Bridging the Micro-Macro Gulf in Social Science Research: Military and Intelligence Applications[1]

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Executive Summary – Key Points

- Micro units of society are individuals
- Methodological individualism and reductionism do not obviate appreciating social wholes
- Appreciation of emergent social phenomena is grounded in understanding the complex interactions of their units
- Units should not be static; people are not static, their states and behaviors change
- Aim of social modeling should be the emergence of macro-phenomena; these are the sorts of phenomena of most national security concern (riots, revolutionary movements, insurgencies, terrorist networks, state collapses, genocides)
- Ultimate models will have emergent social phenomena that will take on their own rules of interaction; modelers are far from this
- Models must be evaluated and validated; they must predict, although precise predictions are not reasonable
- Over-calibration can lead to accuracy and precision but not validity, especially for near-term phenomena
- General long-term trends can, ceteris paribus, be predicted, but there is a many-to-one mapping of models to such phenomena
- Ensemble computing, in which model behavior is explored over its complex parameter space is a more practical and responsible means of judging the validity of a model

Introduction

A primary aim of this session is to consider what needs to be modeled at the micro social level if we hope to produce valid and useful models that address national security concerns. I will provide a consideration of micro dimensions, but also address the emergence of macro phenomena, for if detailed models at the micro level fail to generate the macro phenomena (insurgencies, terrorist movements, genocides, state collapses, etc.) relevant to national security, then the models have failed.

[1] I am indebted to several workshop participants for their inputs, most notably Jerrold Post and David Sallach.

This paper is structured as follows. First, I consider what micro means and list key micro phenomena that should be considered for producing valid models. Second, I review the issue of emergence and generative sufficiency in order to bridge micro models with macro phenomena. Third, I address the very difficult issue of what can be expected in prediction and how that may be measured. I illustrate each issue with contemporary models developed to address national security concerns.

What is Micro in the Social Domain?

What do we mean by the micro level in social science modeling? This is a key concept, and is bound with critical philosophical issues such as methodological individualism and reductionism. Micro most often means the individual, although nuclear families, extended families, lineages, or small social groups may provide fine enough scale for some modeling purposes. However, the atomistic unit of any human society is the human itself. For this reason, I see methodological individualism, the methodological practice of explaining social phenomena as derived from the characteristics and behaviors of individuals (Popper, 1979), as indispensable for fully valid modeling[2]. As a practical matter, some models may be well-served by using other small-scale social units as their fundamental units of analysis; not all models must start with the individual, just as a model of a human being need not begin with all 60 trillion cells of the body. Such units are likely to be families, neighborhoods, terrorist cells, ruling elite cadres, etc. The higher-level social phenomena are, the more they are abstractions of the complex interactions between a society's constituent elements, its people.

Methodological individualism raises immediate problems for explaining social phenomena since, by definition, social phenomena are observed at the group level; a single person does not make a riot. Traditionally, methodological individualists have been criticized for reductionism, for failing to see the social whole for its constituent parts (see Bell, 1994; Harris, 1979 for discussions from a methodological individualist stance; O'Meara, 1999). However, complexity theory provides resolution to the reductionism dilemma – once one realizes that social "wholes" emerge from the complex, non-linear interactions of their constituent elements, one simultaneously gains an appreciation for the wholes and establishes the requirement that understanding and modeling the elements is indispensable (Holland, 1998; Kohler, 2000; Kuznar, 2009). Otherwise, as modeling begins with higher macro-level abstraction, its units have increasingly dubious ontological status.

Micro Modeling: The Essentials

Ultimately valid social models therefore require modeling of individuals, but what needs to be modeled at this level? I would divide the requirement into states and behaviors. It is important to note that I am not arguing that all possible states and behaviors must be modeled in order to create a valid model of behavior. However, modelers must pay

[2] By individual, I am referring to biological individuals. Individual in the sense of individual identity is a group level phenomenon since identity is formed in relation to socially shared concepts, such as mother, doctor, soldier, tribal elder, etc.

attention to the range of states and behaviors necessary to answer a particular model's questions, and to be open-minded about what states and behaviors are relevant. Establishing the range of necessary states and behaviors is challenging and should involve researchers from a variety of social science disciplines and with a sensitivity to the cultural context being modeled in order to insure that a model captures all relevant variables.

States refer to attributes of individuals themselves, and they are important because they condition how individuals behave. I prefer the term state to attribute, since a state is always contingent on a particular time and place; it is important to recognize that most attributes can change, and their values are states of an individual in time and place. It is beyond the scope of this paper to provide an exhaustive list of states for individuals, but they include variables such as: location, nutritional status, age, sex, wealth, social status, marital status, skills, occupation, ethnic, religious, political identities, psychological states, preferences, etc.

Nearly all models that address national security concerns take the individual as the basic unit of analysis. Some models ignore location, but others embrace its fundamental influence on structuring who has an opportunity to interact with whom, whether modeling terrorist networks (MacKerrow, 2003), insurgencies and civil war (Lustick, 2002), or Genocide in Darfur (Kuznar & Sedlmeyer, 2005). Most models capture basic biological attributes such as age and sex (Chaturvedi et al., 2005; Kuznar & Sedlmeyer, 2005; MacKerrow, 2003), and most record basic economic variables such as wealth, socio-economic status and income (Chaturvedi et al., 2005; Kuznar & Lutz, 2007; Kuznar & Sedlmeyer, 2005; MacKerrow, 2003; Silverman, Bharathy, & Nye, 2007).

Other models focus more on psychological states, including knowledge, intelligence and cognitive loads (Tsvetovat & Carley, 2005 on terrorists), and psychological propensities such as needs for control, propensity to violence, greed and persuasiveness (North, Macal, & Vos, 2004 on terrorists) (Silverman et al., 2007 on insurgents and leaders). Lustick's Political Identity models focus on more socially derived states like ethno-political identity (Lustick, 2002; Lustick, Miodownik, & Eidelson, 2004), which also figure in MacKerrow's TAP models of terrorism and grievance (MacKerrow, 2003).

Simply knowing individual states, as essential as it is, is proverbially failing to see the forest for the trees. What makes individuals interesting is what they do and what they do with one another leads to the emergence of the social phenomena that concern the national security community, such as collective violence. One hundred and fifty years ago, the social science pioneer Herbert Spencer noted that societies emerge from "conspicuous peculiarities:

1. That commencing as small aggregations, they insensibly augment in mass….
2. continually-increasing complexity of structure….
3. their parts gradually acquire a mutual dependence….

4. That the life and development of a society is independent of, and far more prolonged that, the life and development of any of its component units… (Spencer, 1972:57)."

So, it is the interactions of individuals that lead to the emergence of long-term, macro-level social phenomena. Modelers capture interaction in the rules of behavior applied to agents. Some behaviors may not involve interaction with other people at all, but are nonetheless important because they condition how people may interact. For instance, movement through space influences the probability that individuals may interact. However, given the social nature of our species, most behaviors involve interaction with others. Some interactions are physical, such as shooting or displacing, which may be important for altering the configuration of individuals to one another. Epstein's (2002) model of social unrest and rioting and Project Albert's models of peacekeeping (Lauren & Stephen, 2000) are good examples of how simple physical behaviors send ripple effects through a larger group. However, most social behaviors form some sort of exchange between and among individuals. Exchanges vary from communication (verbal, electronic, peer-to-peer, broadcast), to contractual exchanges (agreements based on kinship, mutual support, economic exchange), to exchanges of material wealth (food, money, water, housing) and services (transportation, building a bomb).

Most models applied to national security concerns model behaviors in game theoretic terms as dyadic interactions between individuals seeking to satisfy some need or desire. Sometimes, agents are modeled as seeking some utility-maximizing value, although all models cited here qualify that by incorporating considerations of risk through expected utility (Chaturvedi et al., 2005; Kuznar, 2007).

Emergence: The Holy Grail of Social Modeling

Social phenomena are curious abstractions. We routinely speak about them as though they have some concrete existence, such as social movements (communism, Salafism, globalization, tribe), but when social scientists have attempted to observe these phenomena concretely, debates ensue regarding their reality. This is because social phenomena are genuinely emergent. They result from the interactions of individuals who themselves are constantly changing. Therefore, their properties and boundaries are constantly shifting, defying easy observation. The basic social unit of our ancestors was the band, a loose confederation of individuals, usually centered around a stable core of siblings, numbering around 25 individuals who variously cooperate in foraging and defense. However, censuses of bands in contemporary forager societies demonstrate that their membership as well as the actual size of the band is in constant flux (Lee & Devore, 1968). So, the notion of a band has a tenuous reality, but is also indispensable for studying and talking about foraging societies. So it is with all social phenomena, whether they are terrorist organizations, coalitions, juntas, or even fairly well organized states. The morphing of al Qaeda from a loosely structured organization into more of a social movement (al Qaeda 2.0) is a prime example of the tenuous reality of social phenomena (Atran & Stern, 2005; Benjamin, 2007; Sageman, 2008; Stern, 2003). We feel strongly that al Qaeda exists, it seems clear that individuals who consider themselves al Qaeda

would kill real Americans, but the phenomenon of al Qaeda itself has been difficult to identify and bound.

If models are to capture the phenomena that interest us validly, those phenomena should therefore emerge from the interactions of the micro elements of our models. The more concrete the micro elements, the better grounded our models will be. Emergence has, so far, been a holy grail of the modeling community. This does not preclude modeling at higher levels of social abstraction. For instance, a model could take as its starting point, DIMEFIL (Diplomatic, Informational, Military, Economic, Financial, Intelligence and Law Enforcement) levers of power, and model how these impact PMESII (Political, Military, Economic, Social, Informational, Infrastructure) effects in a society. However, the fact that these are emergent phenomena makes measurement of them problematic. Is the appropriate measure of "economic" GDP? Unemployment? Poverty rate? At what level should poverty be defined? For the sake of expediency and to the extent that macro-level variables have some reality, models of purely macro-phenomena can and should be generated to assist analysis and planning. However, the most scientifically valid models will ultimately be grounded in more atomistic and concrete elements of society, and the macro-level variables will emerge from them.

The degree of emergence present in most models is pretty much first-order and closely tied to the coding of the models; in other words, the emergence is practically hard-coded, which is not emergence at all. For instance, the network characteristics that emerge from models of terrorist networks (North et al., 2004; Tsvetovat & Carley, 2005), the spread of grievances throughout the Middle East (MacKerrow, 2003), and the increase in non-viable families as a result of raiding in Darfur (Kuznar & Sedlmeyer, 2005) were the direct result of first-order calculations in these models. Chaturvedi's model of emergent networks and rules of membership in Indonesia (2005), and my model (Kuznar, 2007) of how risk sensitive utility maximization combined with small group psychology effects to create Palestinian political factions come closer to genuine emergence; in these models, agents spontaneously form coalitions and agent states and behaviors within these coalitions create emergent properties of the coalitions that further influence the behaviors of the coalitions as a whole, as well as the members of the coalitions. However, these models still fall short of generating multiple levels of abstract social phenomena and evolving rules of behavior between these abstractions. Modeling of emergent phenomena that interact with one another according to emergent rules is necessary because, going back to Durkheim (1938) and Spencer (1972), social scientists recognized macro-level social regularities that had their own rules of behavior. Ultimately, valid models will capture the interactions of emergent phenomena as well.

The fact that genuine emergence is only beginning to be modeled is not an admonition that modelers are failing, but more a product of the fact that social phenomena are not well-enough understood so that modelers have a body of well-founded theory upon which to base robust models. This is all a work in progress and we should not despair, but at the same time we should recognize that we have a long way to go.

How Well Can We Do? Or, What is Prediction and How Good Can We Be At It?

Provided we can generate models that allow for the emergence of phenomena and rules at multiple levels, how will we know they are valid? There is perhaps no more contentious word in the modeling world than "prediction." People, including modelers, are fond of declaring that there is no prediction. On the other hand, the demand for "predictive modeling" in BAAs and other funding solicitations is de rigeur, and even modelers who claim that prediction is impossible will claim that their model predicts the behavior of concern to a funding agency. Others try to mask the difficulties with prediction by claiming to "forecast," "increase understanding," or "provide insight" (Agar, 2003).

Lustick (2004) argues that virtual experiments separate from empirical prediction are entirely valid, since even empirical observations involve some degree of abstraction; "there is no intrinsic difference between the use by agent-based modelers of an explicitly constructed virtual world as that proxy and the use by researchers employing traditional small-*N* or large-*N* techniques of the implicitly virtual worlds that arise from their assumptions and coding rules as the backgrounds against which their hypotheses are tested (Lustick et al., 2004:212)." Instead, he advocates a method of piecing together validated components of a model, and then using the model to perform virtual experiments without detailed empirical testing (Lustick, 2002). Tsetovat and Carley (2005) likewise advocate the use of models to conduct virtual experiments, and North (2004) advocates the use of models for satisfying analysts' exploratory and extrapolatory needs. Since analysts and policy makers implicitly use models to guide their decision-making, I endorse the use of explicit modeling to facilitate the exploration of the implications of analysts' thinking. However, we are ultimately dealing with a real, external world, and our best models will be able to predict phenomena in that world as well.

Just what do phrases like "exploratory" and "understanding" and "insight" mean anyway? As a practical matter in national security applications, anticipation of threats and prediction of the effects of courses of action is exactly what analysts and policy makers need; having insight into a terrorist WMD attack after the fact is just not acceptable. At the end of the day, a model that fails to generate output that at least looks like the phenomenon of interest should be in doubt; in other words, models must predict, no matter what euphemisms people want to use. What we mean by "prediction," however, is not prediction with a capital "P," or precise, point prediction. Given the uncertainty and contingency of social phenomena, our notion of prediction will have to be more modest. Furthermore, despite the abstractions involved in gathering and coding observable, experienced data from the world, I am deeply unsettled by the notion that the imperfect world of experience should be abandoned. In the end, it is all we really have to go on.

Models developed to address national security concerns for the most part make some attempt at empirical validation. Silverman (2007) makes comparisons of global phenomena such as modeled grievance levels and actual levels of violent activity to advocate the validity of his models. SEAS models are not only justified based on the

theoretical foundations of their elements, but also on their ability to predict the easing of tensions between Aceh rebels and the Indonesian government (Chaturvedi et al., 2005). Finally, my own efforts at re-creating virtual histories of Palestinian political coalitions and radicalism were validated by accurately predicting the demographic profiles of Hamas and Palestinian Islamic Jihad (Kuznar, 2007).

So, how well does a model have to predict, and how shall it be measured? The standard for R&D currently appears to be "viewgraph validation," or the production of pictures that show a convincing story, amenable to PowerPoint presentation (see Oberkampf, Trucano, & Hirsch, 2004 for a criticism of viewgraph validation). It is imperative that we generate metrics of performance for models and test these, not on single favored runs, but on distributions of the virtual histories generated by models (Bankes, S. C., Lempert, & Popper, 2002; Cioffi-Revilla & Gotts, 2003; Kleijnen, 1995, 1997; Kuznar & Kobelja, 2006). Presuming that we have metrics, how good do they have to be? How far in the future, or to what level of abstraction shall models predict?

Near-term prediction of specific events is trivially possible, provided that models are re-calibrated frequently with real-world empirical inputs; even a very poor model will appear to perform well if frequently enough corrected (Hemez, 2004). On the other hand, very long-range prediction of general trends also seems relatively easy, provided one adopt a ceteris paribus stance with respect to random shocks and unforeseen evens known as "Black Swans" (Taleb, 2007). However, the uncertainty in social science means that there are many models that can generate the same outcomes (Fagiolo, Windrum, & Moneta, 2006), leaving the analyst puzzling over what models are actually valid. This many-to-one mapping problem is related to a hazard in using generative sufficiency as a means for judging model validity.

Generative sufficiency is the notion that the minimal requirement of a theory is that it be able to generate the phenomenon it purports to explain (Epstein, 1999). Epstein is clear that this is only a sufficient, and not a necessary condition for model validity. For instance, modelers who favor simple models have argued that simple agents are adequate for modeling, provided the model works (Axelrod, 1997). However, just because a model works, does not mean it is valid. Getting a model to work for a particular situation can be trivial, if one allows the calibration of enough parameters (Hemez, 2004). Furthermore, if a model that fits well for a certain situation has actually failed to capture the relevant features of the system, it will certainly fail to be generalizable (Hemez, 2004). Predicting phenomena in the mid-range may prove the most difficult of all, and therefore may be the most robust test; such a model will have to capture enough relevant variables and relationships to be generalizable, and also cannot be re-calibrated too frequently so as to have constant correction.

Applications cannot wait until the appropriate epistemological methods of model testing are worked out; al Qaeda will not wait for us to get our epistemological house in order to produce theoretically and empirically valid models of terrorist behavior. Ensemble computing represents a practical approach to model evaluation, and a more reasonable way to deal with the problem of prediction (Bankes, S., 1993; Bankes, S. C. et al., 2002).

In ensemble computing, one does not ask what calibration of parameters is sufficient to give the correct answer, but rather what is a model's behavior over the feasible range of its parameters and is this range of behavior consistent with the ranges of behavior witnessed in the real world? Models whose parameter settings produce outrageous behavior are probably not good, as are models that exhibit wildly erratic behavior as one varies their parameters. One benefit of ensemble computing is that it can help modelers to get past deciding which model is correct, and closer to identifying the elements of a model that perform well.

For instance, I employed ensemble computing to test various theories of political decision making under uncertainty in tribal society. The specific example was identifying the drivers of coalition formation in a tribe of Irian Jaya (former Western New Guinea). Theories tested included classic rational choice theory, prospect theory (Kahneman & Tversky, 2000), and bounded rationality theories (cultural norms, simple imitative heuristics) (Kuznar & Kobelja, 2006). Of course, all theories are false to a degree, and so the real issue is which theories are most robust and what elements seem to make them work. The result of this exercise indicated that, because so little is known about how human rationality is bounded, the parameters of bounded rationality approaches are necessarily loose and these approaches produced very erratic (although occasionally accurate) results. Only the concept of loss aversion from prospect theory was robust in the models. Simple rational choice models also did not perform very well. Of the models that did perform the best, they had the following two attributes: 1) agent strategies were in the neighborhood of the optimal strategy, and 2) there was variation among the agents around the optimum strategy. The point is not that rational choice, or prospect theory or bounded rationality is correct; the point is that a good model will model heterogenous agents with some sense of what a good strategy would be. Ensemble computing provides a more realistic view of how generalizable our current state of knowledge is, what degree of prediction we can hope to achieve, and what elements of our theories are currently the soundest.

Conclusions

Addressing what needs to be modeled at the micro level and how we can bridge the micro-macro gap should be the primary aim of social modeling. The founders of social science began with this aim, and modern computer technology and 150 years of theoretical refinements in social theory make progress more feasible than ever. However, there is a very long way to go. Fundamental issues remain in defining the units of society and the attributes and behaviors of those units. Achieving a greater degree of consensus than we now have will require more interdisciplinary collaboration across the social sciences (psychology, anthropology, political science, economics) and a willingness to more genuinely test (and refute/change) theories. Models grounded on more valid units and behaviors will hopefully generate emergent social phenomena that ideally will take on properties of their own, resembling the organic social wholes that actually fascinate or threaten us. Merely achieving such lofty goals is still not enough for validating such models scientifically. The very difficult issue of prediction must be broached and more

flexible notions of theory testing, like ensemble computing, will have to be adopted in order to deal with the complexity of model outputs.

These challenges may discourage those who seek applied solutions through modeling, but they should not. First, when analysts and policy makers evaluate evidence and put forth arguments, they are working with mental models that are ill-defined and implicit. Computational and mathematical modeling at the very least makes these models explicit, enables scrutiny and holds their creators accountable. Complex modeling of complex phenomena is already what policy makers do; they just do not realize it. Second, if social scientists are ever to approach the aims articulated by social science's founders 150 years ago, then they must rise to the occasion and work through appropriate units of analysis, valid components of behavior, emergence and theory testing. Third, modern computational methods enable us to run many versions of many models on numerous data sets, at least enabling us to narrow the field of which models we would want to entertain. Armed with better models, explicitly laid out, policy makers are at the least not as blind as they were, and on the positive side, better armed to understand the complexities of national security challenges than ever.

References

Agar, M. (2003). My Kingdom for a Function: Modeling Misadventures of the Innumerate. *JASSS - Journal of Artificial Societies and Social Simulation, 6*(3) http://jass.soc.surrey.ac.uk/6/3/8.html.

Atran, S., & Stern, J. (2005). Small Groups Find Fatal Purpose through the Web. *Nature, 437*(7059), 620

Axelrod, R. (1997). *The Complexity of Cooperation: Agent-based Models of Conflict and Cooperation*. Princeton: Princeton University Press.

Bankes, S. (1993). Exploratory Modeling for Policy Analysis. *Operations Research, 41*(3), 435-449

Bankes, S. C., Lempert, R. J., & Popper, S. W. (2002). Making Computational Social Science Effective. *Social Science Computer Review, 20*(4), 377-388

Bell, J. A. (1994). *Reconstructing Prehistory: Scientific Method in Prehistory*. Philadelphia: Temple University Press.

Benjamin, D. (2007). *The Nature of the Terrorist Threat*. Washington, DC: House Armed Services Committee, Terrorism, Unconventional Threats and Capabilities Subcommittee

Chaturvedi, A. R., Dolk, D., Chaturvedi, R., Mulpuri, M., Lengacher, D., Mellema, S., et al. (2005). Understanding Insurgency by Using Agent-Based Computational Experimentation: Case Study of Indonesia. *Proceedings of the AGENT 2005 Conference: Generative Social Theory*, 1-19

Cioffi-Revilla, C., & Gotts, N. (2003). Comparative Analysis of Agent-Based Social Simulations: GeoSim and FEARLUS models. *JASSS - Journal of Artificial Societies and Social Simulation, 6*(4), 1-23 http://jass.soc.surrey.ac.uk/6/4/10.html.

Durkheim, E. (1938). *The Rules of Sociological Method*. New York: Free Press.

Epstein, J. M. (1999). Agent-based Computational Models and Generative Social Science. *Complexity, 4*(5), 41-60

Epstein, J. M. (2002). Modeling Civil Violence: An Agent-Based Computational Approach. *PNAS - Proceedings of the National Academy of Sciences, 99*(Supplement 3), 7243-7250

Fagiolo, G., Windrum, P., & Moneta, A. (2006). *Empirical Validation of Agent-Based Models: A Critical Survey*.Unpublished manuscript, Pisa http://www.lem.sssup.it.

Harris, M. (1979). *Cultural Materialism: The Struggle for a Science of Culture*. New York: Vintage Books.

Hemez, F. (2004). *The Myth of Science-Based Predictive Modeling*.Unpublished manuscript, Los Alamos National Laboratory, LA-UR-04-6829

Holland, J. H. (1998). *Emergence: From Chaos to Order*. New York: Basic Books.

Kahneman, D., & Tversky, A. (2000). Choices, Values, and Frames. In D. Kahneman & A. Tversky (Eds.), *Choices, Values, and Frames* (pp. 1-16). Cambridge: Cambridge University Press.

Kleijnen, J. P. C. (1995). Verification and Validation of Simulation Models. *European Journal of Operational Research, 82*, 145-162

Kleijnen, J. P. C. (1997). Sensitivity Analysis and Related Analyses: A Review of Some Statistical Techniques. *Journal of Statistical Computer Simulation, 57*, 111-142

Kohler, T. A. (2000). Putting Social Sciences Together Again. In T. A. Kohler & G. J. Gumerman (Eds.), *Dynamics in Human and Primate Societies: Agent-Based Modeling of Social and Spatial Processes* (pp. 1-18). New York: Oxford University Press.

Kuznar, L. A. (2007). Rationality Wars and the War on Terror: Explaining Terrorism and Social Unrest. *American Anthropologist, 109*(2), 318-329

Kuznar, L. A. (2009). *Reclaiming a Scientific Anthropology, Second Edition*. Walnut Creek, California: AltaMira Press.

Kuznar, L. A., & Kobelja, N. (2006). *Validating Social Simulations: A Case of Political Alliances in Tribal New Guinea.* Paper presented at the Proceedings of the 2006 NAACSOS Conference, Notre Dame University, South Bend, Indiana

Kuznar, L. A., & Lutz, J. M. (2007). Risk Sensitivity and Terrorism. *Political Studies, 55*(2), 341-361

Kuznar, L. A., & Sedlmeyer, R. L. (2005). Collective Violence in Darfur: An Agent-based Model of Pastoral Nomad/Sedentary Peasant Interaction. *Mathematical Anthropology and Culture Theory, 1*(4), 1-22 www.mathematicalanthropology.org.

Lauren, M. K., & Stephen, R. T. (2000). *Modelling Patrol Survivabilty in a Generic Peacekeeping Setting Using ISAAC*. Auckland, New Zealand

Lee, R. B., & Devore, I. (1968). Problems in the Study of Hunters and Gatherers. In R. B. Lee & I. Devore (Eds.), *Man the Hunter* (pp. 3-12). Chicago: Aldine.

Lustick, I. S. (2002). PS-I: A User-Friendly Agent-Based Modeling Platform for Testing Theories of Political Identity and Political Stability. *JASSS - Journal of Artificial Societies and Social Simulation, 5*(3), 1-37 http://jasss.soc.surrey.ac.uk/5/3/7.html.

Lustick, I. S., Miodownik, D., & Eidelson, R. J. (2004). Secessionism in Multicultural States: Does Sharing Power Prevent or Encourage It? *American Political Science Review, 98*(2), 209-229

MacKerrow, E. P. (2003). Understanding Why - Dissecting Radical Islamist Terrorism with Agent-Based Simulation. *Los Alamos Science, 28*, 184-191

North, M. J., Macal, C. M., & Vos, J. R. (2004). *Terrorist Simulation with NetBreaker.* Paper presented at the Swarmfest 2004, Ann Arbor, Michigan

Oberkampf, W. L., Trucano, T. G., & Hirsch, C. (2004). Verification, Validation, and Predictive Capability in Computational Engineering and Physics. *Applied Mechanics Reviews, 57*(5), 345-384

O'Meara, J. T. (1999). Causal Individualism and the Unification of Anthropology. In E. L. Cerroni-Long (Ed.), *Anthropological Theory in North America* (pp. 105-141). Westport, Connecticut: Bergin and Garvey.

Popper, K. R. (1979). Of Clouds and Clocks. In *Objective Knowledge: An Evolutionary Approach, Revised Edition* (pp. 206-255). Oxford: Clarendon Press.

Sageman, M. (2008). *Leaderless Jihad: Terror Networks in the Twenty-First Century*. Philadelphia: University of Pennsylvania Press.

Silverman, B. G., Bharathy, G., & Nye, B. (2007). Profiling is Politically "Correct": Agent-based Modeling of Ethnopolitical Conflict.

Spencer, H. (1972). The Social Organism. In J. D. Y. Peel (Ed.), *Herbert Spencer On Social Evolution: Selected Writings* (pp. 53-72). Chicago: University of Chicago.

Stern, J. (2003). The Protean Enemy. *Foreign Affairs, 82*(4), 27-40

Taleb, N. N. (2007). *The Black Swan: The Impact of the Highly Improbable*. New York: Random House.

Tsvetovat, M., & Carley, K. (2005). Structural Knowledge and Success of Anti-Terrorist Activity: The Downside of Structural Equivalence. *JoSS - Journal of Social Structure, 6*