



Reply to comment

Physics for better human societies Reply to comments on “Statistical physics of crime: A review”

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We would like to thank all the experts for their insightful and very interesting comments that have been submitted in response to our review “Statistical physics of crime” [1]. We are delighted with the large number of comments that have been written, and even more so with the overwhelmingly positive opinions that these comments communicate to the wider audience [2–10]. Although methods of statistical physics have long proven their value in relevantly addressing challenges in the social sciences and the humanities [11–31], such interdisciplinary research often still struggles for funding and recognition at many academic levels.

In this reply, we would like to highlight the coming of age of complex systems research, network science, as well as advanced data analysis as applied to socio-technical systems in the broadest possible sense. We would also like to emphasize that the theoretical and modeling tools that have been developed by physicists, mathematicians, and computer scientists have reached the maturity to effectively address the many challenges of our time, not least aiding the surveillance, analysis, and ultimately also the prediction and prevention of crime. In what follows, we briefly discuss the comments on our review in the light of this fact, and we also point out the many outstanding challenges as well as opportunities for future research.

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The comment by Kenett [6] brings the coming together of physics and social sciences beautifully to the point, and we could not agree more that combining the tools and theories of statistical physics with the ever growing data available in the social sciences will yield a deeper and better understanding of social life and its dynamics. This “marriage” will indeed be most mutually rewarding if experts from both disciplines could work side-by-side to develop optimal resilient infrastructure for sustaining our social wellbeing. Along the same lines, Pacheco [7] emphasizes that, crime as a complex system may benefit significantly from a statistical mechanics approach by drawing on important clues from the impact of simple, yet general concepts that together lead to the emergence of the complex dynamics associated with criminal behavior. For the same reason, and despite their simplicity, evolutionary games [32–35] are emerging as a very promising theoretical framework to study the socio-economic aspects of crime, in particular related to reward, punishment and fear of collective failure as means to further prosocial behavior [36–43]. Abou Chakra and Hilbe [2] also attest usefulness and merit to such modeling approaches, and they constructively conclude that such models are built on simple and intuitive principles that allow us to gain analytical insights into the dynamics of crime and punishment. Similarly, Barbaro [3] advocates a place for agent-based models in crime-related research for their usefulness in the study of intervention strategies or helping to assess the plausibility of behavior hypotheses. We fully agree, and we believe this is an excellent position that will promote such interdisciplinary research long into the 21st century.

In terms of outstanding challenges, a recent Editorial in *Nature* [44] makes an important point. Namely, while physics, chemistry, biology and the environmental sciences can deliver wonderful solutions to some of the challenges facing individuals and societies, if social, economic and/or cultural factors are not included in the framing of the questions, a great deal of creativity can be wasted. As aptly concluded by Donnay [4], this is especially relevant for studies that seek to provide insights that ought to be directly relevant to policy makers. Ultimately, social scientists will be most interested in new methodological approaches and would most easily recognize the full merit of the innovative research reviewed in [1] if studies were to actively address longstanding and central questions that are of broad interest in the field, in some cases with a specific eye to the particular. We fully agree that one of the next steps is to include more local “ingredients” to focus on specific urban layouts, crime types, or societal attitudes, in order to be more to the point and concrete, especially for the benefit of policy makers and stakeholders. To this end, interdisciplinary collaborations matter decisively: inputs from different perspectives will lead to more complete studies, approaches, questions, and possibly answers. The closer the collaboration between experts from the social and physical/mathematical sciences, the better.

On a similar note, Ribeiro [9] rightfully emphasizes that, although statistical physicists may represent the ideal professional to take on such an interdisciplinary challenge, physicists nevertheless need to invest even more into moving further away from their “comfort zone” and to really make their research count in terms of actual applicability. Of course, dialogue with different disciplines is challenging and requires flexibility, openness and humility. We hope the examples provided in our review are an attempt in this direction, as we have made a sincere effort to showcase research involving criminologists, anthropologists, economists and urban planners working together with physicists and mathematical modelers.

As pointed out by Ferrara [5], however, to a considerable degree the actual applicability of the theory and models reviewed is already at hand, for example in the form of computational prediction of crime from mobile phone data [45,46]. Methods of statistical physics, applied mathematics and computational models informed by big data might provide just that crucial edge in the never-ending arms race between law enforcement agencies, policy makers, and researchers, who oppose criminal and terrorist organizations that operate to dismantle modern societies.

We would also like to thank Primicerio [8] for pointing out the important role of mathematical modeling in modern criminology, and to emphasize how rich the panorama of the methods that can help us to better understand and prevent crime truly is.

We conclude by citing from the comment by Rodríguez [10], who notes that “the most important reason why this is such a compelling avenue of research is its untapped potential”. Indeed, current research has only scratched the surface of what can be done, and we gladly join the hope that, as the gap between the modeling and real-life is reduced, this research will hopefully be able to move more and more from having an exploratory nature towards having predictive and truly applicable value.

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