# The effect of social influence and curfews on civil violence

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## ABSTRACT[1]

We investigate the policies of (1) restricting social influence and (2) imposing curfews upon interacting citizens in a community. We compare and contrast their effects on the social order and the emerging levels of civil violence. Influence models have been used in the past in the context of decision making in a variety of application domains. The policy of curfews has been utilised with the aim of curbing social violence but little research has been done on its effectiveness. We develop a multi-agent-based model that is used to simulate a community of citizens and the police force that guards it. We find that restricting social influence does indeed pacify rebellious societies, but has the opposite effect on peaceful ones. On the other hand, our simple model indicates that restricting mobility through curfews has a pacifying effect across all types of society.

## Categories and Subject Descriptors

I.6.5 [**Simulation and Modelling**]: Model Development, Modelling methodologies.

J.4 [**Social and Behavioural Sciences**]: Sociology.

## General Terms

Experimentation, Human Factors,

## Keywords

**Description level:** Experimental/Empirical, Simulations.

**Inspiration source:** Social sciences.

**Focus:** Comprehensive/Cross-cutting (multi-agent based simulation), Social/Organisational (groups and teams, emergent behaviour), Environment (environment modelling & simulation).

## 1. INTRODUCTION

Civil unrest and instances of civil violence have occurred throughout history, and continue to do so up to the present day. Reasons for outbreaks of civil unrest tend to follow a similar pattern, mainly underpinned by perceptions of rights, injustice and oppression. There are many forms of unrest which include riots, rebellions, uprisings, revolutions, insurgency and disobedience. All of these represent a course of action with differing levels of participation, organisation and political affiliation. The target for a majority of civil disturbances is the central authority, the government or ruling body of the nation within which the disturbance occurs. Examples of such are the Russian Revolution, the Boston Tea Party, the 1967 Newark Riots in America, Parisian Riots of 2005 and the June Fourth Incident of 1989 in Tiananmen Square. Modelling of civil unrest has previously been undertaken [6, 8, 9], as has modelling of riots [11] and revolutions [7]. Models presented by these publications focus upon specific sub groups of the generalised civil disobedience, and focus upon modelling factors of an agent without featuring agent-agent interaction. We feel the models all lack some feature which could perhaps cause outbreaks to occur.

Rhetoric is often employed to influence the decisions or viewpoints of people. How effective the influence may be depends upon the degree of influence or skill the speaker may exhibit, and the susceptibility of the audience members. We hypothesise that during times of tension it could be a contributory factor to an escalation in a situation from an initial outburst. Influence, and therefore the susceptibility, of citizens within the crowd could have an effect upon how the crowd manifests.

With social interaction potentially catalysing civil unrest we seek to replicate this interaction within a model and examine the effects such communication may have upon the levels of violence exhibited in various types of society. Social influence has been incorporated in multi-agent simulation environments previously [3, 4], offering us the opportunity to adapt an existing influence model and incorporate it into our simulation model. Of specific interest is not only whether the level of communication may be a factor to levels of social unrest, but also whether varying this could be implemented as a policy by a ruling body in order to tackle the degree of unrest within the population. Curfews are a commonly used tactic to tackle unrest within a population by restricting the mobility of the citizens. As part of this work we create a simplified model of a curfew to examine how such a policy may affect the levels of unrest within a population.

In this paper we create a new model of civil unrest with which we explore the effect free communication has on the level of unrest within a population, as well as its suitability to tackle unrest. We also explore the effect a curfew has upon the level of unrest exhibited and its suitability as a counter measure. We may then compare the two different policies to evaluate the effectiveness under different simulated population types, and comment upon the effectiveness of the policies to reduce levels of violence.

To achieve this, the rest of the paper is structured as follows:

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Section 2 will discuss the suitability of using agent-based modelling to investigate ideas and theories surrounding social phenomena. The motivation for the paper is elicited with the rationale behind investigating the impact of influence and curfews upon the levels of violence exhibited. In Section 3 we will describe the basic model used for the simulations, contrasting it to an existing model [6] and comparing preliminary results for consistent behaviour between models. We conclude section 3 by proposing and examining the extensions for the model in order to fulfil the paper's aims with regards to portraying social influence and curfews.

In section 4 we outline the experiments to be carried out, with the aims of each experiment being undertaken, and discuss the results obtained from the experiments in section 5, where we also present explanations for the observed results.

Finally in section 6 we draw conclusions about the roles of influence and curfews upon the levels of violence.

## 2. BACKGROUND

Social sciences focus on the behaviour and interactions of populations – either individually, or within groups. Studying some of the more controversial or extreme forms of human behaviour can prove, amongst other reasons: unethical, financially unfeasible, logistically difficult or any combinations thereof. Attempting to recreate and observe ethnic cleansing using human actors, for example, would be unacceptable and illegal.

Multi-agent systems offer an opportunity to model these populations from the bottom up. Agents themselves represent individuals within the population, modelling characteristics and behaviours of the individuals to a highly abstracted degree. This allows a simulation to be conducted which, whilst not perfectly modelling the real world equivalent, may provide accurate enough observations for analysis.

The core concept of agent-based modelling is to construct agents which resemble the actors within a scenario. These actors model features, behaviours and decision making in an abstract fashion through a set of utilities, whereby the highest utility results in a specified action. Interaction between agents within the system can often produce observations which are not predictable from the initially defined rules and agent interactions, termed emergent phenomena. Due to this, the agents can perform and produce group behaviour that is akin to real world scenarios, and provide insights into causes and reasoning certain situations occur.

Epstein's influential work [6] on social simulations, focusing specifically upon civil violence, is the basis for this paper. Utilising a simple set of rules, Epstein was able to create a model which exhibited macroscopic behaviours that are observable during periods of unrest and violent outbreak. A more detailed discussion of Epstein's model and findings can be found in sections 3.1.2 and 3.1.3. Extensions to Epstein's model have been proposed by Goh et al [8]. In this work an evolutionary game engine was introduced in an attempt to investigate the effects different learning strategies have in an iterated prisoners' dilemma game with varying jail terms on episodes of violence. In addition, population dynamics were introduced to the simulations making for an unwieldy model yielding ambiguous results.

As indicated in Section 1, rhetoric, and therefore influence, may play an important role in instances of civil unrest. Agent-based modelling methodology has been used to model social influence in various application domains. Work towards specific areas of civil violence has focussed upon riots in particular, with a detailed model featuring various factors, perceptions and the physical environment [12] such as friendship, arousal, leadership and sound. The in depth assessment of the factors affecting the likelihood of a riot forming places more emphasis upon unknown extraneous factors that we will not require modelling. The intention is not to model the likelihood of outbursts of unrest occurring under specific environmental conditions and circumstances, but to gauge a generalised effect of an introduced policy on communication. Other areas focus upon the effects of social influence in market trends [3, 4], for example, the use of social influence to affect decisions on adoption. These models incorporate weighted connections between nodes indicating strengths of relationships and the degree of influence these relationships impart. The relationships are based upon friendships, families and people within a public domain who are admired. In instances of civil unrest, e.g. rioting, crowds are fluid and ever moving. The bonds of influence in such circumstances are not based upon years of acquaintance, but geographical proximity of what we assume to be random strangers. In these circumstances influence is dictated to be the perceived consensus of the neighbours within the geographical, with the degree of influence diminishing with range. Our grid-based simulation loosely captures such links for which network topologies appear unsuitable. Influence models are therefore adapted to work with a different topology and different model type.

The agent-based methodology has been successfully used to model the effects of policy decisions or implementations. Traditional mathematical modelling techniques are often based on a top down viewpoint which requires them to make more assumptions and produce less accurate models. Agent-based modelling is better suited for unknowns and uncertainties [10] by taking a bottom up approach, where interactions between agents within the population will give rise to the effect an implemented policy will have. The ability to include "what-if" scenarios to inform and explore about potential outcomes, compared to a more linear conception of a fixed policy before hand without investigation into factors and the effects. Such flexibility allows modelling to inform decisions about policy making across a large heterogeneous population, with behaviours being modified by the implementation of a policy and observing the effects to inform the decision making process [5] giving a more reliable and realistic real world simulation. Without any source for the specific effects of curfews when employed in times of civil unrest, any curfew based modelling will be simple and based upon intuition.

### 2.1 Motivation

The intention is to produce a model which will represent civil unrest and allow investigations into factors that may affect the levels of civil unrest. Joshua Epstein [6] had previously published work into the area of civil unrest; however, it was felt that several aspects of Epstein's work were un-realistic. This paper proposes several improvements on Epstein's model. These include the incorporation of a new utility system as well as refactoring various aspects of the model such as the arrest probability calculation.

After improving the basic model to a satisfactory degree, other factors are introduced into the model to investigate their effects upon civil unrest. The aim is to investigate the effect of freedom of communication and the effect of the freedom of mobility, on the levels of civil violence exhibited within a population.

## 3. SIMULATION MODEL

### 3.1 The basic model

The model revolves around civil unrest in a hypothesised central state. Within the environment, which is represented as a two-dimensional grid, two different types of agent exist: citizens and cops. At each time step agents move and act. When moving, an agent (citizen or cop) relocates to a randomly selected grid location within its movement radius r. When acting, an agent assesses its surroundings and if it is a citizen agent it decides whether to rebel, or if it is a cop agent it looks for a rebelling citizen to arrest. All agent considerations occur within a Moore Neighbourhood, with the movement radii of the agents defining the boundaries of the neighbourhood.

#### *3.1.1 Agent specification*

First the citizen description; citizens may have one of two basic states to hold during a simulation. They are either peaceful (inactive) or publicly rebelling against the central authority (active). At each step a citizen will take the state that is most favourable to them at that point of the simulation. The decision for which state to take is based upon comparing two utilities $U_{AC}$ (the utility of activity) and $U_{IN}$ (the utility of inactivity) and selecting the state associated with the utility that has the highest numerical value.

The utility of inactivity $U_{IN}$ is exogenous and homogeneous under the assumption that the benefits of remaining inconspicuous are the same for all citizens. The utility of activity $U_{AC}$ is calculated by each citizen during a step and is said to represent the gain for the citizen in turning active; this calculation is shown in equation 1. The calculation of $U_{AC}$ introduces two new utilities, which are the utility of getting arrested, $U_{AR}$, and the utility of not getting arrested, $U_{NAR}$. Additional variables within the calculation are the probability of being arrested, $P_{AR}$, and the probability of not being arrested, $P_{NAR}$.

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

**Equation 1: The Utility of Activity calculation of a citizen, factoring in the arrest probability, the utility of risking arrest, the probability of not being arrested and the utility of not risking arrest.**

$U_{AR}$ is exogenous and homogenous for all citizens. $U_{NAR}$, the utility of not getting arrested, is drawn from a beta distribution for each individual citizen and can be said to represent the gain a citizen feels in expressing their feelings. A beta distribution is a good choice for modelling bounded variables.

The probability of not getting arrested $P_{NAR}$ is calculated as shown in equation 2, where $C$ represents the set of all the cops the citizen is within the movement radius of, and $\propto_i$ represents the number of active citizens within the movement radius of cop $i$. An additional consideration in this calculation is that $\propto_i$ includes the current citizen in question as active, irrespective of their state. This ensures the calculation will give the correct arrest probability if the agent *were* to be active, and not only *when* active.

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

**Equation 2: The probability calculation of a citizen not being arrested if in an active state.**

The calculation of the probability of being arrested is therefore trivial, as shown in equation 3.

$$P_{AR} = 1 - P_{NAR}$$

**Equation 3: The calculation of the probability of a citizen being arrested if in an active state.**

The cops act differently from citizens, with their only consideration to be to arrest, at random, one active citizen from within their movement range. Once an active citizen has been arrested it is removed from the field for a certain amount of time steps. This models the citizen being removed from the community and placed in jail. The length of incarceration for an arrested citizen is a random number between 0 and the maximum jail term. When a citizen is released from jail they are returned to a random location within the field and prison terms do not change the citizens' political viewpoint, i.e. the citizen returns to the field with the same $U_{NAR}$ value.

#### *3.1.2 Epstein's specification*

The model described above differs from Epstein's model in several major respects. In this section we will outline the differences between the two models and show how the model we propose can recreate the behaviour of Epstein's model. More specifically, we will show how:

- Epstein's grievance calculation has been replaced by a system of citizen utilities.
- Epstein's arrest probability calculation has been modified to be more realistic.

Epstein's model centralised around the amount of grievance each individual agent feels towards the centralised regime, where the grievance is based upon the legitimacy of the regime in power, and the hardship endured by the citizens under the regime. Everyone within the population views the regime as having the same level of legitimacy, whilst the hardship was a simple uniform distribution. The grievance calculation is shown in equation 4, where G is the grievance, H is the hardship suffered by the agents under the regime and L is the perceived legitimacy of the regime.

$$G = H(1 - L)$$

**Equation 4: Epstein's grievance calculation, featuring hardship and legitimacy.**

This equation is based on the idea that if a government is highly legitimate the population may endure severe levels of hardship without rebelling, which was likened to the British public during the Second World War. Of course, this would mean those suffering little hardship would, irrespective of the regime, have no cause to rebel – they simply would not care, which was decidedly un-realistic. Within our model $U_{NAR}$ fulfils a similar but more flexible role. The next significant difference exists in the calculation of arrest probabilities. Equation 5 shows the formula utilised by Epstein's model to describe the arrest probability.

$$P = 1 - \exp\left[-k\left({C}/{A}\right)_v\right]$$

**Equation 5: Epstein's arrest probability calculation for an active agent, based upon the surrounding number of cops.**

Where $P$ is the probability, $C/_A$ is the ratio of cops to actives within vision range $v$, and $k$ is selected to give a reasonable (90%) arrest chance when $C/_A = 1$. However, whilst this calculation means on a 1:1 ratio, the arrest probability of the active agent is 90%, a 1:2 ratio yields 68% arrest chance and a 1:3 ratio yields at 53% arrest chance for each agent; the arrest probability is not logical. Our model for calculating the arrest probability was therefore the likelihood of being arrested by each cop within the movement range of the agent in question, whereby the probability of not being arrested by any single cop was shown in equation 2, and the probability of being arrested was given in equation 3. This calculation of the arrest probability is more accurate and rational.

### *3.1.3 Comparing exhibited behaviours*

The model we devised at this point was capable of recreating several observed characteristics from Epstein's work [6]. Specifically, we show our results when the following Epstein experiments were carried out using the model proposed in section 3.1.1.

- Deceptive Behaviour
- Free assembly catalyses rebellious outbursts
- Punctuated equilibrium

Instances of deceptive behaviour were observable, where in the presence of cops, agents tend to turn inactive until the cops, or the citizen, moves out of range - as shown in Figure 1. The explanation behind this behaviour is simply that the individuals arrest probability from cops whose he is within movement range is sufficient that if he remains active, he will be arrested. In our simulation this higher arrest probability reduces his utility of arrest $U_{AR}$ sufficiently so that the utility of inactivity is the more favourable action to follow.

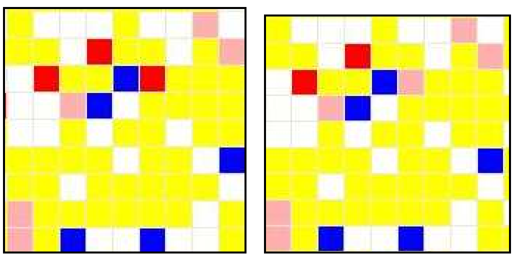

**Figure 1: A small snapshot of the grid as an individual citizen acts to change their state, exhibiting deceptive behaviour due to the cops being in range. Those coloured red are citizens in an active state, those coloured pink are citizens concealing their viewpoint (previously active, now masquerading as quiescent). Quiescent citizens are coloured yellow, the cops are blue.**

Throughout the simulation itself, the levels of active agents within the population can vary greatly, where the number of actives plotted against time can reveal outbursts of unrest in between periods of relative calm, as shown in Figure 2. These outbursts are called punctuated equilibrium, and are a hall mark of complex systems according to Young [13].

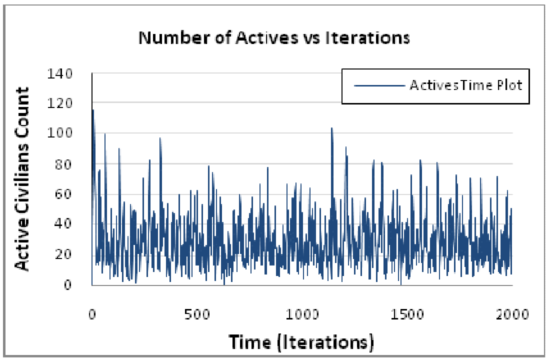


**Figure 2: Showing the variation in the number of actives as the simulation progresses. High peaks example the punctuated equilibrium, where outbursts show a 300% increase over the average number of actives throughout the rest of the simulation.**

The reasons for the overcoming of the equilibrium can be due to the formation of clusters of actives. With a random movement pattern, it emerges that at times low concentrations of cops may occur in an area, giving a low arrest probability for agents within this area. Additionally, active agents may also move into the area, which further decreases the arrest probability. This low arrest probability therefore allows agents that otherwise conceal their distaste for the regime in charge to turn active and publicly show their distaste. Figure 3 shows the high proportion of actives within an area, which is notable for its low proportion of cops.

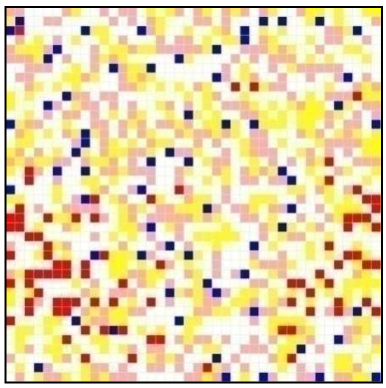

**Figure 3: Areas of high active concentration occur in locations of low cop concentrations. Free assembly catalyses the outburst due to actives reducing the arrest potential far enough in these regions to allow those who would normally contain their distaste to publicly show it. Cops are blue, actives are red, quiescent are yellow, and those who are hiding their distaste (previously active, but turned quiescent due to elevated arrest probability) are pink.**

The model shows comparable results and trends to existing models utilised in prior work [6, 8], itself pleasing as the changes to simplify the model in complexity have not compromised the model's suitability.

Our formulation as described in Section 3.1.1 replaces Epstein's somewhat arbitrary grievance calculation with a system of utilities. Our citizens, while maximising their expected utility, exhibit the same behaviour as Epstein's. The difference is that they do so while following rational behaviour.

## 3.2 Extending the model

Having verified that the model is capable of re-producing observable behaviours exhibited by Epstein's model, and producing comparable results, we therefore extended the model further to examine how communication and mobility affect the levels of civil unrest. Communication itself will be abstractedly represented; the material of communication is not of interest directly, it is the effect that the communication has upon the citizen population we wish to investigate. Therefore, the effect of communication will increase, decrease or retain a citizens potential to rebel or turn violent. Citizens choose to rebel based upon their arrest potential, and their viewpoint of the administration. It is logical to conclude that to change their likelihood of rebelling, the communication should influence their viewpoint. We therefore hypothesise that influence will represent communication.

The freedom of mobility may be modelled into an abstraction of a curfew. Preventing the movement of citizens within a population is a commonly employed strategy by governments or seats of power during periods of unrest.

### 3.2.1 *Social influence model*

In this model the influence is the extent to which neighbours impact upon each other's views. Modelling influence within multi-agent simulations is not new; many have already been implemented, e.g. in innovation diffusion studies [4] and the effects on markets [3]. Adapting a model of innovation diffusion to fit a model of influence should fulfil our requirements. The influence model would result in the diverse opinions of citizens converging towards the mean viewpoint.

To incorporate influence considerations in this model, citizen agents will require two extra parameters representing the level of influence they exert on others $(f)$, and the susceptibility they have towards the influence of others $(s)$. Since the influence will affect the citizen's feelings towards the regime it is logical that in our model the influence affects citizen's $U_{NAR}$ value. Influence and susceptibility will remain constant for each citizen during the simulation. The citizen's $U_{NAR}$ would be calculated with a diffusion equation to allow the neighbours of the citizen to alter its perceptions of the current state during a step, as shown in equation 6 (adapted from an innovation diffusion model in a multi agent system [4]).

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

**Equation 6: Formula to model the influence upon a citizen's $U_{NAR}$ value by its surrounding neighbours, adapted from an innovation diffusion model [4].**

Where $U_i$ is the $U_{NAR}$ of the citizen in question, citizen $i$, and $U_i^*$ is the calculated new value for $U_{NAR}$ of the citizen $i$; $j$ represents the index of all the agents within the movement radius of citizen $i$ who are not citizen $i$; $f$ is the influence of the citizen referenced ($i$ or $j$) and is drawn from a uniform distribution (0,1); $s$ is the susceptibility of the citizen referenced ($i$ or $j$) and is drawn from a uniform distribution (0,1); $d$ is the Euclidean distance between the citizens $i$ and j; σ is the Gaussian kernel, which is set externally before a simulation run.

### 3.2.2 *Curfew model*

To model a curfew effectively, even at an abstract level, we need to establish what exactly a curfew is supposed to achieve. A curfew is defined as "a rule that everyone must stay at home between particular times, usually at night, especially during a war or a period of political trouble" (Cambridge Dictionary), with recent examples of the use of curfews during the Parisian riots of 2005 [1]. This indicates that a curfew limits the mobility of citizens whilst enforced; however, mobility itself is not the single cause of increasing levels of violence. At an abstract level, without mobility citizens are also denied the possibility of interacting. If a curfew is to prevent interaction between citizens, then an implementation of a curfew must also limit the interaction between agents – this interaction being the influence model.

The hypothesised abstraction of a curfew in this model involves preventing the interaction or movement of agents during the periods of curfew. Police, during the curfew, will be free to continue to act as normal and arrest active citizens. This will counter the lack of opportunity to break the curfew. Since active citizens who are active at the start of the curfew will remain active for the duration of the curfew, and police may arrest these active citizens, this will represent the breaking of curfew.

The curfew model does not affect the utility of a citizen directly, but during a citizen's utility calculation the effect of the curfew indirectly affects the utility calculation; the citizen will be incapable of taking into consideration their surrounding neighbours views.

## 4. EXPERIMENTS

The proposed experiments were selected to investigate the effect of communication, abstracted as influence, upon the levels of unrest, and then to investigate the effect of mobility upon the levels of unrest. Model settings for experiments 1 – 4 are given in tables 2 and 3.

- Experiments 1 & 2 will focus on the effects of communication upon the level of civil violence.
- Experiments 3 & 4 will be used to then investigate the effect of mobility upon the levels of violence.

The first set of experiments will yield results focussing upon the effect of communication, where we will examine the level of activity exhibited by the citizen population both with and without the influence model. The second set of experiments will include mobility as a factor, and coupled with the results obtained from experiment 2, will allow us to compare the effects of mobility upon the levels of violence exhibited.

The curfew will be modelled to last for 5 consecutive iterations out of every 15, which means for 10 iterations the model will proceed as normal, with the subsequent 5 iterations occurring with the curfew imposed before the curfew being lifted and the next 10 iterations occurring without curfew.

**Table 2. Individual model settings for experimental runs.**

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

Each experiment that is carried out will hold the same basic settings which are shown in table 3.

**Table 3. Generalised settings for all experimental runs**

| Variable | Value | Variable | Value |
|---|---|---|---|
| Movement range | 4 | Cop Density | 4% |
| Utility of Arrest $U_{AR}$ | 0.01 | Citizen Density | 70% |
| Utility of Inactivity $U_{IN}$ | 0.5 | Grid Size | 40 x 40 |
| Max jail term | 30 | Gaussian Kernel $\sigma$ | 5 |
| Iterations / Runs | 1500 | Topology | Torus |

## 5. RESULTS

During the results, we will be comparing the numbers of active citizens under different model settings for different simulation, or sets of simulation, runs. The rationale behind comparing average numbers of active citizens is simply that this is often a metric utilised to gauge the levels of civil violence exhibited. During the Parisian riots, reports focused upon the numbers of burnt out cars, arrests and police injuries to indicate the levels of violence exhibited by citizens [1]. These figures are more or less proportional to the number of rebellious citizens as we assume each act of violence requires a fixed number of citizens to perpetrate the act.

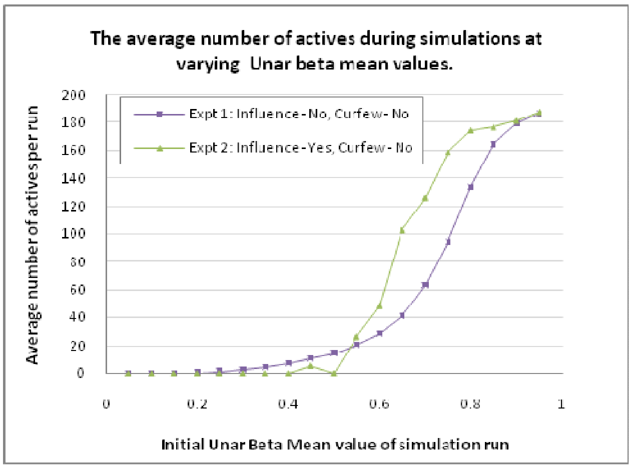


**Figure 4: Graph showing the high-level comparison on the average number of active citizens during a whole simulation of 1500 steps, across the whole range of initial $U_{NAR}$ mean values. This shows the general trend limiting communication (influence) has on the model.**

A point worth making is that under the general settings shown in table 3 the utility of inactivity, $U_{IN}$, is set to 0.5. The relevance of this setting is that a citizen's $U_{NAR}$ value equal to $U_{IN}$ marks the turning point between being rebellious and non rebellious in the model. With $U_{NAR}$ above this value the likelihood of being active depends upon the probability of arrest, whereas below this the citizen will not rebel irrespective of the probability of arrest.

This allows us to make a reasonable assumption that if the mean $U_{NAR}$ of citizens within the field is above $U_{IN}$, the general population is predisposed towards rebellion. If the mean $U_{NAR}$ of the citizens within the field is below $U_{IN}$, the population is predisposed towards peace.

Figure 4 compares the effect of simulations with and without free communication across the range of initial $U_{NAR}$ values. If we assume that the actions of allowing or forbidding communication would be a potential policy employed by a ruling authority, then the results show us that in the event that a ruling authority of a generally peaceful[2] population attempts to enforce a policy restricting free communication, the policy will result in an increase in the level of unrest. In the event that the ruling authority restricts free communication in a population which is predisposed to rebellion[3], the policy will result in decreasing the level of unrest. The general trend emerging is that in peaceful populations free communication helps to maintain low levels of

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[2] A population pre-disposed towards peace will have a mean $U_{NAR}$ value below $U_{IN}$. An individual citizen with a $U_{NAR}$ value below $U_{IN}$ will only become likely to rebel if his $U_{NAR}$ value increases due to the effects of influence from other citizens.

[3] A population pre-disposed towards rebellion will have a mean $U_{NAR}$ value above $U_{IN}$, as above this value, citizens will rebel dependent upon their probability of arrest.

unrest, whereas in rebellious populations free communication will help to inflame the levels of unrest. Figure 5 shows the effect of free communication on the standard deviation of the citizen's $U_{NAR}$ value from the mean during a simulation run.

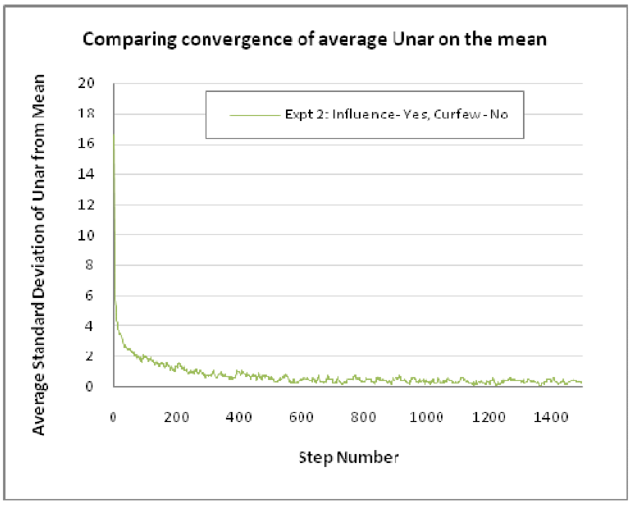


**Figure 5: Illustrating the convergence of citizens' $U_{NAR}$ on the mean during a simulation run.**

This convergence of citizens' $U_{NAR}$ to the mean is the direct result of freedom of communication. Allowing free communication allows citizens to discuss, share and influence each others' viewpoints with everyone eventually accepting the consensus point of view. The reasoning behind this phenomenon is based in the behaviour of conformity [2], whereby citizens will change their behaviour to match the behaviour of others based upon the perceived consensus of its surroundings. Our model captures the conformity behaviour; Figure 5 illustrating the convergence of the population to the mean, where the mean represents the perceived consensus. If the population is peaceful, then the convergence caused by freedom of communication between citizens will result in rebellious citizens being pacified by the more peaceful majority of the population; the net effect is increased peace and calm. In rebellious nations the freedom of communication will cause the incitement of the minority pacifists to the extent that they therefore join in the rebellion and turn active, resulting in increased levels of unrest.

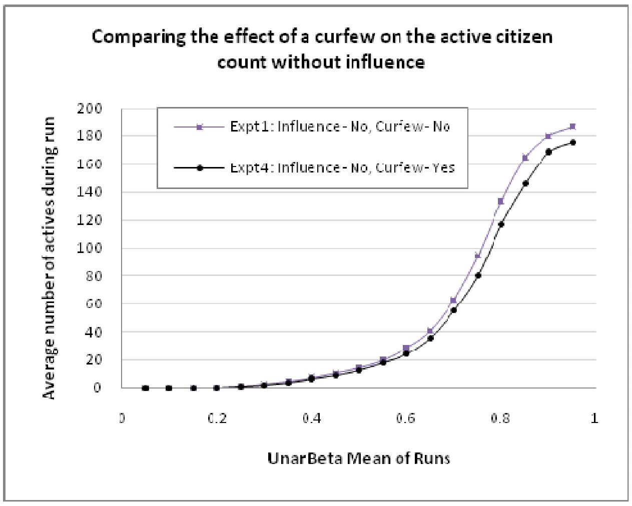


**Figure 6: Examining the effect of a policy of curfew, restricting mobility, to limit the level of unrest in a population where freedom of communication is not enjoyed.**

To examine the policy of implementing a curfew requires combinations of the experimental runs to ascertain the effects of the policy upon different society types. Figure 6 shows the effect of the policy which limits mobility within a population. In the two experiments recorded, freedom of communication is not a factor. The results show that irrespective of the actual predisposition of the population towards either rebellious unrest or peaceful living, the policy will produce the same result, a proportional success in reducing the degree of unrest exhibited by the population.

Since the results only show how a policy of curfew effects the level of unrest on a population which does not enjoy the freedom of communication, Figure 7 shows the results obtained when placing a curfew upon a population which does enjoy the freedom of communication.

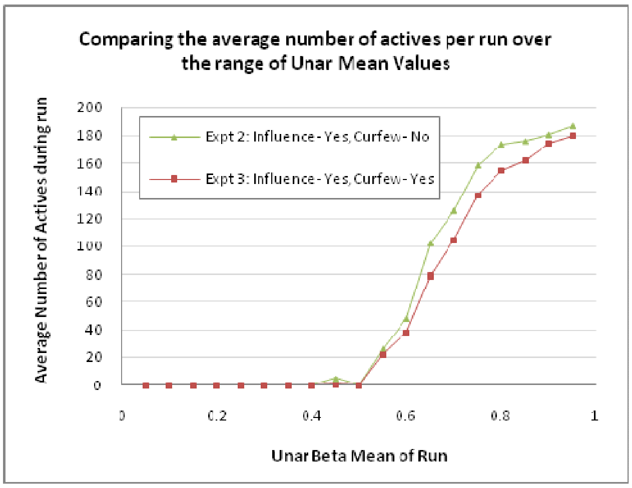


**Figure 7: Examining the effect of the curfew policy on the level of unrest in populations where freedom of communication is enjoyed.**

The results show that under a curfew the level of unrest drops in a population which does not enjoy free communication. Unlike the policy of freedom of communication, figures 6 and 7 show that the results do not depend upon the predisposition of the population towards either rebellion or peacefulness. The effect of the policy of curfew reduces the degree of unrest within a population irrespective of whether freedom of communication is available, and irrespective of the predisposition of the population.

# 6. CONCLUSION

A simple yet 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 been apparent before implementing. We have shown curfews are an effective means of combating instances of unrest, irrespective of the society type upon which they are imposed. Communication, however, differs. Within a rebellious population free communication increases the levels of rebellion, so a policy of restricting communication helps decrease the levels of unrest. Within a more open society, free communication promotes the peaceful nature, whereas restricting it inflames levels of unrest.

The results help us understand why freedom of communication and openness is instrumental in maintaining an orderly and peaceful society, and restricting this freedom may result in increases in the level of unrest. In peaceful societies the policy of free communication acts as a catalyst to maintain the level of peace within the population, allowing more radical members to adopt alternate viewpoints. In a society whereby volatility and social unrest is more common, free communication may instead of curtailing the levels of unrest actually promote further unrest, leading to increased incidences of violence. The free communication acts as a catalyst in spreading discontent throughout the population based upon the principles of conformity and perceived consensus [2]. Therefore the policy of free communication as a method of controlling civil unrest is dependent upon the nature of the society implementing it. Free and open societies will find the limitation on communication as objectionable, whereas volatile societies will find some successes in restricting the degree of openness and communication allowed.

Curfews, however, are shown to have a constant effect across either type of society. Whether rebellious or peaceful, and whether enjoying free open communication or otherwise, curfews have exhibited the trend to lower the incidences of civil unrest proportionally within the population. Restricting the mobility of citizens does not create any adverse affects, helping to perhaps explain why it is such a popular policy irrespective of the controlling authority which implements it – whereas limitations on the freedom of communication usually occurs under a dictatorship.

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