Computer Simulation in Criminal Justice Research

Patricia L. Brantingham, Paul J. Brantingham and **Uwe Glässer**
explain how a new system can help in understanding crime and developing effective policy.

Public discussions about crime and the criminal justice system reflect a plurality of perspectives and concerns. These perspectives include various disciplinary views on the origins of criminality and patterns in criminal events; on the origin, implementation and impact of law, policy, and programmatic services aimed at reducing criminality and criminal events; and on crime and criminal justice issues as seen by victims, offenders and the public at large as well as by policy makers, practitioners and researchers. This complexity of reasons for conducting research is tied to our improved understanding of the complexity of the human environment in which crimes occur and it poses a challenge for criminal justice researchers. All criminological research is oriented toward exploring patterns and possibilities, toward developing explanations for any patterns found and toward developing tools and techniques for reduction of criminality and criminal events. Most research in criminology and criminal justice is structured in an attempt to replicate laboratory science by addressing simple issues within simple constraint sets while assuming other things have been controlled. We have concluded that there is a strong need for criminological research that addresses complexity instead of attempting to control for it.

The development of a research approach that reflects complexity and makes research perspectives and assumptions explicitly clear makes it possible to explore both micro and macro level issues concurrently. It would allow us, for instance, to understand how an individual offender chooses targets or how networks of friends may engage in a crime in one context, but not in others; to understand how the introduction of a policy may completely reduce crime in one urban setting while it abates crime in another setting by displacing it to somewhere else; to understand how some crime reduction policies become fully implemented and prove effective while others do neither.

This article describes an approach called *agent based simulation* that facilitates researching the complexity of crime patterns. This relatively new approach to criminal justice research offers many new ways to understand the unfolding of both criminal events and the policies and programmes intended to address them because it requires development of formal theoretical statements of what is expected.

Simulation modeling

Computer simulation modeling involves the construction of abstract mathematical descriptions of sets of semantic objects, their attributes and active relationships, interactions and constraints, followed by repeated runs of models over simulated time to see what they produce. The models can be validated and used to predict possible future alternatives in order to inform crime reduction policies.

Process models

Simulation models developed to examine flows along formally described processing structures can model how one flow interacts with another. This type of modeling was used in the 1960s and 1970s under acronyms such as JUSSIM or CANJUS to forecast flows of people through the criminal justice system (e.g., Blumstein, 1967; Brantingham, 1977; Cassidy, 1985). Relatively simple flow or process simulation modeling using aggregate or summary data to make predictions about future needs, for instance, for police officer recruitment or new prison construction is well established (e.g., Auerhahn, 2003, Boe, 1997; Brantingham & Brantingham, 2004; McGinnis, 1989).

Agent-based simulation

Agent-based modeling is relatively new to criminology and criminal justice studies. This type of simulation is built of autonomously operating individual entities (agents) endowed with specified behavioural rules and constrained by general and individual limiting rules. These rules direct, with some variability, the course of interactions with other agents and with the environment into which the agents are embedded. The simulation models how agents make decisions or choose actions through interaction in changing contexts over simulated time and space. Agents acting in these simulations develop 'knowledge' of the environment that evolves over time as they gain experience of it. Feedback shapes how an agent interacts with other agents and the environment over successive iterations of the simulation.

Agent-based modeling is relatively new to the social sciences, but holds the promise of becoming a powerful new computational tool in crime analysis and in policy analysis. With agent-based modeling it is possible to see that what appears to be very different crime patterns in two cities may be the result of

different urban backcloths, but with the agents acting under the same rules; or the result of agents acting under the same rules but against different urban backcloths.

Agent-based modeling is usually done using existing computer languages. The best known modeling environment is probably *SWARM*, developed at the Santa Fe Institute (see www.swarm.org). SWARM has now been largely superseded by development environments such as the University of Chicago's *RePast* (http://repast.sourceforge.net/) and the Brookings Institution's *Ascape* (http://www.brook.edu/es/dynamics/models/ascape/). Very advanced agent-based simulations utilise Abstract State Machine theory and the AsmL language (see http://www.eecs.umich.edu/gasm/; Glässer, Gurevich & Veanes, 2004).

Agent-based simulation and environmental criminology

Agent-based modeling starts with the abstract and adds complexity. This capability makes this modeling technique particularly attractive to environmental criminologists because it will allow us to build models that look at the ways that changes to the urban environment change crime patterns and criminal justice system response patterns. For example:

- How do crime patterns change with the introduction of new motorways connecting two cities?
- How is crime attracted to areas around large shopping centres?
- Why does increased enforcement displace crime in one city but abate it in another?
- Why is property crime high along one main road and low along another?

Similarly, it can help us address important questions about criminal justice service provision:

- How do the locations of half-way houses impact on recidivism?
- Why does regulation of pub hours have different impacts in different cities?
- How does the location of senior centres impact on victimization and fear of victimization?

At the aggregate level agent-based simulations can help us understand such questions as:

- How would crime patterns change with increased mobility or migration?
- How do some urban settings create crime attractors or crime generators?

The future of simulation modeling in criminal justice research

Flow or process modeling will become more common as available software becomes easier to use. Some of the current process modeling programs work on the basis of diagrams drawn to show how parts of the system fit together with increased complexity and detailed functional relationships added over time to produce powerful program planning tools.

Agent-based modeling has an interesting future, one of particular importance to the authors. This type of modeling requires thinking about different classes of agents and developing rules that direct their decisions (or describe when decisions should be treated as random). This requires a direct, formal set of behavioural rule statements. It requires formal statements about activity constraints. The purpose of the model must be made clear. Because model building is a learning experience, it draws the model builder into study of the dynamically changing environment; it draws the modeller into understanding how agents interact; it makes the micro become integral to the macro. The value of such modeling will increase with increasing computational power, but even at present agent-based simulation promises development of powerful experimental tools for understanding crime patterns and for enhancing evidence-driven policy development.

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Patricia L. Brantingham *is Professor of Criminology at Simon Fraser University, Director of the Institute for Canadian Urban Research Studies and lead criminologist in the Computational Criminology Initiative.*

Paul J. Brantingham *is Professor of Criminology at Simon Fraser University and Co-Director of the ICURS Laboratory.*

Uwe Glässer *is Associate Professor of Computing Science at Simon Fraser University and lead computing scientist in the Computational Criminology Initiative.*

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