A Recipe for Social Change: Indirect Minority Influence and Cognitive Rebalancing

Jiin Jung[1] and Aaron Bramson[2]

[1] Department of Psychology, Claremont Graduate University
[2] Laboratory for Symbolic Cognitive Development, Riken Brain Science Institute

Abstract. The present paper proposes an agent-based model of indirect minority influence to examine a theoretical assumption that indirect minority influence leads to social change as a function of cognitive rebalancing. An attitude updating algorithm was constructed with minimal assumptions based on social psychological theories on indirect minority influence processes. Simulation results reveal that in the face of direct majority influence, indirect minority influence in combination with cognitive rebalancing is a recipe for social change. We discuss the findings in terms of the social influence literature and suggest some promising avenues for modeling extensions for theory building in minority influence and social change.

Keywords: indirect minority influence, cognitive rebalancing, social change, agent-based modeling

1 Introduction

Minority influence on social change has been a major topic of social psychology over the past half century (Prislin & Crano, 2012). Early researchers viewed minority dissents as frequent catalysts of social change (Moscovici, 1976),and typically assumed that if minority dissents successfully influence the majority's attitude in favor of a minority position, this can potentially change the societal norm. Social change refers to the process whereby a society adopts a new belief, attitude, or idea which eventually becomes accepted as a norm. Although by definition social change is a societal-level phenomenon, social psychologists often reduce it to an individual level and then measure individuals' attitude change, or to a small interactive group level and measure the small groups' decision in favor of an initial minority position as a proxy of social change (Levine & Tindale, 2015). This can be partially attributed to the limitations of the prevailing research methods in social psychology (Smith & Conrey, 2007). For most cases, variables are measured from individuals or small, often minimal,

groups, and interactions among group members often are not allowed (or if they occur, are minimal and only for a short time period within the small group). However, individual attitude changes and small group decisions are not reasonable approximations to social change.

These limitations of the prevailing social psychological methods can be resolved, complemented by using an agent-based modeling (ABM) approach (Miller & Page, 2007; Vallacher, Read, & Nowak, 2002). ABMs can bridge between the micro-level of social psychological processes (e.g., intra-individual processes and interpersonal interactions) and the macro-level emergent consequences of social dynamics. Because ABMs can capture dynamical properties of social systems, many ABM studies indicate that the macro-level consequences of multiple-agent interactions over time often turn out to be other than the linear sum of individual agents' attributes. As a result researchers using ABMs often get surprising results from their modeling and simulation efforts (Epstein, 1999). In this article, we propose an agent-based model of indirect minority influence and establish the cross-level link of indirect minority influence and social change.

2 Theoretical Foundations

2.1 Conversion theory

Moscovici's conversion theory (1980) contrasts the differences underpinning the motivational and cognitive processes elicited when people encounter disagreement from members of large vs. small factions (i.e., majority vs. minority). Disagreement creates inner conflict and therefore results in a motivation to reduce the conflict. This conflict is resolved via different influence processes depending on whether the counter-attitudinal source is the majority or minority. Because the majority controls resources or other sources of power, adopting the prevailing attitude can be directly rewarding. Therefore individuals may change attitudes simply to comply with the group's consensus. This compliance reflects motives of group belongingness, but not an evaluation of the majority's arguments. Consequently, the immediate direct attitude changeis typically superficial and may easily be changed again.

On the other hand, when someone in the society breaks the attitudinal unanimity, people take notice of this salient event and the nascent idea captures people's attention. Even when minority positions are not viewed as correct, their arguments are scrutinized in-depth. Because contemplation takes time, belief validation results in delayed focal attitude changes. Also, because people carefully evaluate the uncommon ideas, attitude changes induced by exposure to minority ideas via this path are stronger and last longer.

According to conversion theory, consistency is an important condition for attitudes held by a minority to have in order to be influential. His blue-green

study verified the importance of consistency in minority influence (Moscovici, 1969; 1980). Empirical studies confirmed that minority opinions are particularly influential in related (not focal) attitudes (when their behavioral style is perceived as consistent and coherent (Clark, 1990; Moscovici, Lage & Naffrechoux, 1969; Wood, Lundgren, Ouellette, Busceme & Blackstone, 1994). The attitude changes happening in other, non-focal dimensions related to the nascent idea is called indirect influence.

However, conversion theory did not explain why minority-induced delayed change often doesn't happen, how indirect minority influence occurs, or what the relationship between immediate indirect influence and delayed direct influence is. Specifically, if contemplation takes time, why and how does immediate indirect change happen? Context/categorization-leniency contract theory(CCLC),which integrates social identity and information processing approaches,explains the full range of minority influence processes from immediate indirect influence to delayed direct influence (Crano, 2001).

2.2 Context/categorization–leniency contract theory

Crano's CCLC theory extended Moscovici's conversion theory and explained when, why, and how the immediate indirect attitude change and delayed focal attitude change occur through minority influence. This influence starts with changes to individuals' attitudes within the local ingroup, and eventually can percolate through society and lead to global-level social changes in which a nascent idea replaces the prevailing one (Crano, 2010).

CCLC theory postulates that when the belief minority is made up of ingroup members and their messages are not threatening to the ingroup's identity (Abrams & Hogg, 2010), they may be influential due to the "leniency contract". The leniency contract refers to an implicit agreement between the majority and minority within a group such that the majority listens to the minority's dissenting opinion in order to maintain the viability and cohesion of the group as a whole, and the minority also accepts that a change in the focal belief is unlikely. His theory states that due to the leniency contract between the majority and minority within a group, minority influences lead to both immediate indirect attitude changes (i.e., changes to attitudes besides the focal countervailing attitude) and also delayed focal attitude changes via cognitive rebalancing process.

Thus, even though a direct change in the focal attitude is unlikely, there exists pressure to change indirect/related attitudes within the same cognitive constellation. Minority influence then becomes a function of message quality. If minority argument is strong, it will likely lead to an *immediate indirect change*, but an immediate focal change is unlikely. This minority influence toward indirect attitude changes has been empirically supported. Alvaro and Crano found that participants who were exposed to an ingroup minority idea compared

the idea to both majority and outgroup minority ideas, thenelaborated and recalled the message's contents (Alvaro & Crano, 1996) and changed their attitude in a related issue (gun control) that was linked to a focal issue (ban of homosexual soldiers) (Study1, Alvaro & Crano, 1998). Indirect influence elicited by minority idea consideration was also found when the focal and related issues were reversed (Study2, Alvaro & Crano, 1997).The ingroup minority had indirect influence when the minority idea is viewed as distinctive (Alvaro & Crano, 1998) and when its proponents consistently promoted their opinion over time (Crano & Alvaro, 1998).

Finally, indirect attitude changes can lead to a focal attitude change via *cognitive rebalancing* process. Because attitudes do not exist in isolation, but rather are structurally interrelated in belief constellations, attitudes that occupy the same cognitive constellation may all be affected when one element of the set is changed. As indirect changes accumulate, *delayed focal change* can occur due to the motivation to maintain consistent and coherence within the cognitive constellation (Crano & Chen, 1998:1440; Fink & Kaplowitz, 1993; Judd, Drake, Downing & Krosnick, 1991; McGuire, 1990; McGuire & McGuire, 1991). Although empirical testing indicated that indirect attitude change was further associated with delayed focal change when the message from an ingroup minority was strong (Crano & Chen, 1997), the role of cognitive rebalancing still remains a conjecture.

3 Model

The goal of this paper is to test the theoretical assumption that the cognitive rebalancing process links immediate indirect minority influence to delayed direct influence, finally leading to social change. We construct an attitude updating algorithm with the rules of influence postulated in context/categorization–leniency contract theory (CCLC), implement the algorithm with minimal assumptions, and simulate the model to test the key hypothesis that in the face of direct majority influence, indirect minority influence in combination with cognitive rebalancing process is a recipe for social change[1].

3.1 Agents Properties

Each agent (a^j) has *two* attitudes and each attitude takes *binary* values. For

[1]Although Moscovici and Galam proposed an agent-based model of attitude change in groups (Galam and Moscovici, 1991; Galam, 2002), their model did not examine indirect minority influence.

convenience one attitude is represented as color (a^j_1: 0 = yellow, 1 = blue) and the other as shape (a^j_2: 0 = circle, 1 = square) (Figure 1). Thus, there are four different states: yellow circle (a^j = {0, 0}), yellow square (a^j = {0, 1}), blue circle (a^j = {1, 0}), and blue square (a^j = {1, 1}). We regard the attitude system of an agent as *internally consistent* or *cognitively balanced* if the two attitudes take the same values (yellow circle and blue square).

3.2 Multi-agent Systems

In our basic setup as shown in Figure 1, 1600 agents populate a 40-by-40 toroidal square-grid topology (wrapping boundaries and no empty spaces). An agent's ingroup is defined as the eight agents in that agent's Moore neighborhood. In this way, each agent's ingroup is a distinct set of agents.

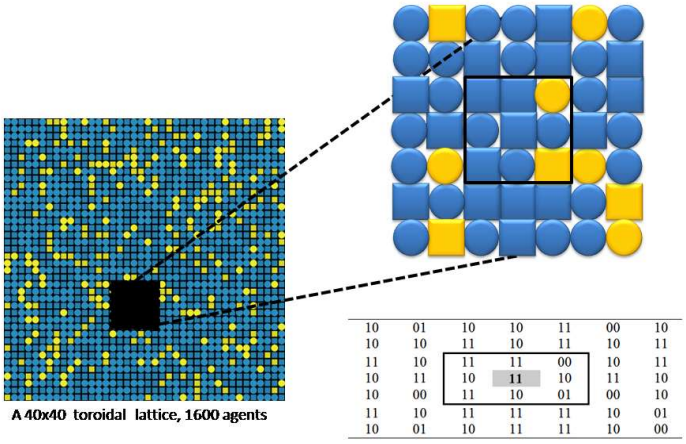

Fig.1. An example demonstrating the agent updating process.

3.3 Interaction Rules

In each iteration, each agent identifies its *local ingroup*; the collection of agents with the potential to influence it. Then each agent randomly selects one member of its local ingroup to be an influence *source* (a^k). Each agent then compares a randomly selected *focal attitude* with that of its source agent. If the focal attitude of the source agrees that of the agent (i.e., $a^j_i = a^k_i$), social influence is not initiated because the source affirms the agent's view. However, if the focal

attitudes of the source agent disagrees (i.e., $a^j_i \neq a^k_i$), then that disagreement draws the agent's attention, evokes inner conflict and creates uncertainty that the agent is motivated to resolve (Moscovici, 1976). How the agent responds is contingent upon the majority/minority status of the source's attitude in the agent's local ingroup.

If the focal attitude of the source is held by the majority of ingroup members, then the agent conforms to the source (i.e., changes that attitude to match the source; *direct majority influence*). On the other hand, if the focal attitude is held by the minority of ingroup members, then the agent examines whether the source is attitudinally consistent by comparing the values of the focal and related attitudes (i.e.,$a^k_1 = a^k_2$). If the related attitudes of the source are consistent (i.e., $a^k_1 = a^k_2$), the agent changes the related attitudes to the direction of the source's focal attitude (*immediate indirect minority influence)*. However, if the attitudes are not consistent (i.e., $a^k_1 \neq a^k_2$), the agent does not change any of its own attitudes.

Upon completion of the social influence process, the *cognitive rebalancing process* is initiated: these two processes are independent in the current model. All agents turn their attention to their own attitudes in order to rebalance their cognitive system. Each agent *j* randomly picks one of the two attitudes and examines if the chosen attitude and the other attitude have the same value.If the two attitudes are consistent, the cognitive system of the agent is balanced and the agent does not need to rebalance its cognitive system. However, if the two attitudes are not consistent, this means the attitude newly changed via the social influence process has introduced imbalance to the cognitive system. To rebalance, the agent tunes the randomly chosen attitude toward the other attitude. As a result, two forms of cognitive readjustment to the imbalanced attitude structure appear (Crano & Chen, 1998, p.1440). The newly changed attitude reverts to its original position (*persistence*). Or, the newly changed attitude unbalances the belief structure, which pressures the linked focal attitude to be brought into accord with the newly altered attitude *(delayed direct minority influence)*.

We will test our key hypothesis that even while majority influence is direct and focal, social change can occur if agents change their related attitude as a result of minority influence and their cognitive system gets rebalanced to be consistent and coherent.

3.4 Running Simulations

We simulated our model to validate the theoretical assumption that indirect minority influence at the ingroup level, in combination with the cognitive rebalancing process at the intra-individual level, can lead to social change at the society level in the face of direct majority influence. We also tested to what degree social change is sensitive to cognitive rebalancing. We furthermore

parameterized a few important factors in our model: (1) whether the agents initially holding the nascent idea are clustered as a community vs. scattered randomly across a society, (2) a variety of lattice topologies in which agents have differing numbers of neighbors (ingroup size), and (3) the size of the initial minority belief holder population.

We initialize the system with a randomly chosen 1% of the agents holding the nascent attitude (yellow; i.e., $a_j^1 = 0$). The shapes are initially distributed in equal proportions and randomly assigned over the population. For each combination of rules and initial conditions (described below) we performed 100 runs of the model until (a) all the agents have the same attitude, (b) no agents can change attitudes, or (c) 10,000 time steps (to terminate non-equilibrium runs and facilitate analysis of extremely long convergence times). At each step we track the percent of the population of each color and of each shape as well as the percent of the agents that are consistent.

Social change as a main dependent variable is measured both as a dichotomous variable; i.e., whether a system eventually reaches an equilibrium in which all agents hold the initially nascent idea (social change=1) or an equilibrium in which all agents hold the initially prevalent idea (no social change=0) and as a continuous measure for social change: average cumulative proportion of agents holding the nascent attitude.

4 Results

For each of the six combinations of majority and minority influence and cognitive rebalancing process, emergent system patterns are summarized in Figure 2.

4.1 Indirect Minority Influence Alone

Because the indirect minority influence process will increase the prevalence of whichever property is a local minority, it will always (by itself) spread a nascent attitude from 1% of the population toward 50% of a population. Once reaching approximately half of the population, however, the nascent idea is no longer a minority, and so minority influence balances the two attitudes at the global level in a never ending constant, but stochastic, churning of both color and shape (as described above). Thus indirect minority influence alone cannot lead to social change although it is demonstrably instrumental in bringing an idea from obscurity to popularity.

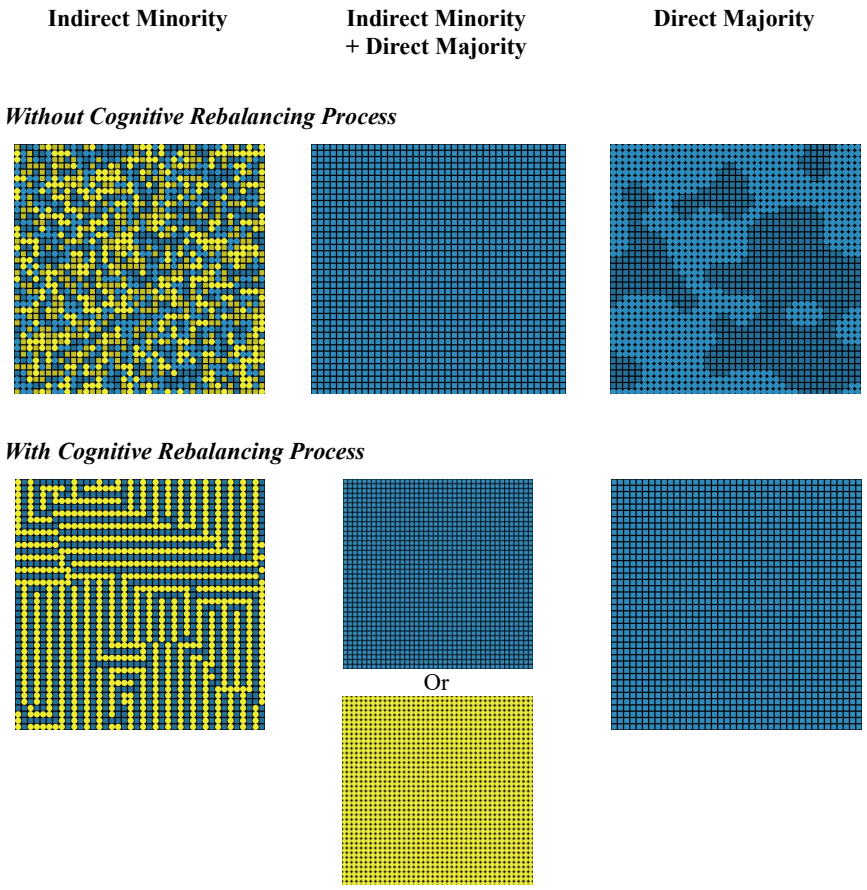

Fig.2. Emergent system patterns and characteristics at an individual and system level for six combinations of majority and minority influence and cognitive rebalancing process.

4.2 Indirect Minority Influence and Cognitive Rebalancing Process

Adding the cognitive rebalancing rule to minority influence also brings the population up to a 50% distribution in every run, but the dynamics are somewhat different. The agents quickly align themselves into maze-like linear arrangements of yellow circles and blue squares at which only the line ends and corners are unbalanced. Eventually these runs reach an equilibrium of all

vertical or horizontal lines of each consistent type, equally dividing the population. It is also clear that regardless of these assumptions the combined mechanisms will produce a world of equal or roughly (and stochastically) equal proportions of yellow circles and blue squares.

4.3 Indirect Minority Influence Facing Majority Influence

Majority influence dominates minority influence process on the color attitude and so the system quickly converges to all blue, thus minority influence cannot spread the nascent attitude. One surprising result we would like to highlight is that the final state of agents is always internally consistent (blue square) even though the internal consistency rule is not operational. This occurs because minority influence only occurs when agents are consistent, this puts indirect pressure on the shape attribute and leads eventually to a full population of blue squares.

This result implies that the fact that a society comes to have a coherent set of beliefs (cultural formation) can be partially attributed to influence by a consistent minority even though that minority idea may go extinct.

4.4 Indirect Minority Influence and Cognitive Rebalancing Process Facing Majority Influence

Consistent with Crano's conjecture, the indirect minority influence process in combination with cognitive rebalancing can spread an initial minority position in the face of majority influence (H1). That is, the combination of all three rules suffices to enable the possibility of social change but does not guarantee this result. Strengthened by the consistency requirement, minority influence can often move the population toward the 50:50 split at which point both colors have equal standings. Although every run will eventually reach an equilibrium of all yellow circles or all blue squares, the random-walk-like behavior sometimes extends the required time to hundreds of thousands of time steps. The dynamics of these simulations are extremely volatile and unpredictable: the population can reach 99.8% of one color, and then swing back with an end result of the opposite color. It's not the equilibrium result we are truly interested in: even if a nascent idea fails to dominate in the end there can be widespread and long-lasting partial social change (Figure 3).

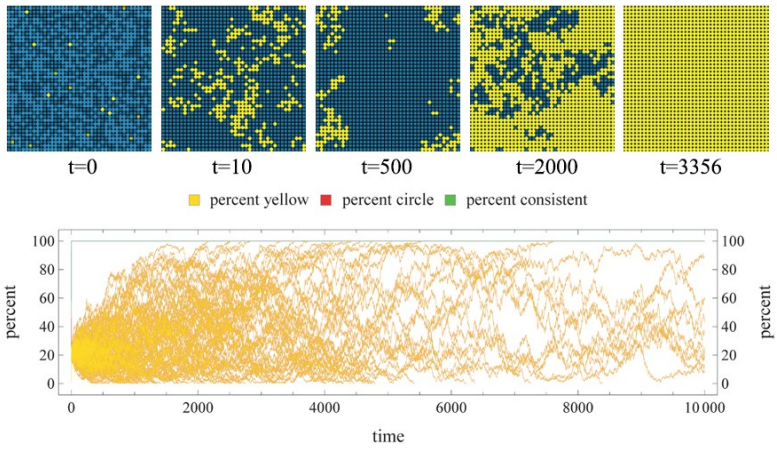

Fig. 3. Screenshots from one run demonstrate the high volatility of the attitude proportions (top). The time series of100 runs highlights this long-lasting volatile behavior (bottom).

4.5 Cognitive rebalancing and social change

We explore the role of the cognitive rebalancing process by making the consistency check rule's activation dependent on a stochastic variable – specifically a probability of performing the consistency check. Each agent that finds itself in an inconsistent state after the majority and minority influences will make itself consistent only if its random draw falls below the threshold for checking.

The results of varying the self-consistency check probability are shown in Figure 4. The result is consistent with CCLC theory's claim that cognitive rebalancing is a key process facilitating indirect minority influence's ability to lead to social change. This high degree of sensitivity to cognitive rebalancing underscores its importance for minority influence's ability to bring an uncommon nascent idea to an equal social footing.

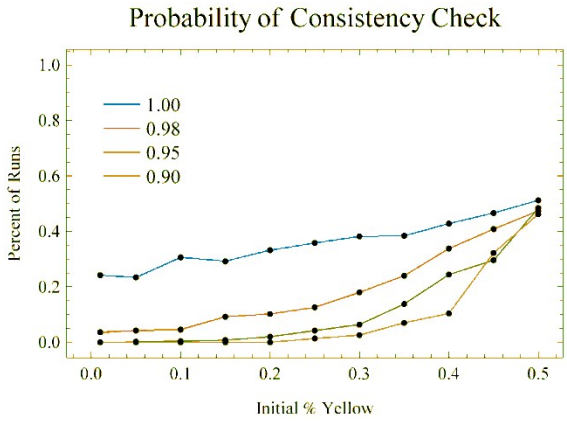

Fig.4. Small decreases in the probability of a self-consistency check have a large downward effect on the percent of runs achieving social change. The Y-axis represent the proportion of runs that end with social change (or with a population of at least half yellow agents at the 10,000 halting time) aggregated over 500 runs.

4.6 Initial minority size

It is important to note that the reported initial 1% of agents that are yellow is a bit misleading due to a nuance of how the rules are implemented. That number is immediately expanded in the first iteration when agents enact the self-consistency rule. Approximately half of the blue circle agents will make themselves consistent by becoming yellow circles − that's an additional 24.25% of the agents on average (again visible in Figure 4). We are interested in the relationship of the initial percent yellow and the proportion of runs resulting in social change, and for this we tracked both the initial-percent-yellow parameter and the average effective initial percent yellow (see x-axis of Figure 5). Although the expected value can be exactly calculated, we report the mean empirical value from after all three rules have run in the first step.

Our sweep of the initial-percent-yellow parameter reveals that across 500 runs there is a clear and approximately linear relationship between the initial percent yellow and the proportion of runs resulting in social change (the yellow attribute dominating). Furthermore, the effective initial percent yellow is a reasonable, though imperfect, indicator of both the proportion of runs achieving social change and the proportion of runs that reach a 50% mean cumulative number of yellow agents. From these results we conclude that the combination of all three rules produces a system which generates an overall unbiased propagation mechanism such that although the individual runs are highly

volatile and unpredictable the aggregate behavior (across runs) is consistent and predictable from the initial percent of yellow agents. Although it is unsurprising that increasing the initial percent of yellow agents increases the chance that social change will happen, the behavior of individual runs belies this relationship. It only becomes clear through large numbers of runs and could not be demonstrated analytically or through thought experiments.

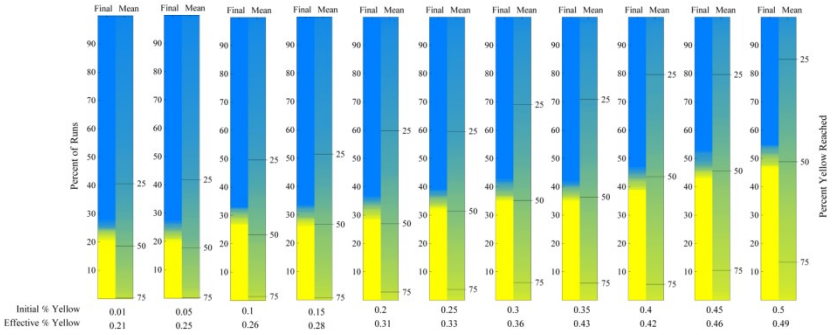

Fig. 5. This chart shows the proportion of yellow agents at the end of (left half of each bar) and on average (right half of each bar) for 500 runs when all three rules are activated. On the left of each bar, runs that reached equilibrium are solid yellow or blue depending on the outcome, and runs that did not complete appear as a gradient in between reflecting the proportion. The left axis reveals what percentage of runs reached that outcome. The right sides of the bars indicate the distribution of the average cumulative proportion of yellow agents; the axis indicates the proportions of runs in which 25, 50, and 75 average cumulative percent yellow are reached. There is a clearly increasing tendency to achieve social change with increasing initial percent holding the nascent idea.

4.7 Random locations vs. community of nascent idea holders

We tested the effects of clustered initial nascent idea holders by running 100 trials for each of the rule combinations and 500 simulations for the all-three-rules combination with identical parameters as the base model: the only difference was the initial location of the yellow agents. The community of yellow agents is grown from a single yellow agent by randomly turning blue agents that are adjacent to yellow ones yellow until the initial percent yellow is reached. Thus each configuration is likely different, but always with yellow agents forming a contiguous group.

Although the system behavior appears quite different at first, the two configurations produce nearly indistinguishable long-term results for all rule combinations. Because only local neighborhoods are considered by the agents,

the forces that move the aggregate behavior are generally invariant to regional effects such as a clump. For example, when all three rules are active majority and minority both work to quickly mix the population, dissolving the initial clump of yellow agents across the landscape. At the time scales required to reach equilibrium the initial locations of the yellow agents is irrelevant as is evident in Figure 6.

4.8 Ingroup size

Among the artifacts introduced by this style of modeling is the use of square grids and either the von Neumann or Moore interaction neighborhoods. To test the sensitivity of the model's behavior to this topological assumption we released the agents from the grid and instead connected them via lattice networks. In this way each agent has the same size ingroup and we can control that size as a parameter from 3 to 26. For some node degree values it is only possible to achieve that many immediate neighbors in a lattice by extending the visualization into 3 dimensions, although the physical spatial locations are not relevant. For some number of neighbors there are simple 2D and 3D configurations, and both were explored to vary the second-order interaction effects. All these lattice changes were performed while keeping the total number of agents fixed at 1600.

The results depicted in Figure 7 show that the number of neighbors has no significant effect on the aggregate long-term likelihood of achieving social change when all three rules are in operation. Because majority and minority influence both operate upon relative popularity the effects are consistent across scales, even from the extremes of 3 to 26. Other rule combinations also produced extremely similar aggregate results, although some particular equilibrium configurations vary across the different topologies; e.g. minority influence plus consistency yields static equilibria for some values and balanced churning for other values.

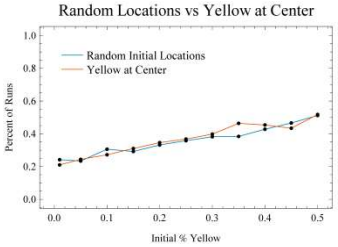

Fig. 6. Random vs. Clustered

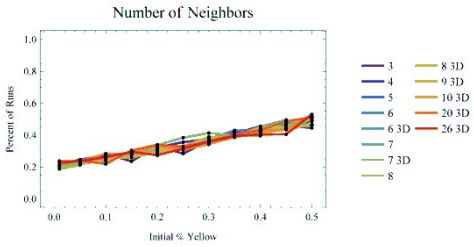

Fig. 7. Ingroup size

5 Conclusion

Our goal in this paper is to propose a minimal model capable of embodying the mechanisms of majority and minority influence as described in the social psychological literature. Simulations were performed to test its theoretical assumption regarding the cross-level relation between indirect minority influence and social change. Results demonstrate that in the current formulation the indirect minority influence alone cannot lead to social change in the face of the direct majority influence, however, consistent to Crano's conjecture, indirect minority influence in combination with cognitive rebalancing process is a recipe for social change in the face of direct majority influence. When examining model parameters, we found that the likelihood of social change depends on the initial proportion of nascent idea holders in a nearly linearly relationship despite extreme volatility in the system behavior over time. Ingroup size and distribution of minority did not affect the relationship between indirect minority influence and social change.

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