence into the Hopfield network model. By computing we find that opinion could evolve into two-polarization steady pattern. Section IV is our concluding remarks.

2 Social influence and social identity

Social influence occurs when an individual's thoughts, feelings or actions are affected by other people. One of the important principal underlie group opinion polarization is social influence on behavior. Extensive research shows that social influence may trigger individuals to revise their estimates[10], change their attitudes. When individuals observe attitudes or opinion of others, they follow the wisdom of crowds[11], then the herding effects created have an pressure to adjust their opinions toward consensus. Herding effects are widely studied in many domains[12]ranging from cognitive neuroscience[13] to economics.

However, homogeneous attractive, heterogeneous repulsive and neutral attitudes effects among agents are equally important in social systems, herding effects can only partially explain one aspect of collective behaviors, this pattern is derived from individuals in a group can act together without planned direction, based on indefinite individuals social identity.

The question is what the opinion dynamic pattern will be if consider both the positive attractive homogeneous and non-positive neutral, re-

pulsive impact? To answer this problem, next we distinguish three different social influence from social identity perspective.

Social identity theory suggests that individuals have the self-concept identity derived from perceived membership of social groups. Individuals are likely to display favoritism when an ingroup is central to their self-definition and a given comparison is meaningful or the outcome is contestable. In other words, individuals display positive attitude about ingroup members, but negative about outgroup ones, for example in the case of voting and debating about wages allocation, different classes may have different political tendencies and interests, individuals will favor ingroup and against outgroup opinion.

In many real situations, negative repulsive impact in social systems is an important ingredient such as the conflict attitudes or interests among voters who in the two-party system, although it has been barely modeled together with positive attractive influence behavior in social cultural dynamics.

Generally to say, especially to voting, from the social influence point of view, three types of impact runs through the whole processes of group decision-making. One is positive influence among ingroup members, this kind of social force accelerates ingroup opinion convergence, as we discussed above. The second one is negative social impact which blocks the formation of consensus among different outgroups. Individuals within different subgroups find it difficult to gain the agreement when they face group decision making even under the pre-condition that they share the same initial opinions, since they have different social subgroup unified interests, emotions, actions and value orientation. This impact for individuals opinions selection can be named heterogeneous repulsion. The uses of both positive and negative interactions in social systems has been previously introduced to study coalitions among a set of countries[14]. Especially, in this paper, we introduce the third one, unsocial phenomena as a type of special individuals attitude, in which the individuals do not belong to any label subgroup. Members in this group have no common social identity, no firm position about some social opinions and in a state of neither fish nor fowl.

In this work we consider Hopfield network model based on the aforementioned three types of social influence mechanism, in other words, as to the group voting result we have non-positive influence involved among voters. This model is described in the following section.

3 Hopfield network model

In literature[15], Macy et al. presented a Hopfield model to describe group polarization problems. They concluded many interesting results with considering individuals decision making dimensions, social influence and culture dissemination theories etc. The basic formulas are listed as following:

$$P_{is} = \frac{\sum_{j=1}^{N} I_{ij} s_j}{N}, j \neq i, \qquad (1)$$

for each individual i, the cumulative social influence pressure for her/him to choose s_i is donated as Equ (1). Where $s_i = \pm 1$ represent binary voting opinions, N is group size, I_{ij} is the social influence that individual $j(j \neq i)$ imposed to i. With the motivation of investigating the relationship between non-positive social influence and group opinions polarization, we add the three types of social influence into the model. Individuals (voters) are impacted by others and also influence others, as conditioned by the valence of the social identity tie I_{ij}, where $I_{ij} \in \{-, 0, +\}$.

(A) "+" donates for the positive homogeneous social influence,

(B) "-" stands for xenophobia, antagonistic, negative social influence,

(C) "0" represents for unsocial attitudes.

Furthermore, if we consider the individual i's external influence intervention (the external intervention means that the influence for individual i's opinion not only come from the group itself but also from other beyond group impact), then the Equ(1) transforms into Equ (2), the logistic form,

$$\tau_{is} = \frac{v_s}{1 + e^{-KP_{is}}} + (1 - v_s)X_i. \qquad (2)$$

Where v_s is used to trade off the internal and external group influence for individual i opinion. K is the size of opinions dimension. Given a randomly selected threshold π, if $\tau_{is} \geq \pi$, then individual i chooses "+1", else i chooses "-1". Equ (3) describes the update influence processes of individual $j(j \neq i)$ to i.

$$I_{ij}(t+1) = I_{ij}(t)(1-\lambda)+\frac{\lambda}{K}\sum_{k=1}^{K} s_{jk}(t)s_{ik}(t), j \neq i. \tag{3}$$

Where t is the time step, λ is an adjustable parameter.

4 Simulation implementation

The pseudo codes of implementing Hopfield network social influence processes are listed as below:

Step 1: Let t=0, given v_s, λ, initialize each voter kth dimension opinion $s_{ik}(0) = \pm 1$, $k = 1, ..., K$; $i = 1, ..., N$. Randomly generate each pair of voters social influence I_{ij}.

Step 2: When t=t+1, compute (1),(2),(3)

for each voter i, randomly generate π

if $\tau_{is} > \pi$

$s_{ik}(t) = 1$

else

$s_{ik} = -1$

Step 3: Fix any small positive real number ϵ, if $|I_{ij}(t)-I_{ij}(t-1)| < \epsilon$ stop, else update $I_{ij}(t)$, $s_{ik}(t)$ and substitute them into (1), then go to Step 2.

5 Simulation results analysis

In this simulation, we set $N = 1000, K = 5, \epsilon = 0.01$, and each plot we run 100 times for average. Fig 1, 3 partially illustrates the simulation results. Fig .1 (a) shows the group initial random opinions states when each voter i face K dimensions decision making(before self-organize polarization), Fig.1(b) illustrates the group bi-polarization state under the condition of no imposing external influence this is $v_s = 1$ and introducing negative and neutral influence. We can observe that two voting patterns appear after group polarization, e.g. one voting pattern is "(+1, +1, -1, -1, -1)", the other is "(-1, -1, +1, +1, +1)" and the ratio of the two voting pattern size is approximate to 0.5.

The relationship between exogeneous intervention parameter v_s to group polarization is shown in Fig. 2. We can see that when $v_s = 1$ namely no external intervention to the group interaction processes, the ratio of the two opinion choosing patterns size is approximate to 0.5, however the fifty to fifty well matched equilibrium will be destroyed just cut a little of v_s, in other words, having introduced some external influence will lead to majority pattern appeared, in particular, when $v_s = 0.5$ this is to say group opinion is evenly affected by external and internal factors, we observe that group consensus appears.

It is clearly suggested that, under the condition of imposing external intervention, the group reaches majority or consensus pattern, on the contrary, the group evolves into bipolarization state in the end.

Furthermore, Fig 3 shows the scenario that one dominant voting pattern "(-1,+1,-1,+1,-1)" appears if we only consider the homogeneous positive social influence, or constantly let $I_{ij} =$ "$+$" in Hopfield network model.

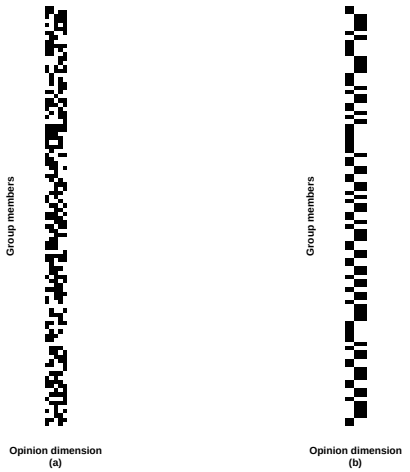

Figure 1. Group opinion before and after polarization (in the condition of imposing three types of social influence)

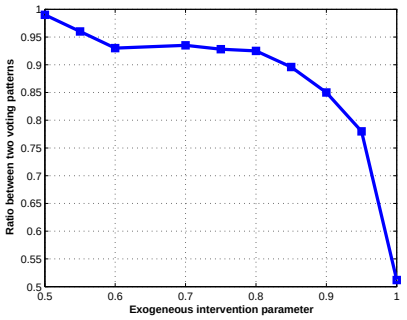

Figure 2. exogeneous intervention impact on group polarization

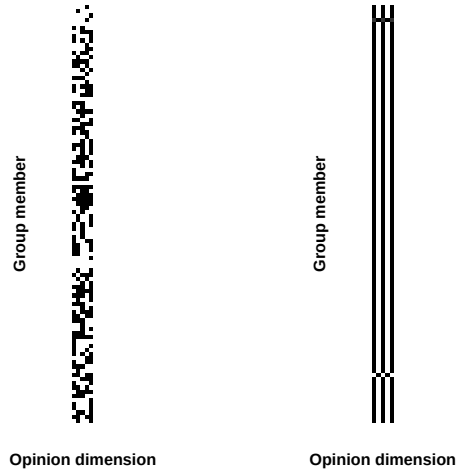

Figure 3. Group consensus appears under the condition of homogeneous positive influence (the left figure illustrates the initial group opinion distribution, the right figure demonstrates the group consensus state)

6 Conclusions

In this paper, we discuss the implications of three types of social influence based on social identity theory, and investigate the non-positive social impact on group polarization based on Hopfield network model. By simulation we find that group tend to form bipolarization pattern under the condition of no imposing external intervention. On the contray, simulation shows that majority or consensus occurs among group members if the non-positive influence is neglected. This result is agreed with the conclusion drawn by Thomas, F. et al that coexistence of social norms will emerge based on attractive and repulsive forces caused by friendly and adversary relations among agents[16], and also consistent with the earlier work on structural balance[17].

Most literatures stress that the homogeneous social influence will result in the global stability of social homogeneity, where convergence to one leading polarization is almost irresistible in a closely interconnected or interrelated population. However, this study based on Hopfield network model demonstrates that social homogeneous stable state is highly brittle if we consider "influence ties" to be negative or zero.

This study also demonstrates that in-group/out-group differentiation and rejection antagonism, and the difference are labelled in the voters' cognition as assumed by social identity theory, are the emergent properties of social network self-organization, which argument is different from the conclusion that agents' cognitive are not inscribed in Macy's work[15].

We contribute to this literature by looking into "facet" of self-identity of group members. The finding indicates that the voting behavior of heterogeneous group is, in fact, different from that of homogeneous. The prism of social identity theory, which holds that people maintain an "us" versus "them" portrait during the processes of the collective behaviors is the explanation of heterogeneous group voting result.

Especially, the conclusion might partially explain a series of recent fifty-fifty voting result in western countries, such as Bush-Gore 2000 presidential election in US, Stoiber-Schröder 2002, the 2005 Schröder-Merkel German elections, and the 2006 Prodi-Berlusconi Italian elections. Galam used the "contrarian effect" to explain these well matched voting phenomenon[18]. However, in this paper we make a step forward to illustrate this type of human collective voting pattern from non-positive social influence point of view.

Consider a person is not only influenced by those who have the same or the opposite social identities, but also (even more strongly) influenced by his or her relatives, colleagues, friends and neighbors (those who have close ties with the focal ego in local network structure)[19][20], in our future work, we hope to include "local network structure " and various types of network structures into this model.

Finally, we hope that this work may stimulate more and more further research of combined non-positive or heterogeneous repulsive and neutral behavior in social dynamics.

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