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Article · August 2017

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An Immune System Inspired Theory for Crime and Violence in Cities: Media Summary

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MEDIA SUMMARY

Taxation and death may be inevitable but what about crime? It is ubiquitous and seems to have been around for as long as human beings themselves. A disease we cannot shake. However, therein lies an idea, one that Oxford Mathematician Souyma Banerjee and colleagues have used as the basis for an understanding and quantifying crime.

Their starting-point is that crime is analogous to a pathogenic infection and the police response to it is similar to an immune response. Moreover, the biological immune system is also engaged in an arms race with pathogens. These analogies enable an immune system inspired theory of crime and violence in human societies, especially in large agglomerations like cities.

An immune system inspired theory of crime can provide a new perspective on the dynamics of violence in societies. The competitive dynamics between police and criminals has similarities to how the immune system is involved in an arms race with invading pathogens. Cities have properties similar to biological organisms - the police and military forces would be the immune system that protects against invading internal and external forces.

The arms race between immune system and pathogens is similar to the competitive dynamics between police and criminals. Cities have properties similar to biological organisms and in this theory the police and military would be the immune system that protects against both internal and external forces. The system is depicted in Fig. 1.

Police are activated by crime just like immune system cells are activated by specialized cells called dendritic cells. Non-criminals are turned to criminals in the presence of crime. Hence crime is like a virus. This specifically simulates a spread of disorder. The police is analogous to the immune system and criminals are like infected cells. Police also remove criminals similar to how T-cells kill and remove infected cells. The analogies between the immune system and police are summarized in Table 1.

Table 1: Analogies for an Immunological Theory of Crime

| Human Societies                  | Immune System                  |
|----------------------------------|--------------------------------|
| Crime                            | Virus                          |
| Non-Criminals                    | Susceptible normal cells       |
| Criminals                        | Infected cells                 |
| Police                           | Immune System                  |
| Police first responders           | Innate immune system (dendritic cells) |
| Specialized police forces         | Adaptive immune system (T-cells and B-cells) |
| Police taking out criminals      | T-cells killing infected cells  |
| Police removing crime            | Clearance of virus by B-cells  |
| Crime database                   | Immune memory                  |
| Police crimes against innocent people | Immune system attacking itself |
| Police stations                  | Lymph nodes                    |
| Patrolling police                | Circulating T-cells            |
Figure 1. A simplified depiction of the arms race between police and criminals. The interaction between criminals and normal people (non-criminals) causes crime. Crime triggers a police response. Police in turn respond by removing crime and removing criminals (adapted from [2]).

The model is diagrammatically represented in Fig. 1.

This model can be simplified under conditions of steady state (holds during normal peaceful time periods and not during times of violence) to yield an equation for crime [2]:

\[ C_{ss} = \frac{\alpha \cdot D_C \cdot D_{NC}}{\beta \cdot D_{LE}} \]  

(2)

where \( C_{ss} \) is the number of crimes in cities at steady state, \( N_{criminals} \) is the number of criminals, \( N_{non-criminals} \) are the number of non-criminal people, \( N_{police} \) denotes the number of police in cities and \( \alpha, \beta \) refer to constants of proportionality in the relationship. Equation (2) is a general equation which unites crime in different contexts: from crime in cities to crime in universities [2].

The work has implications for public policy, ranging from how much financial resource to invest in crime fighting, to optimal policing strategies, pre-placement of police, the number of police to be allocated to different cities, and how to tackle sensitive issues like immigration. The research can also be applied to other forms of violence in human societies (like terrorism) and violence in other primate societies and social insects like ants.
The work is a first step towards a deterministic theory of human behavior and violence in societies. Isaac Asimov had written imaginatively about a field of predictive human behavior which he called psychohistory. Although this remains an extremely ambitious goal, in the era of big data we may be able to predict behaviours of large ensembles of people without being able predict actions of individuals.

The researchers hope this will be the first step towards a quantitative theory of violence and conflict in human societies, one that contributes further to the pressing debate about how to design smarter and more efficient cities that can scale and be sustainable despite population increase - a debate that mathematicians, especially in Oxford, are fully engaged in.

Acknowledgements
The author thanks Dyrol Lumbard in editing and proofreading this text.

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