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Comment

# Crime as a complex system
# Comment on "Statistical physics of crime: A review" by M.R. D'Orsogna and M. Perc

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Maria R. D'Orsogna and Matjaž Perc [1] summarize, in this review, a growing body of research that applies mathematical methods, some of which originating in statistical physics, to the understanding of the emergence and diffusion of crime.

As they state, our understanding of the mechanisms underlying the emergence and diffusion of crime is very limited, particularly when quantitative models are considered. It is undeniable that the intricacies of Human behavior are so complex that there is little hope that one is able to model theoretically, in detail, every aspect of a human population of decision makers. Yet, what at first seems to be an apparent disadvantage turns out to be amenable to constitute an advantage. In fact, the interference of such a diverse plethora of complex behaviors may actually render the description of average salient properties and their evolution not only feasible but also prone to be governed by considerably simpler laws [2]. In this sense, a statistical mechanics approach may provide important clues on the impact of simple, yet general, concepts which, together, lead to the emergence of the complex dynamics associated with crime. For the same reason, the recent use of evolutionary game theory methods looks very promising, as the socioeconomics of crime can be seen as a complex ecological system, where conflicts of interest, and relations of cooperation or exploitation prevail.

Like most phenomena resulting from human activity, crime is best described resorting to methods stemming from the physics of systems away from equilibrium. In this realm, this manuscript allows us to quickly recognize the truly interdisciplinary nature of the problem, whose study requires the combination of methods that, 10 years ago, would stand alone as respected methods of equally respected, but separated, disciplines.

While the spatio-temporal dynamics of crime hotspots exhibits remarkable similarities to the mathematics of pattern formation, thereby being addressed in the framework of reaction–diffusion equations, burglary and gang activity invites us to study seismic activity phenomena and recurrent burst dynamics. Furthermore, the arms race between those that commit crime and those that fight it can also be recast in the form of competing social dilemmas, such as

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the adversarial game — in which informants, paladins, villains and apathetics comprise the 4 different types of members of a population where there is room for individuals that commit crimes and those who do not, as well as those that may act as witnesses and those who may not. Similar to other social dilemmas, the resultant dynamics portrays rich scenarios, where parameter combinations allow for societies to evolve towards "*utopian states*" where crime is absent, or conditions under which mafias, drug cartels, or even war may be present.

While assuming that societies comprise solely 4 types of individuals may look simplistic at first sight, it is also true that, from a theoretical perspective, such a framework constitutes already a challenge. It paves the way, however, to test the theory by complementing it with experimental work — one of the most important hallmarks of Physics — usually performed in the realm of behavioral experiments employing volunteer students.

An important dimension in combining game theoretical techniques with population dynamics is the possibility to investigate the role of incentives (carrots), punishment (sticks), or even both (the so-called carrot and stick strategies [3]) in managing crime, including the dimensions of rehabilitation and recidivism.

Finally, understanding criminal networks, their structure, adaptability, robustness and resilience, paves the way for a unified treatment in which geography may stand *at par* with other means of networking which, in the midst of the information age, transcend geography. The combination of tools and methods stemming from network science with those of game theory and dynamical systems [4,5], applying them to populations and studying the emergence and deterrence of crime, offer much ground to be explored. Those important steps made to date are nicely reviewed in the work of D'Orsogna and Perc, that also offers much inspiration and references for all those eager to dwell into this fascinating topic.

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