Prison Architecture and Violence

EECS 472 Final Project – Antonio Hazboun

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Introduction and Motivation

Rates of prisoner on prisoner violence have more than doubled in the past 10 years[1]. In an interview on the increasingly escalating rate of inter-inmate as well as inmate-on-guard violence in the Holman Correctional Facility, Alabama's Prison chief attributed the increase in violence to the 20% decrease in staff numbers due to cuts in federal funding[2]. A statewide investigation by the Bureau of Justice Statistics found that the vast majority of state prisons operated at above design capacity, defined as the number of inmates that architects and planners originally intended for the facility, with an average occupancy of 150% of design capacity[3]. The Hollman Correctional Facility, discussed more in depth in the interview, was initially part of a 15 prison state initiative in the 1960s to design prisons that would foster community and diffuse hostility between inmates[4]. The role that socialization[5] and community development[6] in prisons plays in reducing violence is well documented. The use of architecture to engineer social spaces where communities can be fostered and avoid isolation and predation has been a central pillar for late 20th century Norwegian reform[7] in a country that now has a recidivism rate below 20%, amongst the lowest in the world[8]. However, budget cuts in the US have led to increasing prisoner density and decreasing guard to prisoner ratios. Tensions arise over struggles over amenities and public spaces. Eldon Vail attributes the rise of aggression in US prisons principally to these two factors[9].

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[1] Zhen Zeng, Ph.D., Margaret E. Noonan, E. Ann Carson, Ph.D., Ingrid Binswanger, M.D., *Bureau of Justice Statistics*, Patrick Blatchford, Ph.D., *Colorado School of Public Health*, Hope Smiley-McDonald, Ph.D., Chris Ellis, *RTI International*

[2] Mike Cason, "Alabama Prison Chief Says Violence Rising as Staffing Falls," al.com, November 30, 2016,

[3] "State Prison Capacity, Overcrowded Prisons Data," accessed June 3, 2019

[4] Christopher Harress, "The Architecture of Violence in Alabama's Prisons," al.com, February 12, 2017

[5] Stanton Wheeler, "Socialization in Correctional Communities," *American Sociological Review* 26, no. 5 (1961):.

[6] Donald Clemmer, "Observations on Imprisonment as a Source of Criminality," *Journal of Criminal Law and Criminology (1931-1951)* 41, no. 3 (September 1950): 311, https://doi.org/10.2307/1138066.

[7] "Can the Architecture of a Prison Contribute to the Rehabilitation of Its Inmates?," Design Indaba, June 4, 2019

[8] Christina Sterbenz, "Why Norway's Prison System Is so Successful," Business Insider, accessed June 4, 2019

[9] Dunn, et. Al, The Expert Report of Eldon Vail, The District Court of the US, Middle District of Alabama (2016)

Prisons in the US fall into one of three main design categories, designed by a small collection of the same architects using very similar design principles[10]. As such, an abstract simplification of these designs can be constructed that maintain core design elements. Studies into the emergence of violence or formation of social systems within these different abstract designs can then be generalized to form conclusions pertaining to US prisons and inform future prison designs.

There have been case studies into the increasing prison population density in individual prisons and the ensuing changes in violence levels[11]. In this paper, I seek to examine the sensitivity of different prison layouts to the changing prison demographics that could result from expected budget cuts, including sensitivity to changing guard to prison ratios, changing prisoner density and changing percent occupancy. The aforementioned sensitivity will be measured with respect to ratio of violent to kind interactions between inmates as well as to a new calculated parameter based on the weighted closeness centrality of the network that will be explained in more detail in the analysis section.

The theory is that certain prison designs allow for more cohesive social network formation or easier supervision of the inmates by fewer guards and so will be more sensitive to a shrinking guard to prisoner ratio.

Description of Phenomenon

It is well documented that prisoner violence goes down in "Direct Supervision" guard layouts, where the guards are stationed in public spaces and encouraged to roam amongst the inmates, as compared to "Indirect Supervision" layouts, where the guards predominantly stay in guard houses and offices near the public spaces[12]. The average normalized occurrence of violence in direct supervision

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[10] "The Evolution of Prison Design and the Direct Supervision Model," *Lexipol* (blog), March 17, 2017
[11] "Crowding, Social Control, and Prison Violence: Evidence from the Post-Ruiz Years in Texas", 1987
[12] Atlas, R. The Future of the American Jail. Dade Country Stockade Expansions. 1984

facilities is roughly 30% of that of indirect supervision facilities[13]. This difference is largely attributed to the decrease in inmate fears of punishment in the absence or decreased presence of an enforcer (lower number of guards)[14].

Prisoners also have base, statistically derived, propensities for violence and kindness that correspond to their personas[15]. Depending on their likelihood to conform to and abide by legitimate standards of guard authority, their propensity to be violent will decrease in proportion to the number of guards present. It is also well documented that prisoners will often outsource their assessment of another inmate, effectively deciding to be violent or kind towards someone they otherwise would have behaved differently towards because of how their clique members feel about them[16].

Crowded prisons with many opportunities to get lost in a large group of prisoners have been theorized to promote prison violence because the large crowds shelter inmates from the eyes of guards or other inmates that might otherwise punish them for their misconduct[17]. These are the rules I sought to encode to observe how they interact under different prison demographics in different floor layouts.

Role of Agent Based Modelling

Moral codes and acts were passed in the late 1600s then repealed and passed again in 1790 describing a more humane approach to prisoner confinement and punishment[18]. However, historically, discourse on prison architecture and social engineering was largely rooted in philosophy and speculation with limited empirical validation[19]. One notorious example is that of Jeremy Bentham's Panopticon,

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[13] Bigelow, T. Comparing the Cost of Direct Supervision with Traditional Jails. Tallahassee: The Florida Criminal Justice Executive Institute Associates. 1993.
[14] Dilulio, J. Governing Prisons: A Comparative Stufy of Corrections Management. New York: Free Press. 1987.
[15] Peter G Garabedian, "Social Rules in a Correctional Community," n.d., 11.
[16] Professor James McGuire, "Understanding Prison Violence: A Rapid Evidence Assessment," n.d., 9.
[17] Christopher Harress, "The Architecture of Violence in Alabama's Prisons," al.com, February 12, 2017
[18] Blake McKelvey, *American Prisons: A History of Good Intentions* (P. Smith, 1977).
[19] Barbara A Thompson, Prison Design and Prisoner Behavior: Philosophy, Architecture and Violence (Oberlin College 1980)

wherein the prison layout was constructed to instill a fear of constant surveillance in the inmates, ensuring that they abide by prison rules in fear of further punishment. It is prohibitively expensive to construct mock prisons of varying designs for the purposes of studying emergent social patterns and inmate behavior. Rather, it would be much more convenient to develop a predictive model, incorporating known patterns in prisoner psychology, social behavior and interaction rules to hypothesize how changes to the prison environment could influence social network formation.

Agent based modeling, as described by Wilensky[20] and Grimm[21], is a powerful approach to model and study emergent patterns in complex systems in a decentralized way, such that each individual inmate is encoded with their own rules for how to behave under different circumstances and the aggregate phenomena resulting from the turtles interacting is recorded and studied.

The development of an agent based model for the purposes of this paper is appropriate, given that there is extensive documentation on the social roles assumed by different inmates[22], the emergence of violence in prisons[23], the role of guards as well as decentralized social enforcement of a prison culture[24] and the nature of inter-inmate social interactions under different circumstances[25]. The quantitative and statistical nature of many of this data, as well as the understanding derived from long form interviews with inmates, provides valuable insights into agent rules that could be reliably encoded and observed in different environments.

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[20] Wilensky, U. (2001, updated 2013) Modeling nature's emergent patterns with multi-agent languages. Proceedings of Euro Logo 2001. Linz, Austria

[21] Grimm, V., & Railsback, S. F. (2013). Individual-based modeling and ecology. Princeton university press.

[22] Peter G Garabedian, "Social Rules in a Correctional Community," n.d., 11.

[23] Professor James McGuire, "Understanding Prison Violence: A Rapid Evidence Assessment," n.d., 9.

[24] Christine Chong and Michael Musheno, "Inmate-to-Inmate: Socialization, Relationships, and Community Amongst Incarcerated Men," n.d., 53.

[25] Peter G Garabedian, "Social Rules in a Correctional Community," n.d., 11.

All agent based models discussed in this paper have been developed using NetLogo, a programming environment developed by Wilensky for the development of agent based models[26].

Overview of the Model

Layout

A certain prison layout is generated in which the patches serve specific purposes. They can either be walls that the turtles cannot walk over, doors that the turtles can walk through but not see through, guard spaces that represent either the guard lounges or the shift posts that the guards have to occupy, living quarters that represent an inmate's home to which they return throughout the day and could potentially share a roommate. The patches are marked by different colors and are imported from prison floor layout .pngs using the Bitmap extension.
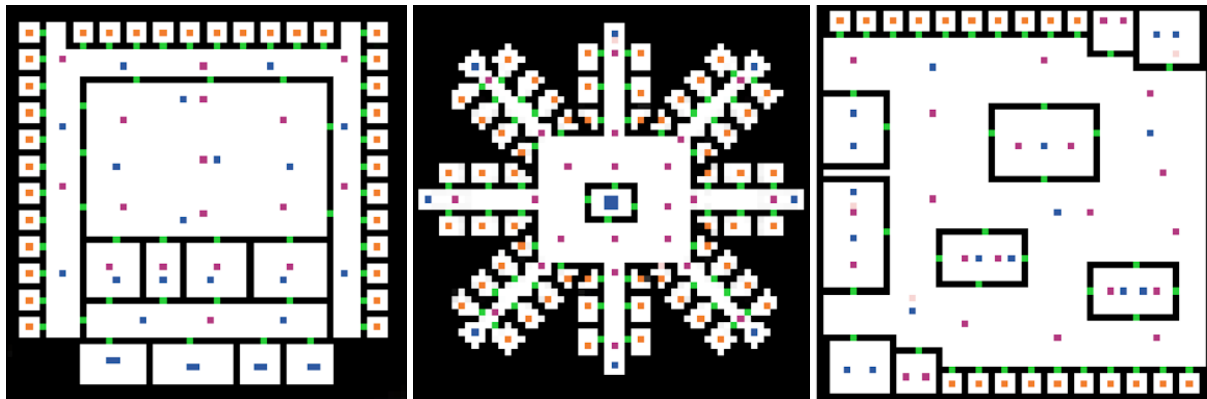
Figure 1: Abstract layouts for Courtyard, Radial Turtle and Campus Prison Designs Respectively. This is Where the Turtles Interact

Moving Around

The turtles have a target patch they want to go to that they approach by identifying intermediate target patches. Going to these intermediary patches forms a path, clear of obstacles, leading to their long term target. For example, a guard's target could be their next shift post that they

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[26] Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL

then travel to by finding the shortest unobstructed path around walls and doorways. Once they arrive, they immediately identify another long term target, probably another guard post.

Interactions

For inmates, they approach their long term and intermediate targets in the same way. However, for each tick on the path to their target patches, they conduct a survey of their surroundings. First, they identify all inmates in their field of vision, identifying the closest inmate to them as a "potential partner" in social interaction, someone with whom they could potentially have a "kind" or "violent" interaction.

Whether or not they interact at all is dependent on their "interaction rate", which specifies the fraction of the time that a potential partner is pursued in any capacity, violent or kind. After an inmate has decided to interact, whether that interaction is kind or violent depends on the inmate's "base kindness propensity", representing the fraction of interactions that are kind. The base violence propensity is defined as $(100 - base\ kindness\ propensity)$ and goes down exponentially as a function of the number of guards to which the inmate is visible.

How Inmates Evaluate their Relationships

While assessing what to do in each interaction, the inmate will assess its relationship with its potential partner to determine if it wants to be kind or violent. Inmates do this by taking the weighted distance between them in the network as computed by the NW NetLogo extension. A neutral link or relationship weight is defined as a parameter. The inmates use the deviation of the weighted distance of their relationship from that of a completely neutral relationship to inform how they behave. For example, if a neutral link connection has a weight of 5 and my connection to you had a weight of 6, then the relative strength of our relationship is $\frac{6}{5} = 1.2$ and the deviation from neutrality is $1.2 - 1 = 0.2$ in comparison to a neutral relationship of 1. Seeing that this is a positive deviation from neutrality, my propensity for kindness towards you would be multiplied by 1.2 and my propensity for violence would

be multiplied by 0.8. This makes it so that you are more likely to be kind to your friends and violent towards your rivals.

The interaction rate itself is also affected by the intensity of the relationship, in a similar fashion to that described above, the absolute value for the fractional deviation from relationship neutrality is responsible for an increased interaction rate, wherein you are more likely to interact with someone if you really hate them or really like them, regardless of the positivity of the interaction.

Social Component of Evaluation

To properly account for the social dynamics at play in a prison environment, two modifications are made. First, the turtles do not simply act on their views towards their potential partner; instead, they consider the relationship evaluation of all the turtles in their vicinity towards their potential partner and account for their opinions as well. This rings true to reality as well in that you are much less likely to be disparaging to someone in the company of their closest friends and much less likely to stand up for a friend in a room full of people who hate them.

The second thing that is done is a function of how the weighted distance to a potential partner is computed. If there is no direct connection between inmates, the shortest connection using other turtles is used as a proxy. As such, even if you do not know someone, you are more likely to be kind to them if they are a close friend of one of your close friends. Both these features help account for the social behavior and outsourcing of relationship evaluations.

Different Social Roles in the Prison Environment

Different types of turtles are encoded into the model to represent the different social roles taken up in correctional facilities. These personas inform an inmate's approach to social relationships. There are two main categories of inmate personas, those doing "tough time", who are constantly aware of their sentence and refusing to let go of their commitment to the social rules of free society instead of

absorbing themselves into the prison community, and those doing "easy time" who integrate themselves into the affairs of the prison social circles as if they were in any other social network[27].

The first set of inmates doing "tough time" are referred to as "Square Johns". They remain naïve to prison culture and refuse to accept prison social rules and dynamics, instead opting to orient their affective attachments towards legitimate norms and standards. As such. Their loyalties and affinities are directed towards their outside support system in the free community as well as towards the prison administrative staff and guards. They have the highest rate of social contact among the different personas with staff members and the lowest rate of social contact with other inmates. They overwhelmingly conform the most to staff norms and have virtually no serious conduct infringements.

The contrasting "easy time" analogue to a Square John is called a "Right Guy". Right guys similarly also avoid compulsion and are collectively oriented in their interactions. However, unlike Square Johns, Right Guys are more committed to *illegitimate* norms and constructs, choosing to minimize contact with staff members in lieu of heavy social contact with other inmates. Their strict adherence to prisoner social codes means they are the group with the second lowest conformity to guard authority and the second highest rate of conduct infringements.

A more individually oriented persona that does "easy time" is that of the "Con Politician". Con politicians work to serve their own interest and describe limited compassion or commitment to the prison social community. As such, they are neutral in their adherence to either legitimate or illegitimate social norms or constructs and will do what is necessary to advance their social standing and comfort. They have the second highest rate of social contact with staff, the third highest with other inmates and the second highest rate of conforming to authority.

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[27] Schrag, Social Role, Social Position, and Prison Social Structure, 1959 PROCEEDINGS OF THE AMERICAN CORRECTIONAL ASSOCIATION 178.

The final social role, the "Outlaw", is also individually oriented and will work towards personal enrichment. However, unlike the Con Politician, they will utilize compulsion, force and intimidation to advance their interests. They have the lowest rate of social contact with both staff members and other inmates, the highest rate of conduct infringement and the lowest rate of conformity to staff norms.

Translating Different Social Roles into Turtle Breeds

Two breeds of turtle are defined, the guards, who simply walk around and, for the purposes of our model, do not form social connections with prisoners, and inmates, who interact based on their propensities for violence and kindness, which are defined uniquely for different social roles. The parameters extracted from the literature[28] are as follows.

Table 1: Personality Parameters for Different Inmate Personalities - Derived from Literature

Inmate Type	Square John	Right Guy	Con Politician	Outlaw
Fraction of Inmate Population (%)	17	35	32	16
Base Kindness Propensity (%)	65	67	41	27
Base Violence Propensity (%)	35	33	59	73
Percent Conformity to Authority (%)	80	60	70	40

Simplifications, Assumptions and Justifications

Simple Floor Layouts

Many assumptions and simplifications were made in this model. The most obvious is that no plans for any real prisons were utilized and so no empirical comparison can be drawn from the results to verify the model's conclusions. Rather, an abstract simplification of the three most common prison floor layouts were constructed for modeling purposes.

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[28] Peter G Garabedian, "Social Rules in a Correctional Community," n.d., 11.

No Schedule or Bedtime

The inmates in the model were largely allowed to roam free and randomly identify new target location to visit. Although it is the case that prisoners are rarely required to attend any staff sponsored prison activities, it is also the case that a significant portion of them do and so have schedules that inform when and where they are at different locations. Inmates also generally go to the cafeteria at fixed times and in large groups. There is a certain fraction of time spent in bed at night or in the gym, where the preoccupation would reasonably make someone less likely to be violent. These scheduled timeslots were not encoded into my model. It is unclear what unit of time a "tick" represents and so the temporal component of the emergence of violence cannot really be used to inform analyses. These simplifying assumptions were made because the macroscopic and qualitative nature of the emergence of violence can still be studied and compared across prisons. Even if it does not accurately predict the exact rate of violence one should expect, we can at least identify what prison design would be superior.

Functions for Relationship Evaluation

A simplifying, inverse-exponential function was also used to represent how the propensity for violence went down as a function of the number of guards present. This assumption was not grounded in any empirical measurements or trends but still accurately captures the general rule of prisoner violence going down in the presence of guards.

Social and Personal Stagnancy

Another large simplification was the assumption that people remain in their respective personas forever and that these personas are immutable. In fact, there is a great body of evidence demonstrating the effect that the time spent in prison as well as the lived experience in prison can have on prisoner philosophies[29]. Prisoners have also been documented to become significantly isolationist and secluded

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[29] "Assessing the Relationship between Exposure to Violence and Inmate Maladjustment within and Across State Correctional Facilities," n.d., 80.

at times of great emotional hardship[30]. As such, it would be more accurate to have the inmate kindness

propensities, interaction rates and exploratory nature change with time in response to experiences.

The main justification for this choice is that the conditions outlined represent the average

parameter interactions at any point in time. It is the case that if 17% of the inmate population on the

first day are Square Johns that they are not likely to all be Square Johns after a year. However, at any

point in time, there will reliably be around 17% Square Johns and the total interaction rate will average

around 10%, even if that number is the result of some horribly depressed individuals averaging out with

extremely community oriented extroverts.

Social Hierarchy

In this model, I assume complete decentralization of social leadership. Wherein, an inmate will

consider the opinions of all other inmates in their vicinity towards a potential partner before deciding to

abuse or befriend the turtle. In reality, prisons have ring leaders and social elders whose opinions are

valued much more greatly[31]. Their seniority is grounded in the nature of their crimes as well, their

seniority in the prison as well as their connectedness with other inmates and choosing to not account

for this social mechanism was a large simplification. The justification used is that a state of pseudo-

leadership emerges if turtles have positive connections with many other turtles and is accounted for

using the current method of relationship evaluation.

Race and Background

The turtles were also assumed to be completely homogenous in terms of their cultural and

ethnic backgrounds. This makes way for the assumption that a turtle with a certain propensity for

violence would have that same propensity for violence with any inmate. In reality, prisoners have

different propensities for violence for different groups of inmates and enter prison with a certain affinity

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[30] Charles W. Thomas, "Theoretical Perspectives on Prisonization: A Comparison of the Importation and Deprivation Models," *The Journal of Criminal Law and Criminology (1973-)* 68, no. 1 (March 1977): 135
[31] Stanton Wheeler, "Socialization in Correctional Communities," *American Sociological Review* 26, no. 5 (1961)

and increased likelihood to absorb themselves into specific social cliques[32]. This mechanism is greatly

simplified in the model used in this paper with the premised justification that the overall rate of violence

will average out to the literature values referenced and that some component of the social clique

formation observed can then simply be attributed to racially charged exclusion and aggression.

Spectrum of Interactions

In the model used, violence and kindness are encoded as a binary dyad, wherein, one can only

be kind to the same extent every time. This is not at all representative of interactions in the real world.

Kind gestures exist on a spectrum and one is not likely to view someone who smiles at them in the

hallway with the same warmth as someone who comforted them in times of emotional hardship. The

assumed justification for this model is that over the course of many interactions, this binary nature to

kindness and aggression will balance out into behavior approximating that observed from a full

spectrum of kind acts to abusive acts.

Model Parameters

Model parameters used can be seen in the screenshot below and are derived from the literature

as cited in the background section on turtle personas. The "Number-of-" inmate parameters actually

refer to their fractions out of 100 for the total inmate population, which is defined elsewhere. These

fractions are held constant as per the literature values. The base kindness propensities are defined for

all inmate personas and the base kindness propensity is defined as 100 minus that. The percentage of

the time that these inmates conform to social rules as opposed to acting on their own urges is also

defined. All other parameters used in an intermediate fashion are calculated at each timestep as

described previously and is seen in the info section appendix as well as the supporting code.

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[32] Professor James McGuire, "Understanding Prison Violence: A Rapid Evidence Assessment," n.d., 9.
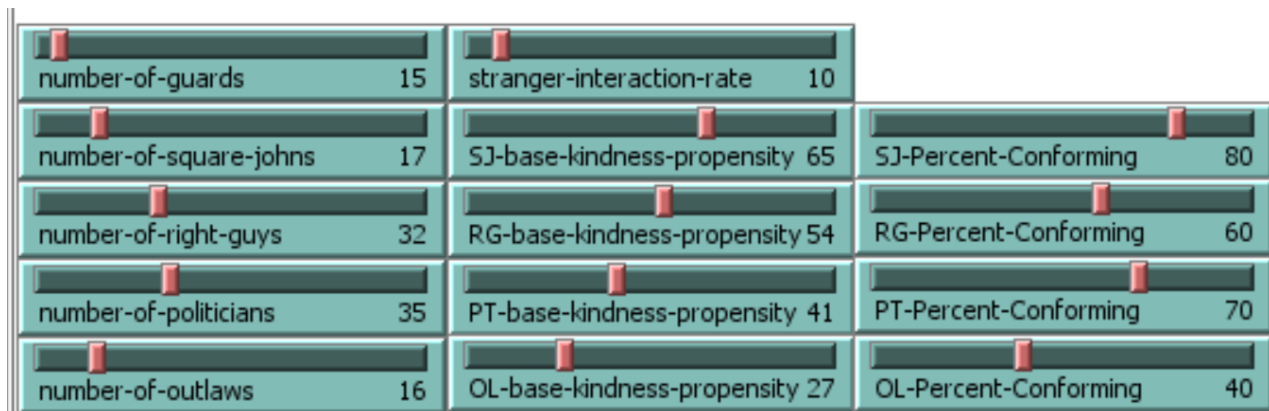
Figure 2: Parameters Relating to Inmate Personality Types - Default Values are from Literature

More universal parameters that affect all turtle movement such as vision and speed are defined as well.

Figure 3: User Specified Parameters Relating to How Model Works

Experiments Run – Parameter Value Breakdown

An investigation into the effect of varying different parameters was conducted using the

BehaviorSpace toolbox in NetLogo. The model was allowed to run for 200 ticks in each run, sufficient to

observe how the social networks had developed. The main reported studied were:

1. **The inverse weighted closeness centrality** of the network as well as that of the individual turtle personas. As defined in the NW extension, the weighted closeness centrality is the inverse of the average weighted distance between the turtles it takes as inputs. The inverse of the WCC is taken to obtain the weighted distance. The weight used in this case is reflective of the strength of the relationship. As it is encoded in my model, a neutral relationship is defined as having the user specified "neutral-link-weight" with a possible range of values going from zero to two times the neutral link weight. For the purposes of model analysis and accurately quantifying relationships on the same scale. The value used is the deviation of the weighted distance from the maximum positive value, normalized for the neutral link weight (done in google sheets for model analysis, the NetLogo parameter extracted is just the WCC). As such, the smaller the value of the inverse WCC metric reference in the analysis section, the more cohesive and closer a network is. If it has a value of 0.5, then the network has roughly neutral relationships on average.

2. **The ratio of kind interactions to violent interactions** between inmates. A global counter parameter is defined for kind and violent interactions that is updated by adding one every time the be-kind and be-violent inmate procedures are called. The ratio of these two is reported.

Different demographic and layout parameters are altered as follows.

- All runs are repeated for each of the three floor layouts outlined earlier. Each run is also repeated three times, the average value is plotted in the figures below and the error bars represent the standard deviation of the three replicates.

- For each floor layout, 100% design occupancy is defined as having one turtle per patch labeled "living-quarters". In reality, many prisons define 100% design occupancy as having two inmates

sharing a living quarters but, so long as the definition is consistent, this definition will suffice. Runs are then conducted at 50%, 100%, 150%, 200% and 400% design occupancy.

- At 100% design capacity, runs are then simulated with guards representing 0%, 25%, 50%, 100%, 150% and 200% of the prison population. The current average rate in US prisons is closest to 25%[33] and so this ratio will be used for further tests.

Results and Discussion

The following figure shows the effect of increasing the guard over prisoner ratio on the ratio of kind interactions to violent interactions for the different prison layouts. These datapoints pertain to and are normalized in accordance with 100% design capacity for the respective prisons. Given these conditions, we see the expected pattern of the ratio of kind to violent interactions going up in the presence of more guards. This is mediated by a reduction in violence more than it is mediated by an increase in kindness. This is because an inmate's immediate propensity to be violent goes down in the presence of a guard in fear of repercussions but they are not more likely to be kind.

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[33] "State Prison Capacity, Overcrowded Prisons Data." Accessed June 3, 2019.
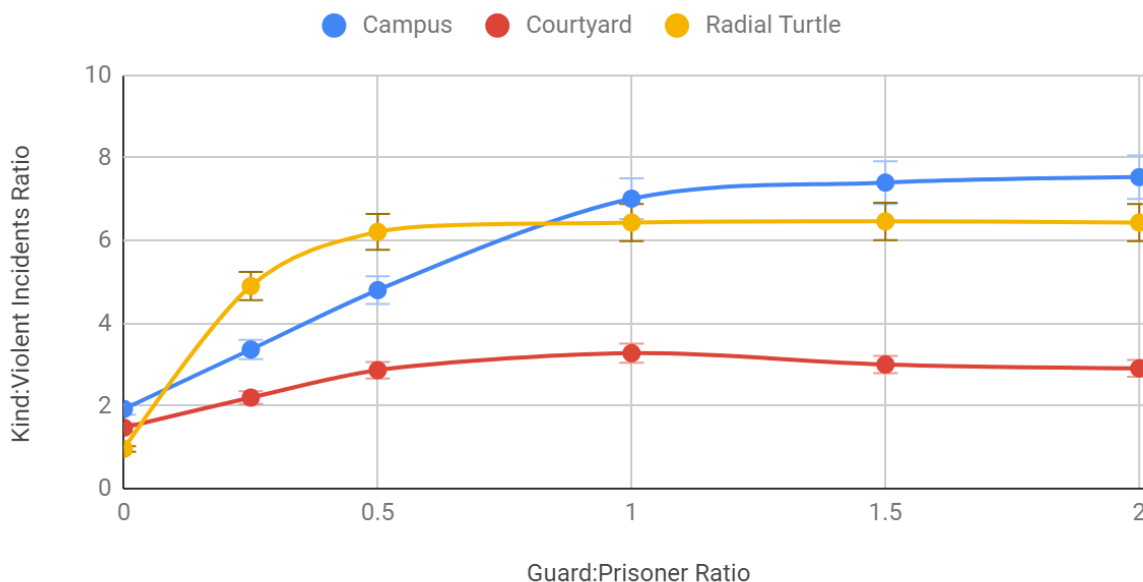
Figure 4: Effects of Guard:Inmate Ratio on Kindness:Violence Ratio in Different Prison Layouts

It is noteworthy to look at the behavior of the most common prison designed used in the US, the Campus design. It had the highest kindness to violence ratio by a statistically significant margin but only for guard over inmate fractions greater than 1 or in the case of there being absolutely no guards. These two conditions are not representative of any prisons in the United States, seeing that most of them have guard over inmate fractions of 0.20 as explained in the background section. Studying the for the guard fraction of 0.25, we see that the campus layout is clearly underperforming in relation to the Radial Turtle layout. This is attributable to how the radial turtle layout is designed so that all inmate social spaces (i.e. living quarters and social rooms) are sandwiched in between guard spaces so that they are always observed and there are no enclosed inmate spaces beyond the living quarters.

The courtyard design is the worst performer by a large margin. This is because, although it has large open spaces where the inmates would theoretically hang out and be observed by the guards, it also has secluded and hidden hallways leading to these social spaces where the majority of the violence

takes place (this is discussed in greater detail in the next section). In light of this, it is understandable

why the campus prison, which is a happy middle between completely secluded hallways where guards

are unlikely to see you and fully monitored spaces where guards are always watching, would be a middle

of the road performer. The reason it performs better at higher guard ratios is because most turtles will

take a generally efficient path to their target location and will not rummage in corners. In a densely

packed design with many hallways like the radial turtle or courtyard, the most efficient path will involve

more hidden corners than an open design like the campus and so will have more violence generally.

The following figure shows the effects of prison crowding (increasing prison population as a

percentage of total design capacity) on the ratio of kind interactions to negative interactions for the
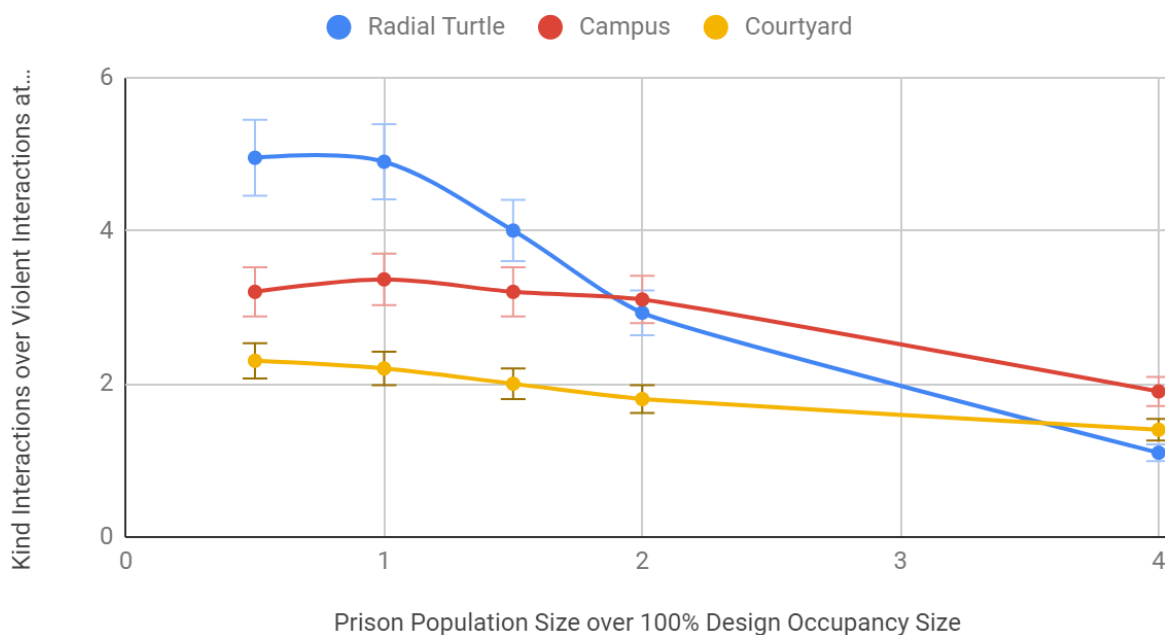
three prison designs tested.

Figure 5: Effect of Crowding on Ratio of Kind to Violent Interactions at Guard:Inmate Ratio of 1:3

It is notable that at extreme crowding conditions, the proportion of kind to violent interactions

becomes virtually identical to that of the simulations with 100% design occupancy and zero guards,

which showed increased lawlessness and violence on account of lacking supervision and discipline. I theorize that this is the case because, at very high crowding levels, each individual inmate is practically surrounded and shielded by many other turtles, none of which is likely to be a guard because they have specific shifts and locations that they usually stand by. As such, they are made invisible to most guards and can feel free to engage in violence. These results suggest that the main mechanism by which violence increases in higher density, higher crowding prisons is not tension and competition over resources, as was previously thought, but is instead more principally a function of the newfound anonymity that inmates experience when part of a crowd. I generate this hypothesis largely because no mechanism for tension as a result of scarce resources is encoded in this model and yet these results showing the expected values of increased violence were still observed.

once again, we find that the most popular prison layout in America, the campus layout, is actually not the best performer with different crowding levels. For the same aforementioned reason, it performs in between the courtyard and radial turtle design but begins to outperform them at higher crowding conditions that resemble the state of lawlessness observed in zero guard prisons. The radial turtle design is a clear best performer at lower crowding densities but quickly becomes the worst performer at higher crowding densities. This is because its main draw of being fully monitorable by guards begins to go away when the density of the inmates allows perpetrators of violence to be shielded and hidden by the crowds; the crowds are also much denser in the radial turtle design, simply because of its thin corridors, high density and compactness.

However, for the range of occupancy observed in most US prisons of about 160% of design capacity, the radial turtle is clearly the best performer by this metric, followed by the campus and courtyard layouts respectively.

It is important to remember that low levels of violence do not directly translate to high levels of social camaraderie and community; low violence could simply be a product of an immense fear of repercussion from the guards. To properly quantify the extent of social community, the inverse weighted closeness centrality is used. As explained previously in more details, this metric quantifies the average weighted distance (representing closeness) between inmates. As defined, higher values signify a model with less social harmony and affection.

The following figure shows how the inverse WCC changes with guard to prison ratio for 100% design occupancy in the different prison layouts studied.
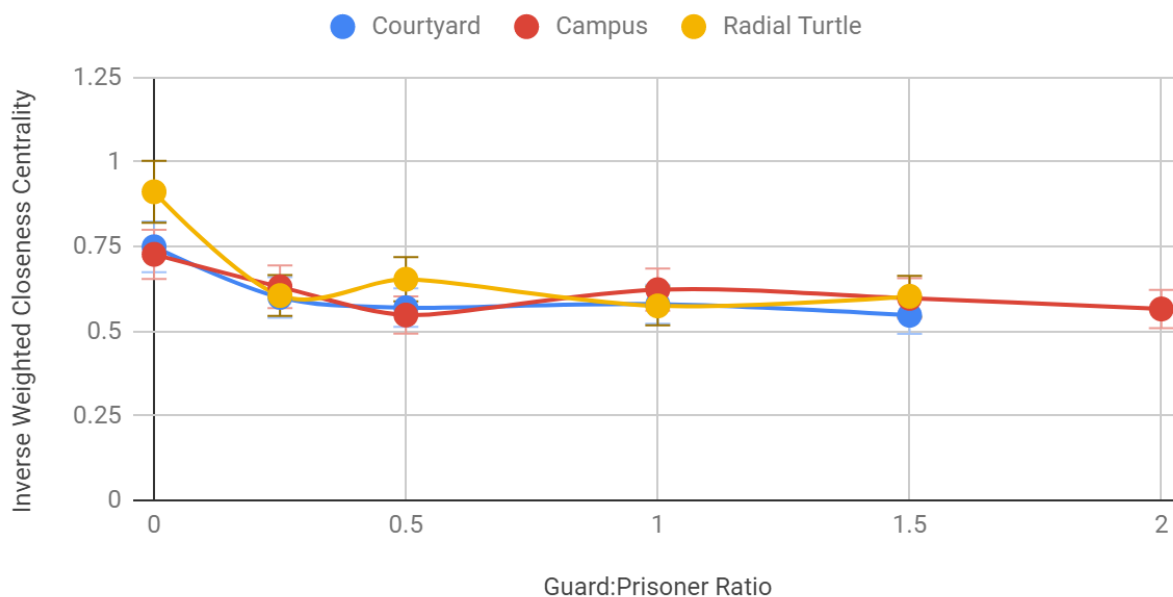

Figure 6: Effect of Guard over Prison Fraction on Final Inverse Weighted Closeness Centrality of Inmate Social Network for 100% Design Occupancy

We note that there is a statistically significant decrease the distance between inmates (increase in their closeness) as the guard fraction goes from zero to fifty percent. This suggests that the expected result of a certain minimum threshold of guards being necessary to ensure social harmony and the avoidance of complete chaos and infighting. However, it is also notable that there is no statistically

significant change in the inverse WCC beyond the guard fraction of 50%. There was also no statistically

significant difference between prison designs in fostering a community at the only guard fractions that

represent anything close to real world fractions (0.25 and 0.50). Radial turtles were once again the worst

performers at very low guard numbers. This is expected as they were designed specifically to promote

guards' capacity to monitor the entire premises and offer little functional benefit in the absence of that.

These results are not surprising given that the presence of guards only diminishes the propensity

for violence but in no way increases propensity for kindness, the real driver of increased community. As

such, much like how rates of violence plateau after a certain guard to prisoner ratio, so too does the

inverse weighted closeness centrality.

We then break down this closeness score by the different prisoner personas below. Once again,

there is no statistically significant variation amongst the floor layouts but there is amongst the personas

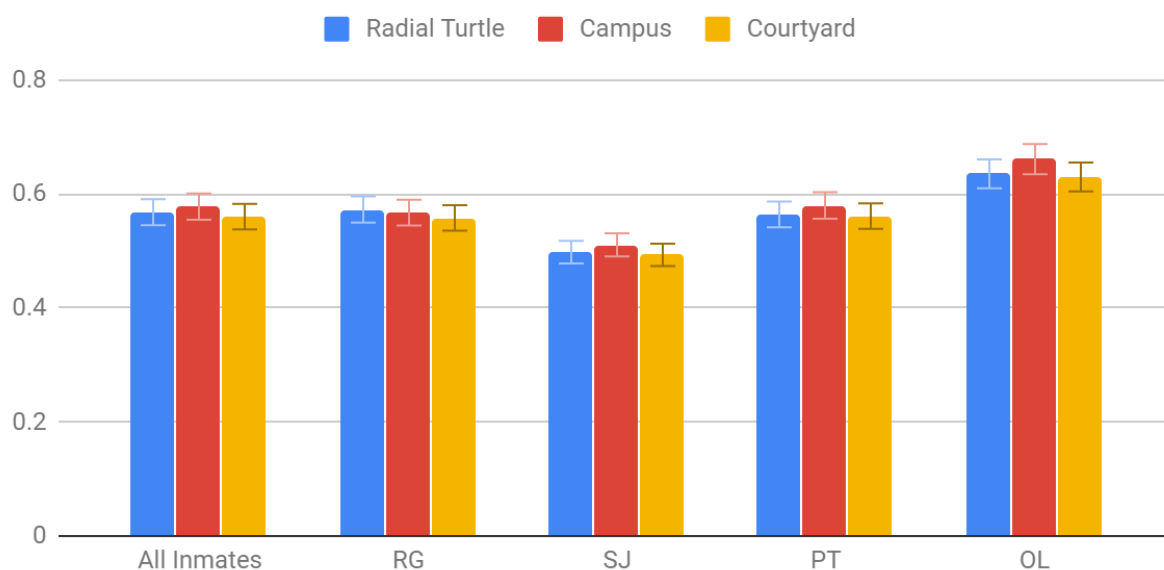within each floor layout.

Figure 7: Inverse WCCs of Different Groups at 1:3 Guard Prisoner ratio and 100% Design Occupancy

As expected, the prisoners that were the least integrated socially were the Outlaws with the highest propensity for violence. Somewhat surprisingly, the ones who were the most well integrated socially were the Square Johns, despite having been documented in the literature as preferring legitimate social avenues like interactions with guards over interactions with inmates. This is attributable to their very low propensity for violence and nonconformity. However, in future iterations of this model, the results could be made more accurate if the inmates were given different propensities for kindness and conversation for guards as compared to the other inmates, so that the social dynamic of "Tough Time" vs "Easy Time" with respect to how open one is to integrating themselves into the social community is better reflected by the results.

Where Does Violence Take Place?

A feature was encoded into the model that makes patches turn progressively darker shades of red depending on how often violent interactions take place on them. This was used to produce what approximates a heat map of the violent locations in the prisons and is shown below for each layout at 100% design capacity and a 25% guard fraction.
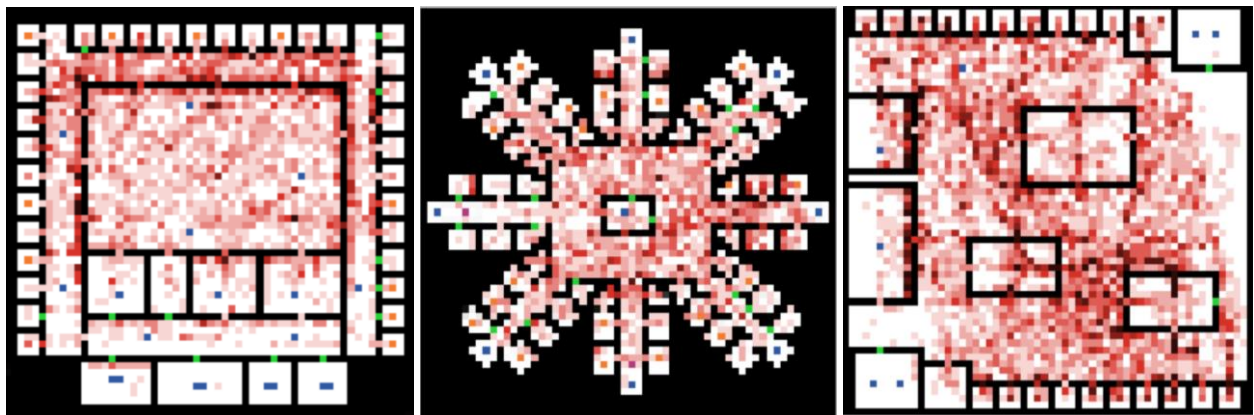
Figure 8: Heat Maps of Violence for Different Prison Designs at 100% Design Occupancy and 25% Guard Fraction at 2000 Ticks

As mentioned previously, we find that violence tends to cluster close to walls, specifically near corners, because that is where one could be most secluded and invisible to guards. In a similar fashion,

we see that the connecting points between target places are hotspots for violence, not necessarily doors per se, but the patches surrounding doors that are more hidden.

To better quantify these heat maps, a weighted distance of violent patches form notable landmarks (doors, guard-spaces and living-quarters) was calculated and normalized for the length of each map (square root of number of non-wall patches, which was assumed to be the area, to give the number of patches along its length). This means the Y-Axis represents the distance to each landmark as a fraction of side length.
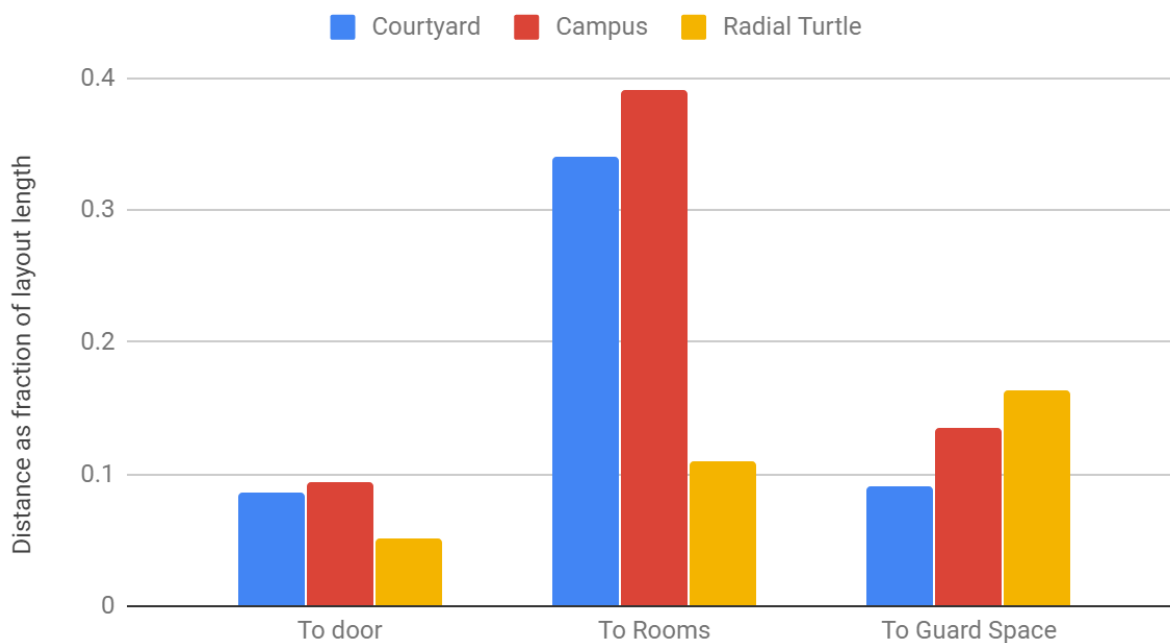
Average Distance of Place of Violence from Landmarks

Legend: ■ Courtyard ■ Campus ■ Radial Turtle

Figure 9: Average Distance of Patches on which Violence has Taken Place from Different Landmarks

We notice that the distance from the rooms is the largest amongst the landmarks studied for both the campus and courtyard designs. This can be attributed to the fact that inmates only return to their own personal living space, meaning that when the turtles randomly identify a target patch of the ones they can access, they are less likely to choose their rooms and so spend less time there in total. The fact that inmates have no reason to visit other inmates' rooms means that rooms are generally not

social spaces where turtles interact and could potentially engage in violence. The distance from doors is quite small in the radial turtle design, principally because there are fewer designated social spaces for the turtle to otherwise go to and so they are much more likely to randomly select their living quarters as their target location to approach. It is also attributable to the fact that the rooms emerge from dense hallways, much like in the courtyard model, which had the second greatest proximity to living quarters. It is the case that dense and narrow hallways connecting between locations make for prolonged contact between inmates and greater likelihood for violence. The radial design compensates for this by ensuring that there are guard posts at both ends of a dense hallway so they can remain monitored and safe.

The opposite logic is applied to understanding why the distance to doors is so small. Looking at the heat map, we see that most violence around doors does not actually take place on the doors proper, but rather on the patches near the door; these patches are still close to the path everyone has to walk down when they go through doors to approach a target but they are also less visible to guards on account of having a separating door in between.

The distance to guard space patches reveals interesting features about the prison layouts. The radial turtle design, where the guards are stationed at the ends of straight, directly visible hallways and are very much entrenched in the social spaces where prisoners interact; this is where their guard spaces (shift posts and lounges) are located. As such, distance from these spaces maximizes the probability that other inmates hide a potentially violent interaction. It is significant that the observed average distance of 15% of layout length corresponds to the length halfway down a hallway with guards at both ends.

In contrast to this, the courtyard layout has the guards largely stationed in an "administrative offices" section at the bottom of the map, much like in an indirect supervision model with walls separating the guards from the inmates at all times. The "average distance to a landmark" was calculated irrespective of the presence of walls in between the inmates and the guards at the time of violence. This is why the

distance to guard spaces can be so low in the courtyard design; the violent incidents and the guard spaces were regularly on opposite sides of a wall and so were hidden from each other, despite close proximity.

Has the Model Been Validated?

The simplifications and assumptions in floor layout as well as a lack of rigid scheduling make it so that the results from this model cannot be directly compared to a real world analogue. Approximated 1 in 5 inmates report having been victims of intense inmate-on-inmate violence[34]. The same source estimates that roughly 12 stabbings occur every month. It is unclear what number of ticks in this model corresponds to a month, especially given that there is no regularly scheduled nighttime for sleep. The fact that all violence is treated as having the same intensity makes it more difficult to compare our model data to real world prison data, which typically only records (an incomplete fraction of) the most violent acts such as prison stabbings that resulted in visits to the emergency center or reported rates of sexual assault and rape.

As such, model validation will have to be conducted on a "Macro Face" level. In this regard, the following qualitative phenomena that were previously explored in the background section are observed in our model:

- Violence goes down in the presence of guards[35]

- Increasing prisoner density leads to increased rates of violence[36]

- Social networks stabilize - who someone considers close does not vary wildly with time[37]

- Violence happens in more hidden spaces and is exacerbated by tight hidden spaces[38]

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[34] "10 Stats about Assault and Sexual Violence in America's Prisons." Mother Jones (blog). Accessed June 7, 2019.
[35] Bigelow, T. Comparing the Cost of Direct Supervision with Traditional Jails. Tallahassee: The Florida Criminal Justice Executive Institute Associates. 1993.
[36] "Crowding, Social Control, and Prison Violence: Evidence from the Post-Ruiz Years in Texas"
[37] Christine Chong and Michael Musheno, "Inmate-to-Inmate: Socialization, Relationships, and Community Amongst Incarcerated Men," n.d., 53
[38] Christopher Harress, "The Architecture of Violence in Alabama's Prisons," al.com, February 12, 2017

As such, the model can be said to be valid on the macro face level.

Hubnet Extension

For the purposes of allowing future researchers to experiment with more nuanced inmate strategies for choosing to be violent or kind, the Netlogo Hubnet Extension was used to develop this simulated prison into a playable videogame of sorts. Wherein, student would log on as inmates, roam around the prison and decide if they wanted to be violent or kind to their potential partner.

Instead of approximating what a prisoner would do in any situation through complex network calculations relating to their weighted closeness to a potential partner or by accounting for the presence of punishing guards and other inmates, a prisoner's decision to be violent or kind now depends entirely on whatever arbitrary decision the player (student) controlling them decides is appropriate. The mechanism for identifying a potential partner remains the same, wherein an inmate-own "potential partner" parameter is constantly updated to reference the closest inmate to them. The students have no control over who the potential partner is; students can simply choose to be violent or kind after the potential partner is identified automatically. Students influence who gets identified as a potential partner by moving their inmate around to approach other inmates. They are prohibited from walking through walls or on dead space outside of the layout. The user interface students see is shown below.
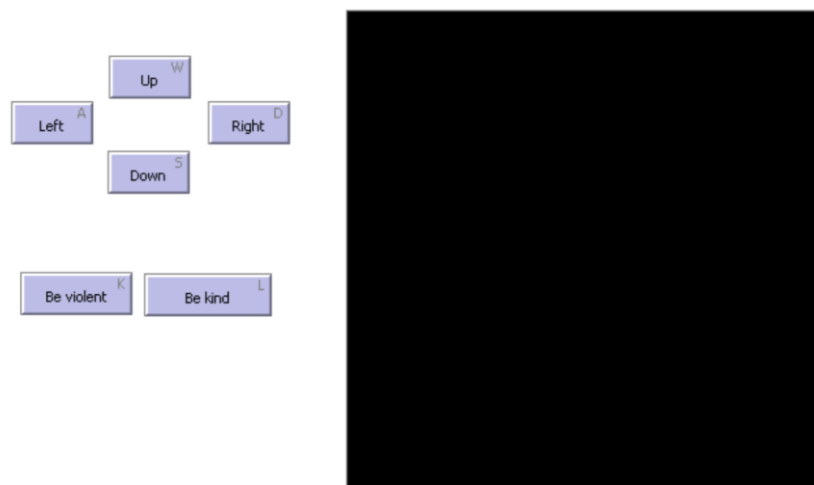
Figure 10: User Interface for Hubnet Model Developed

It is very simplistic and provides them with no information on how well or closely connected they are to the other turtles in the network. As such, students are much more likely than the encoded inmates to perpetuate cycles of violence, simply because they do not have access to accurate enough information about how negatively connected they might be and could instead arbitrarily choose to be kind, as compared to the encoded inmates who utilize information about their connections and links to inform their decision to be violent.

Hubnet Experimentation

Ten students were assembled to play with the Hubnet activity developed. Because of the more qualitative nature experiments with Hubnet, follow up interviews were conducted with the participating students to identify what strategies they used while playing. The students were then asked to repeat the Hubnet sessions once while only being allowed to be violent and then once more, only being allowed to be kind. The Hubnet activity was run multiple times with different numbers of non-student inmates but a fixed guard-to-prisoner ratio of 1:4. The purpose of this was to investigate how big a group of differently behaving inmates needs to be before they influence the closeness of the entire network.

Results and Discussion

The following figure shows the inverse weighted closeness centrality as described previously for different iterations of the Hubnet experiment with the 10 participating students representing an increasing fraction of the total inmate population. Due to time constraints, the experiments were only repeated once for each set of conditions and so the standard deviation associate with these results is not known and the extent to which the trends observed can be accepted remains unclear.

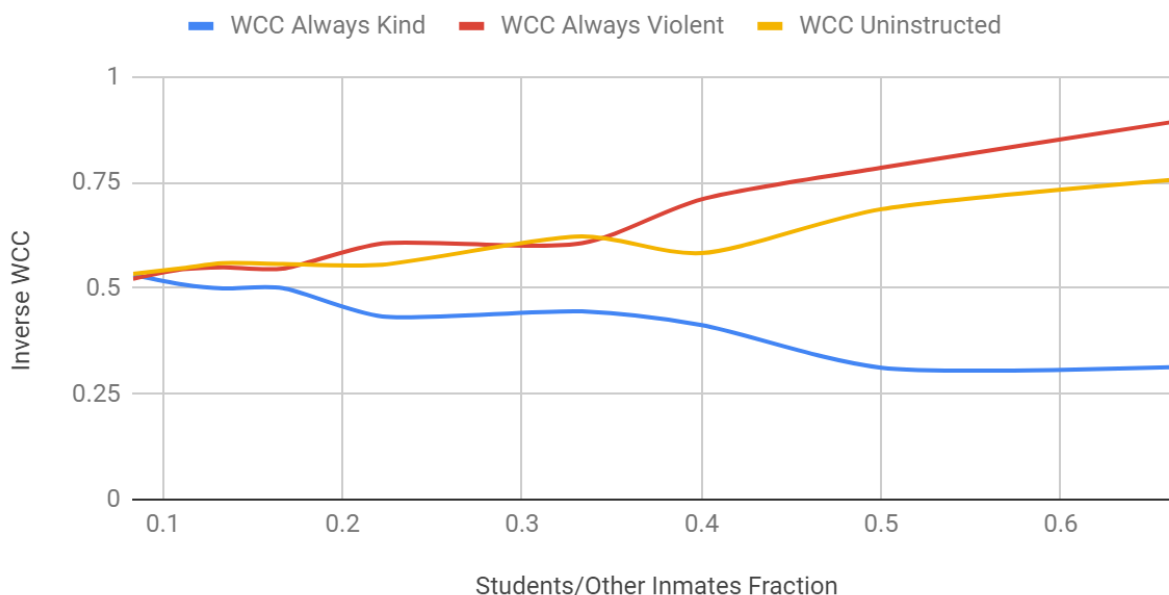## Inverse WCCs from Different Hubnet Student Strategies in Campus Environments

Figure 11: Impact of the Student/Other-Inmates Fraction on the Effect Student Behavior Has on Network Dynamics

We can see that when the students represent a small fraction of the total inmate population, their behavior has no major impact on the overall WCC of the network. In fact, all three strategies, even those oriented in fundamentally opposite directions, converge at smaller student population fractions to the same average inverse WCC that was observed with fully encoded populations. As the student population fraction increases, the impact the students have on the network is more noticeable. Judging from the graph, one could say that a minority must have a ratio to the rest of the population of 2:8 in order for its behavior to form a noticeable difference on the network dynamics.

As expected, the inverse WCC of the network, which was calculated to represent the average distance and negativity of relationships between inmates (i.e. larger values are worse) was higher when students were told to always be violent and lower when students were told to always be kind. What is interesting is that when students were completely uninstructed and were allowed to play in the

simulation however they say fit, their behavior (or at least the effects of their behavior as they impacted the inverse WCC) seemed to line up much more closely with when they were always being violent. Both inverse WCCs of the uninstructed and always violent students were considerably worse than those of the fully encoded population explored in this paper, signaling that participating students had a much higher propensity for violence than the simulated inmates naturally had. This could be attributable to the fact that it is seen as a game in their mind with no real consequences. In light of that, it is understandable that it would be less fun to "be kind" to someone in a game than to see how much havoc one could wreak.

Conclusion

Our model displays behavior that is qualitatively and macroscopically in line with the relevant literature. Moving forward, it was found that the closeness and sense of a fostered community did not vary greatly at different guard to prisoner ratios beyond a certain minimum threshold of guards, prior to which a sense of lawlessness and chaos emerges where violence skyrockets. There was no major difference in the strength and closeness of the communities formed across the three most popular prison designs in the US. However, there was significant variation in the extent to which a negative community manifested violence. No mechanism for competition over resources or increased tension between inmates on account of scarcity was encoded into the model and yet increased prisoner density was still shown to lead to increased violence as the relevant literature would predict. This suggests that the main mechanism by which increased prisoner density contributes to violence is actually by increasing the extent of anonymity felt by individual prisoners, wherein they are shielded from the gaze of the prison guards and can be violent with less fear of identification or repercussion. The closeness of different inmate populations (right guys vs outlaws) varied within reason as one would expect given the relevant literature. It was found that the proportions of different prisoner personas observed in modern US prisons leads to an average positivity to negativity ratio of relationships that more or less balances

out, suggesting that these persona fractions emerge and arrive at an equilibrium that stabilized the community as opposed to being innate to the inmates in a vacuum. For the crowding levels and guard to prisoner ratios in modern US prisons, it was found that Campus prison layouts, the most common layout used today, are actually not the best performers. In fact, for the parameters in question, violence is minimized in Radial Turtle design, which is in line with the observation that increasing the guards' capacity to monitor decreases prisoner violence.

Future Work

This work could be greatly improved upon by increasing the granularity and detail of the results extracted from the model so that more robust comparisons and validations with real world data could be conducted. This would involve minimizing the simplifications explored above and would encompass:

- Increasing the detail associated with an interaction: how violent or kind was it? Is it a memorable interaction that will greatly influence the strength of the relationship or just a mild negative comment?

- Adding prisoner schedules to reflect them going to the gym or the cafeteria at specific times and updating their propensity for violence based o how preoccupied they are. These schedules would also help document the passage of time so that the temporal component of prison violence can be compared to real world data

- The influence of guard personalities on prison dynamics as well as incorporating guard schedules so they are at different posts at specific times as opposed to simply wandering around randomly between guard spaces.

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