# Opposites Repel: The Effect of Incorporating Repulsion on Opinion Dynamics in the Bounded Confidence Model

## (Extended Abstract)


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## ABSTRACT

Various computer and analytical models have been studied that analyze population dynamics of opinions of agents in societies under various assumptions of interaction restrictions and influences. Of particular interest to us are societal models based on Self-categorization Theory which addresses how agent opinions are affected based on interactions with other agents. The Bounded Confidence model, for example posits that two agents whose opinions are not too similar influence each other and are more likely to change their opinions towards each other after an interaction. Several extensions have also been proposed to such models that include interaction restrictions based on group memberships and the possibility of agents shifting their opinions away from each other after an interaction. We are motivated to study more realistic repulsion models where agents with extreme opinions will tend to further polarize after an interaction. We develop, simulate, and analyze several repulsion schemes within the Bounded Confidence Model of interaction and show interesting emergent phenomena that have been observed in real-life scenarios. We also present analytical models that are able to predict major features and timings of emergent opinion patterns in such interacting populations.



## Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Multiagent systems*

## General Terms

Experimentation

## Keywords

opinion dynamics; bounded confidence; repulsion


## 1. INTRODUCTION

Our opinions are influenced by social interaction. Developing agent-based models of opinion adoption in social groups enable us to simulate a wide range of social situations, and help us understand the origin of emergent social patterns. We are particularly interested in a simple yet effective model of opinion adoption called the Bounded Confidence (BC) model [1], which describes how agent opinions can become more consistent through interaction. This basic rule set is able to generate complex behavior such as emergent clustering patterns that reflect real-life scenarios. Various enhancements have been proposed to address the opposite trend, increased dissimilarity and opinion polarization, through psychological constructs such as Self-categorization Theory [3] and Social Judgment Theory [2]. We present another alternative based on Self-categorization Theory, and compare its behavior to a previously proposed model.

## 2. MODELS

The repulsion models presented in this paper share design similarities and can be effectively compared. Agent opinions are initialized at regularly spaced intervals over [0,1], i.e., the initial opinions of $n$ agents are placed at $\frac{0}{n}, \frac{1}{n}, \ldots, \frac{n}{n}$. Each simulation is run for 200 rounds; in a round, all agents are selected in a random order to interact with another. Attraction for both models follows the rules of the BC model. For a pair of agents, $a$ and $b$:

$$\left|a^t - b^t\right| \leq \epsilon \Rightarrow \begin{cases} a^{t+1} = a^t + \mu(b^t - a^t) \\ b^{t+1} = b^t + \mu(a^t - b^t) \end{cases} . \quad (1)$$

The conditions for attraction and repulsion will never hold simultaneously for both models.

### 2.1 M1: Repulsion by Social Judgment

M1 is based off of the Jager's model of repulsion in [2]. In M1, $\epsilon_r$ denotes the barrier beyond which repulsion occurs. Repulsion occurs when:

$$\left|a^t - b^t\right| > \epsilon_r. \quad (2)$$

The rule $\epsilon_r > \epsilon$ is necessary to prevent simultaneous attraction and repulsion. When the repulsion condition is met, agent opinions are effected as such:

$$(2) \Rightarrow a^{t+1} = a^t + \mu(a^t - b^t), b^{t+1} = b^t + \mu(b^t - a^t) \quad (3)$$

After repulsion, opinions are "clipped" to ensure they do not exceed the range $[0, 1]$.


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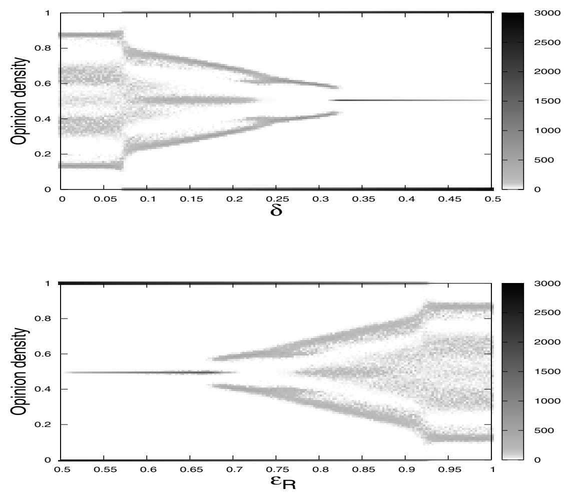


**Figure 1: Opinion densities vs $\delta$ for M2 (top), $\epsilon_r$ for M1 (bottom), 100 runs, $n = 5000$, $\epsilon = 0.1$, $\mu = 0.5$**

## 2.2 M2: Repulsion by Categorization

Repulsion in M2 is influenced by Self-categorization Theory [4]. Individuals in the model have a personal and group identity – the former differentiates an individual from other individuals, the latter from other groups. Repulsion for M2 represents of the increasing salience of the group identity. Two agents, $a$ and $b$, repulse when:

$$(a^t \leq b^t) \wedge (a^t < \delta) \wedge (b^t > 1 - \delta), \quad (4)$$

assuming $2\delta + \epsilon < 1$; which prevents simultaneous attraction and repulsion. In other words, both agents must be in opposing groups to repulse. Repulsion is implemented through agents offsetting their opinion by:

$$(4) \Rightarrow a^{t+1} = a^t - \mu \left|0 - a^t\right|, b^{t+1} = b^t + \mu \left|1 - b^t\right|. \quad (5)$$

Unlike M1, agents in M2 do not need to "clip" their opinions since they will never go beyond the range [0,1].

# 3. RESULTS AND DISCUSSION

Figure 1 shows that the dynamics for M1 mirror those of M2. Regions of repulsion form in M1 when $\epsilon_r \geq 0.5$: agents only repulse from one extreme of the opinion spectrum. These "pseudo-groups" act like the groups in M2, yet, groups in M1 are not as rigid as those in M2: in M2, any member of a group may repulse from any member of an opposing group, but repulsion does not always occur between members of pseudo-groups. The interesting similarity between these two applied social theories shows that, when attitudes are split by only two groups, attitudinal judgment acts identically to group judgment.

## 3.1 Predicting extremist group formation

For a random interaction in model M2 between agents with opinions $x$ and $y$, with $(x < 1 - \delta) \wedge (x < 1 - \epsilon)$, either $y \in [x, x + \epsilon]$, and $x$ will increase by an average of $\frac{1}{2}\mu\epsilon$; $y \in [\max\{0, x - \epsilon\}, x]$, and $x$ will decrease on average by $\frac{1}{2}\mu \min\{x, \epsilon\}$; $y \in [1 - \delta, 1]$, and $x$ will decrease by $\mu x$; or $x$ does not change. We predict that an extremist group will appear if there is a group of agents on the interval $[0, x_0]$, for some $x_0 > 0$, such that the average opinion change for the group is negative. When $x_0 < \delta < \epsilon$, the average opinion change is $\frac{\mu}{2}\int_0^{x_0}(\epsilon - x - 2x)\,\mathrm{d}x = \frac{\mu}{2}\left(\epsilon x_0 - \frac{3x_0^2}{2}\right)$, and the desired condition is satisfied for $x_0 > \frac{2}{3}\epsilon$. Since $x_0 < \delta$, the minimum associated $\delta$ value is $\frac{2}{3}\epsilon$. Since $x_0$ can be increased up to $\delta$, we predict that the extremist group will capture all agents on the interval $[0, \delta]$. Analogous work predicts that extremist groups always form when $\delta > \epsilon$, and never when $x_0 > \delta$. Results for M1 are similar for typical configurations, despite a small dependency on the value of $\mu$.

## 3.2 Conditions for reduced variability

Experiments showed that large $n$ or small $\mu$ reduce variability in cluster position and formation. As $n \to \infty$, the distribution of opinion changes for agents with opinion $x$ will approach (almost surely) the corresponding probability distribution. Large $n$ population behavior can be closely approximated with a deterministic model using discrete opinion-space buckets. As $\mu \to 0^+$, continuous opinion change probability measures are more frequently sampled, and agents will almost surely approach the mean opinion adjustment across possible interactions.

## 3.3 Cluster formation in M2's middle region

Cluster formation in the middle region is very similar to that of the BC model. In fact, parameter values in M2 can be translated to an attraction threshold in the BC model such that cluster positions from M2 may be mapped to the BC model: $\epsilon_{BC} = \frac{\epsilon}{1-2\delta}$, with the limitation $\frac{\epsilon}{2} < \delta < 0.5 - \epsilon$ (where the middle region forms in M2). The result is that the middle region for select parameter values could be mapped to the BC model with $\epsilon_{BC}$. This provides an interesting outlook on how categorization and lack thereof intermingle to reach a converged system.

## 3.4 Concluding Remarks

We investigate the similarities in emergent behavior of two distinctly motivated models of opinion adoption, M1 and M2; predict (a) the presence, size, and space consumed by extremist groups (b) the number of opinion clusters in the converged state, and (c) the bias distribution for large populations of agents; and explain decreased variability for large $n$ and low $\mu$. The dual-group setup of M2 is limited, but easily can be expanded to multiple groups.

# 4. REFERENCES

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