

Introduction

We investigate the policies of restricting social influence and imposing curfews upon interacting citizens in a community featuring citizens and the police force which guards it. We compare and contrast their effects on the social order and the emerging levels of civil violence.

We find that restricting social influence does indeed pacify rebellious societies, but has the opposite effect on peaceful ones. On the other hand, our model indicates that restricting mobility through curfews has a pacifying effect across all types of society.

Model

Features **cops** and **citizens**, who move within their Moore neighbourhood to a randomly selected free location.

Citizen specific:

- Two states; **active** (rebellious) or **inactive** (not rebellious).
- Each state has an associated utility, the utility of activity U_{AC} and the utility of inactivity U_{IN} .
- Adopt state associated with highest utility. U_{IN} is pre-set externally, whilst U_{AC} is calculated for each citizen at each turn, as shown in equation 1.

$$U_{AC} = P_{AR} * U_{AR} + P_{NAR} * U_{NAR}$$

Equation 1: Calculating a citizen's utility of activity

- P_{AR} is the probability being arrested.
- P_{NAR} is the probability of not being arrested.
- U_{AR} is the utility of arrest, externally set.
- U_{NAR} is the utility of not being arrested, drawn from beta distribution.

- U_{AR} is the gain from expressing opinion and being arrested.
- U_{NAR} is the gain from expressing opinion and not being arrested.
- P_{NAR} is the citizen's cumulative probability of not being arrested by any cop within movement range, shown in equation 2.

$$P_{NAR} = \prod_{i \in C} (1 - \frac{1}{\alpha_i})$$

Equation 2: Calculating a citizen's probability of not being arrested.

- C is the set of all the cops within movement radius of the citizen.
- α_i is the number of active citizens within movement radius of cop i .

- P_{AR} is the probability of being arrested, being $1 - P_{NAR}$.

Cop specific:

- Cops examine their neighbourhood and arrest one randomly selected active citizen.
- Arrested citizens are removed from the environment for X turns.
- X is drawn from a range $(0, J)$ where J is the max jail term.

Influence Model:

- Influence experienced comprises of citizen's susceptibility and neighbours influence and proximity, as shown in Equation 3.

$$U_i^* = (1 - S_i)U_i + S_i \frac{\sum_{j \neq i} U_j f_j \exp\left(-\frac{d(i,j)^2}{\sigma^2}\right)}{\sum_{j \neq i} f_j \exp\left(-\frac{d(i,j)^2}{\sigma^2}\right)}$$

Equation 3: Calculating an agent's U_{NAR} incorporating influence.

- i is the citizen in question, j is a citizen from the set of i 's neighbouring citizens. U_j is the U_{NAR} of the citizen, U_i^* is the new U_{NAR} value. f is the influence of a citizen, s is the susceptibility of a citizen. $d(i, j)$ is the Euclidean distance between citizens i and j . σ is the Gaussian kernel, externally set.

Curfew Model:

Each curfew lasts 5 consecutive turns out of 15, with interval of 10 turns.

Table 1 shows our curfew modelling assumptions with regards to the behaviour of citizens and cops.

	During Curfew	Citizens	Cops
Movement		☒	☑
Act		☒	☑

Table 1: Curfew modelling assumptions.

Experiments

Tables 2 and 3 show the specific experiment, and generalised simulation settings, from which the results were obtained.

Table 2: Model settings used in various experiments to investigate the effects of the influence and curfew policies.

Experiment	Influence	Curfew
1	No	No
2	Yes	No
3	Yes	Yes
4	No	Yes

Variable	Value	Variable	Value
Movement range	4	Cop density	4%
Utility of arrest	0.01	Citizen density	70%
Utility of inactivity	0.5	Grid size	40 x 40
Max jail term	30	Gaussian kernel σ	5
Iterations	1500	Topology	Torus

Table 3: Generalised settings common to all experiments.

Simulations were repeated ten times at each mean value of the U_{NAR} beta distribution. Simulating across a range of mean U_{NAR} values represents different society demographics.

Experiment cont.

During a simulation a citizen compares U_{AC} to U_{IN} . When $P_{AR} = 0$, $U_{AC} = U_{NAR}$. Therefore when the U_{NAR} mean is above U_{IN} we say the society is pre-disposed towards rebellion. With U_{NAR} below U_{IN} it exhibits a more peaceful pre-disposition.

Results

The results show the effect the policies have upon the levels of violence across a range of modelled society types, with the U_{NAR} mean of 0.5 representing the "tipping point" between peaceful and rebellious societies as U_{IN} is set to 0.5. The graphs show curfews reduce rebellion in any society, whereas the effect of limiting free communication depends upon the type of society.

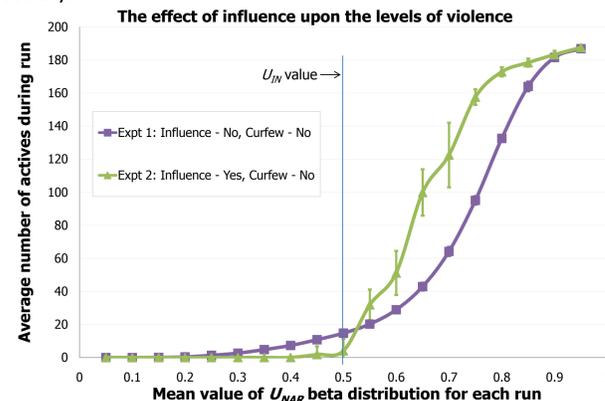


Figure 1: Investigating the effect a policy restricting free communication has upon the levels of unrest across different society types.

Figure 1 shows:

- If the population is generally peaceful ($U_{NAR} < U_{IN}$), restricting communication leads to an increase on the levels of unrest.
- If the population is pre-disposed to rebellion ($U_{NAR} > U_{IN}$), allowing communication increases levels of unrest, whereas restrictions decrease it.

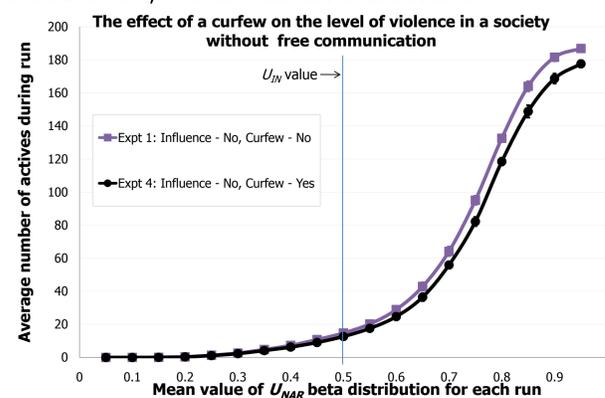


Figure 2: Investigating the effect a curfew policy has upon the level unrest in populations where free communication is restricted across the range of society types.

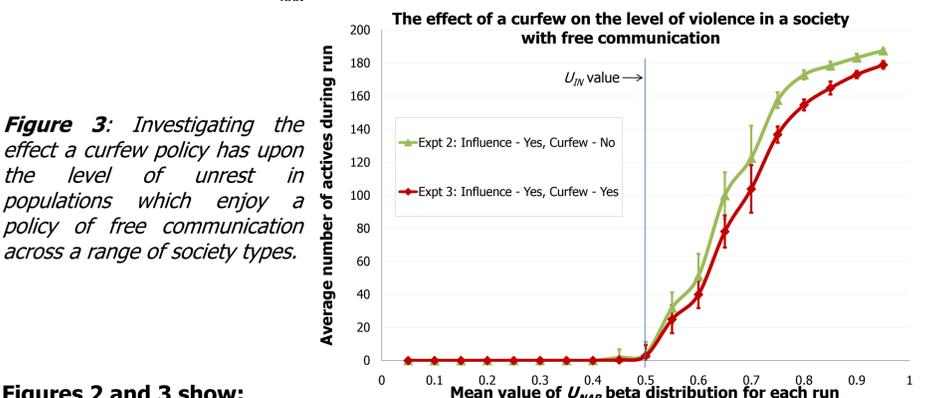


Figure 3: Investigating the effect a curfew policy has upon the level of unrest in populations which enjoy a policy of free communication across a range of society types.

Figures 2 and 3 show:

- Irrespective of the actual predisposition of the population, a curfew policy effectively reduces the level of unrest exhibited independent of other factors.

Conclusion

An elegant agent-based model allowed us to investigate the potential effects of various policy decisions in a simulation of civil unrest. Despite the degree of abstraction, the results have shown trends across various population types which may not be apparent before implementing.

We have shown that:

1. Curfews are an effective means of combating instances of unrest, irrespective of the society type upon which they are imposed.
2. While in a volatile society restricting free communication decreases the levels of unrest exhibited within the population, in peaceful societies restricting free communication acts as a catalyst to increase levels of unrest.

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Effect of mobility on violence in a bi-communal population



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Introduction

• We develop a multi-agent based model to simulate a population which comprises of two groups of civilians and a peacekeeping force. We investigate the effects of different strategies for civilian movement to the resulting violence in this bi-communal population. Specifically, we compare and contrast random and ingroup-based migration strategies.

• Previous work in this area has shown that ingroup clustering instigates violent behavior in otherwise passive segments of the population. Our findings confirm this.

• We show that in settings where only one of the two groups adopts ingroup-based migration it is a winning strategy especially in violently predisposed populations. However, in relatively peaceful settings clustering is a restricting factor which causes the group that adopts it to drift into annihilation.

• We also show that when ingroup-based migration is adopted as a strategy by both groups it results in peaceful co-existence even in the most violently predisposed populations.

Model

The model comprises a grid containing two sets of agents: civilians and peacekeepers.

- Civilians represent members of the population, and are split into two groups: blues and greens.
- Peacekeepers are members of a military force deployed to act as a deterrent against inter-group violence and to arrest civilians who engage in it.
- Civilians are able to "go active" and kill a member of the other group or to migrate to another grid location.

Violence

A civilian's decision to go active is made by comparing two utilities, the utility of being inactive (U_I) and the utility of being active (U_A), and choosing the action which carries the highest utility.

- U_A is made up of two further utilities and a probability values for each:
- U_{NAR} , the utility of going active and not being arrested, and the probability of this happening, P_{NAR} .
- U_{AR} , the utility of going active and being arrested, and the probability of this, P_{AR} .
- α and P represent the number of active civilians and the number of peacekeepers within a given civilian's field of vision, respectively.

$$\text{Equation 1: } U_A = P_{AR} U_{AR} + P_{NAR} U_{NAR}$$

$$\text{Equation 2: } P_{AR} = 1 - P_{NAR}$$

$$\text{Equation 3: } P_{NAR} = \left(\frac{\alpha - 1}{\alpha} \right)^P$$

Migration

There are two types of migration allowed for in this model: random migration and ingroup-based migration.

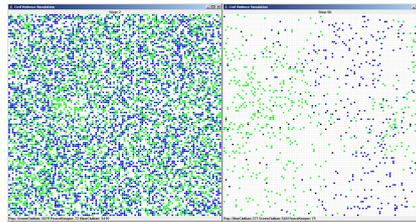
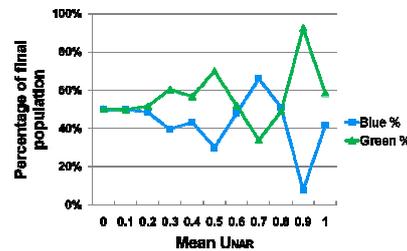
- Random migration means that at each step, civilians move to a random empty cell within their field of vision.
- Ingroup-based migration leads to civilians moving to the location neighbored by the greatest number of members of the same group.

Results

• Three sets of experiments are conducted, each seeking to explore the effect that ingroup-based migratory behavior of civilians had upon inter-group violence within the simulation.

• We examine levels of violence when civilians migrate randomly, when they migrate towards members of their ingroup, and the two types of behavior are run together to produce a comparison of the relative merits of each behavior.

Run 1: Random Migration Only

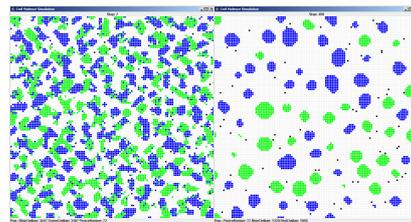
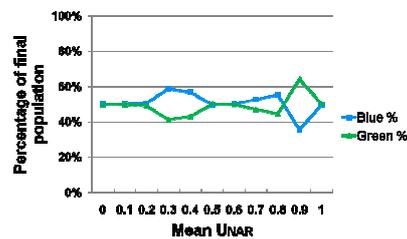


Beginning of simulation Behaviour during run

When both groups migrate randomly, we see:

- Relatively high levels of violence
- Low final population values
- Little obvious clustering
- A random winner

Run 2: Ingroup Migration Only

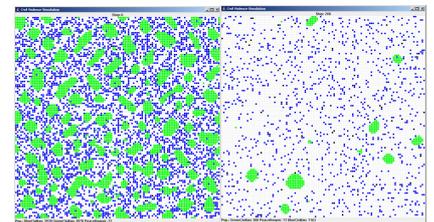
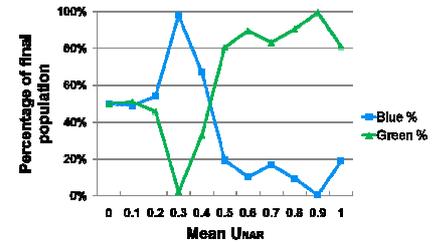


Beginning of simulation Behaviour during run

When both groups adopt ingroup migration, we see:

- Relatively low levels of violence
- High final population values
- Many tightly packed clusters of civilians segregated by group
- Eventual peaceful coexistence
- A random winner

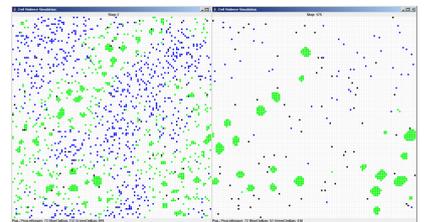
Run 3: Random Migration vs. Ingroup Migration



Beginning of simulation Behaviour during run

When one group migrates randomly and the other adopts ingroup-based migration, at lower average violence dispositions we see:

- Relatively low levels of violence.
- A densely populated grid means blues are more easily able to find and overwhelm clusters of greens.
- The random-migrating blues tend to win.



Beginning of simulation Behaviour during run

At higher average violence dispositions, however, we see:

- Relatively high initial levels of violence.
- A sparsely populated grid means greens are more easily able to defend themselves.
- The ingroup-migrating greens tend to win.

Conclusion

Using the results of our model, we were able to establish a link between the relative success of random and ingroup-based migration in peacefully or violently predisposed populations.

- Ingroup migration was found to be the optimal strategy when civilians are more violently predisposed.
- Random migration gave a better chance of survival in relatively peaceful populations.
- We also found that peaceful coexistence arises when both groups of civilians adopt ingroup migration.

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