A New Kind of Social Science:
Moving Ahead with Reverse Wolfram Models Applied to Event Data

by

Valerie M. Hudson, Brigham Young University

Philip A. Schrodt, University of Kansas

Ray D. Whitmer, Jhax.Ltd.

Version 1.0

23 February 2005

Paper prepared for delivery at the Annual Meeting of the International Studies Association, Honolulu, Hawai'i, USA, March 2004.

Authors can be contacted via email at the following addresses:
valerie_hudson@byu.edu, schrodt@ku.edu, and ray@jhax.net.

This research was supported in part by grants from the U.S. National Science Foundation (SES-0455158), the Brigham Young University College of Family, Home, and Social Sciences, and a University of Kansas Hall Center Humanities Research Fellowship. We would also like to acknowledge the research assistance of Matt Stearmer at BYU, and the work of Deborah Gerner, Dennis Hermrick, Bradley Lewis, and Ömür Yilmaz in the development of the CAMEO actor coding scheme.

The analytical web site for this project, which includes the graphic tools for analyzing event patterns is currently at http://ep.jhax.org, but will be moved in the near future to the NKSS project web site http://www.nkss.org. The data sets discussed in this paper, as well as a pdf version of the paper with color graphics, can be downloaded from the KEDS project web site: http://www.ku.edu/~keds/.

Abstract

Existing formal models of political behavior have followed the lead of the natural sciences and generally focused on methods that use continuous-variable mathematics. Stephen Wolfram has recently produced an extended critique of that approach in the natural sciences, and suggested that a great deal of natural behavior can be accounted for using rules that involve discrete patterns. This paper reports some initial findings from a new NSF-funded project designed to apply this pattern-based method to political event data. The core of this project is a new, publicly-accessible web-based tool designed for the analysis of event data patterns. Using data on the Israel-Palestine conflict for the period 1979-2004, we first consider some differences between the activities of various sub-state actors. While most prior event data analysis has simply

aggregated all activities, we demonstrate that some sub-state actors produce streams of activities that are statistically independent. We continue the analysis by showing there are distinctive—and very plausible— differences in the patterns found during the tenures of various Israeli prime ministers, and the "interesting" patterns go well beyond the simple variations on tit-for-tat that we found in our earlier work.

For the past two centuries, the social sciences have aspired to produce law-like generalizations about human behavior comparable to those found in the deterministic study of mechanics in physics or the probabilistic models found in epidemiology. Unsurprisingly then, social science has embraced the view that "the stature of a science is commonly measured by the degree to which it uses mathematics" (Weinberg, 1975, 264). Considerable scientific work has been done over the past sixty years in international relations (IR)—our field of research, though its methods and conclusions can be applied to social science more generally—but this effort has produced virtually no law-like generalizations, and what few might be said to exist give us almost no mileage in excess of what common sense already provides (Bull 1966, Gaddis 1992, Green and Shapiro, 1995; Walt, 1999; Bennett and Stam 2004).

Indeed, a deep-seated methodological discontent is growing in IR, in political science, in economics, and in other social sciences. The most 'advanced' methods we can use seem an ill fit with the types of questions we would like to pose and to answer in social science. The more esoteric our fields become methodologically, the more removed from reality and the more irrelevant to pressing human concerns the research seems to become. The Post-Autistic Economics Movement in economics and the Perestroika Movement in political science are but two recent manifestations of the yearning of social scientists, especially young social scientists, to move beyond what is perceived to be the increasing barrenness of their respective fields (see Hogarth and Reder 1987, Fullbrook, 2001, *PS* special issue July 2003;).

Yet the alternative methodological standpoints most often articulated frequently propose to refocus social science research on anecdotes, history, constructivism/discourse analysis, or nihilistic postmodernism, and thus seem to have similar potential for controversy and paralysis. The issue here is falsifiability and its relationship to causality (Yee, 1996). Unless some concept of a causal link is maintained in a methodology, it seems difficult to decide when a particular historical or constructivist account is false, or even less satisfactory than another account. And since the findings of social science aim to inform social practice and policy, which may have profound impact on the lives of individuals, some minimal falsifiability seems morally imperative, if not theoretically imperative.

In 2002, a methodological gauntlet was thrown done by Stephen Wolfram in his work, *A New Kind of Science*. Though his book was not written from or for a social science perspective, several of his assertions are pertinent to that endeavor. Wolfram asserts that most modern scientific methods used in the physical and biological sciences are but idiosyncratic and limited derivations from something much more basic, more fundamental, and more powerful. In place of the continuous-variable mathematical structures that underlie classical mechanics and statistics, Wolfram's approach focuses on the discrete transformation of patterns. Simple pattern-based models can, through iteration, produce surprisingly complex behavior in physical and biological systems. Biochemists, for example, search for patterns in amino acids as elements for understanding the functions of a strand of DNA, and then the patterns of those strands combine to produce the patterns formed by larger strands, then by chromosomes, then by the entire genome. Though the patterns themselves are simple, they can ultimately produce highly complex organisms, including human beings themselves.

Conveniently for social scientists, humans do not only originate from patterns, but human psychology is intensely linked to the ability to perceive patterns and to find meaning in patterns (Newell and Simon 1972, Abelson 1973, Simon 1982, Anderson 1983, Kohonen 1984, Holland et al 1986, Margolis 1987, Khong 1992, Reber 1993, *Political Psychology* 2003). Indeed, it is not

far off the mark to suggest the ultimate basis of all human epistemology is discrete pattern identification. As Wolfram puts it, "observers will tend to be computationally equivalent to the systems they observe," (Wolfram, 2002, 737) an observation we will expound upon shortly.

The Issue of Complexity as the Root of Discontent

All sciences are set up in such a way as to avoid, elude, and overlook complexity as much as possible. Complexity is the bane of the would-be scientist, and yet complexity is a characteristic of much, if not most, of the world around us.

> Science is . . . unable to cope with [complexity], though its success with systems of its own choosing has misled many scientists and politicians into thinking of science as a way of effectively dealing with *all* systems. . . . The fruits of science are simple fruits, or more precisely, the fruits of simplification. . . . We must begin to understand the limitations . . . for its principal method is to squelch [complexity]. (Weinberg, 1975, 20-21).

For the social scientist, of course, the object of study—human beings—is irreducibly complex:

> Social scientists have had even less success, because their main interest--"humanness"--is a [complex] property that disappears when the system is taken part or abstracted and averaged. . . . Perhaps we are reaching the useful limits of a science . . . whose philosophical underpinnings are techniques restricted to systems of small and large numbers. (Weinberg, 1975, 22)

We suggest that complexity is one of the roots of our current methodological discontent in IR, political science, and other social sciences. The areas of study justifiably approached through mathematical or statistical analysis and modeling are really quite small. The vast remainder of reality—including social reality—cannot be effectively approached in these ways: these approaches operate within very small confines, and if one's subject matter cannot reasonably be placed inside those confines, use of the approaches will feel, and indeed be, inadequate.

To date, the reaction to this situation has also been less than helpful. One response, very common, is to simply ignore these issue and apply mathematical or statistical methods beyond the confines where their use is justified. This results in a strange methodological anomie, where one uses these methods as if all is straightforward, while becoming ever more disengaged in one's questions and answers from the reality wrestled with on a day-to-day basis by those who live within it. Statistically speaking, we cannot justify assumptions of random or normal distribution in much of what we are studying as social scientists. These assumptions, when used without justification outside of areas where aggregation and large-sample properties cause statistical regularities, are actually an effort to avoid the issue of complexity. Mathematically speaking, we have an enormous N-body problem—in the sense of the problem in astrophysics, not statistics—, for which we have very little in the way of methodological capabilities. In a sense, we also have a parallel problem in *small* N situations, where idiosyncratic factors such as the fact that in the conflict over the Old City of Jerusalem, the Al-Aqksa Mosque, the Western Wall and the Church of the Holy Sepulcher are within a 500-meter radius of each other is intensely important to this conflict but it is decidedly not a large-sample property subject to the normal or Poisson distribution. So we use simplifying assumptions that evade the complexity with which we cannot cope.

But there is more. Most of our existing methods derive from a strictly arithmetic view of what can be the form of an interaction and usually involve a firm quantity-based definition of all elements of understanding: models involving the analysis of interval-level variables are substantially more developed than those involving nominal-level variables. For example, most contemporary analyses of nominal variables use either dummy variable regression (nominal independent variables) or variations on logit analysis (nominal dependent variables). Both techniques are essentially mathematical tricks for treating the nominal variables as if they were interval, and their estimation is performed entirely in the domain of continuous variables.

But we as humans know from our own lives that there are plenty of interactions in the world that have no counterpart in continuous-variable operation, nor can we define every concept in terms of quantities. As Wolfram puts it, "it is in many cases clear that the whole notion of continuity is just an idealization—although one that happens to be almost required if one wants to make use of traditional mathematical methods." (Wolfram, 2003, 729). That is why we continue to have human diagnosticians, intelligence analysts, and police detectives. As pattern recognition devices, our own brains are more powerful—and utilize quite different mechanisms—than the most sophisticated mathematical and statistical methods, and at a deep level, we realize that anew every time we read a piece of quantitative research in the social sciences.

Mathematical and statistical approaches are a tiny and quite restricted subset of what the human brain is able to bring to bear on a subject matter in pursuit of understanding. This is not to say those approaches are not useful—they are very useful, particularly in realms involving large samples, high levels of noise, and variables that can be naturally operationalized using continuous measures. But they are elementary methods compared to what we already know how to do. As Wolfram puts it, "the field of mathematics as it exists today will come to be seen as a small and surprisingly uncharacteristic sample of what is actually possible" (Wolfram, 2002, 821).

Humans were built to make sense of complexity. In a sense, the way to move past the methodological discontent in our social science disciplines is to discover more about how our minds in fact do this. "How we do this" is certainly the foundation of mathematical and statistical approaches, but that foundation could supports much more in a methodological sense. If we can explore that "more," we will give ourselves more powerful and less restricted methodologies specifically geared towards the understanding of complexity (see).

Pattern Recognition, Human Understanding, and Political Behavior

Pattern recognition is the ability of an individual to consider a complex set of inputs, often containing hundreds of features, and make a decision based on the comparison of some subset of those features to a situation which the individual has previously encountered or learned. In problem solving situations, *recall can substitute for reasoning*. For example, chess involves a well-defined, entirely deterministic system and should be solvable using purely logical reasoning. Chess-playing computers use this approach, but Chase and Simon (1973) found that human expert-level chess playing is done primarily by pattern recognition.

The chess analogy also helps us recognize that pattern recognition by humans can be the basis for human action itself. Meaning for human beings comes from the recognition of patterns, and thus meaning in one's own behavior likewise comes from enactment of patterns, or, rather, the rules that produce them. That is how chess is played, but that is also how virtually all social behavior

takes place, as well. To see the pattern-based nature of human understanding, then, is to simultaneously see the pattern-based nature of human behavior.

Pattern recognition and rule-based human behavior are two sides of the same coin: the way that we impute meaning through pattern recognition is the way that we create meaning through our behavior. While this is easy to see for, say, individual chess players, most domestic and international political behavior is primarily the product of bureaucracies rather than individuals. An individual may influence the direction of a policy, but the implementation is still left to bureaucracies. In everyday language this organizational interaction is simplified—"Hitler decided to attack Poland"—but in virtually all cases (and certainly in systems which have a strong democratic and/or bureaucratic component) individuals are constrained to choose from a very small set of options that have been made available through a bureaucracy. While the "Great Man" [sic] model attempts to allow the cognitive processing of an individual replace bureaucratic decision-making in an organization, the individual is still dependent on an organization to supply (and filter) information and implement decisions. Behind every Great Man is a well-entrenched bureaucracy pleased to have someone else taking responsibility.

Many of the computational modeling projects in political science (Carbonell 1978, Thorson and Sylvan 1982, Sylvan and Chan 1984, Majeski 1987,Andriole and Hoople 1988, Mefford 1991, Sylvan, Goel and Chandrasekran 1990, Hudson 1991) assumed that due to the rule-oriented nature of bureaucracies and the simplifications inherent in popular ideologies, one would be able systematically to extract an organizations rules and precedents from a sufficient quantity of debates, formal regulations and internal memoranda, and from these rules one could simulate much of the decision-making process. The qualitative literature, example Cyert and March (1963) and Allison (1971), has also long emphasized the rule-based nature of organizational decision-making. Based on the subsequent success of rule-based systems in replacing some routine managerial decision-making in business, this was not an unreasonable proposition. In much of their behavior, the bureaucracies are not acting *as if* they followed rules; they are instead *explicitly* following rules and are expected to do so, rule-following being a *sine qua non* of bureaucratic behavior.

Some of these rules are implicit, or buried deep within an organizations internal processes where it will not be seen in the public record. However, much of it will be accessible. Since human understanding involves matching observed events to a pattern, the function of political discourse is to provide sufficient information—in the forms of declarative knowledge, event sequences and substitution principles—to cause the audience to understand (i.e. pattern match) the situation in the same manner that the individual transmitting the information understands it. Political information transfer attempts to stimulate pattern recognition in the mind of the audience and thereby trigger a desired behavior. This process can occur between competing organizations as well as within them, and, in democratic situations, in how an organization explains itself to the public. Signaling in a conflict situation involves exchanging messages with an opponent in an attempt to get the opponent to take, or refrain from taking, certain actions. Consequently we would expect to see, in the reports and the discourse involving political behavior, a great deal of use of, and reference to, specific patterns of behavior.

It is also important to look at actions *within* governments and organizations, which is generally a departure from the state-centric "unitary actor" approach used in most quantitative research in IR. (The qualitative literature, in contrast, tends to deal extensively with sub-state processes, thus providing us with a rich set of potential patterns and theories). For example, if one looks just at

"Israel", this includes not just all parts of the Israeli government—including the actions of opposition leaders and parties—but also non-governmental actors such as settler groups and citizen activists. "Palestine" is even more diffuse, and encompasses over time the PLO, various militant groups such as Hamas and Islamic Jihad, the quasi-governmental Palestinian Authority (after 1994), and individual Palestinians.

Each of these groups may be operating according to rules, but they are not necessarily using the same rules. In some instances—on both sides of the Israel-Palestine conflict, possibly *most* instances—groups that would be included within a single actor in a state-centric analysis can also be working at cross-purposes. The on-going competition between the PLO/PA and Islamic militant groups is one conspicuous example of this problem, but conflicts have also occurred between the Israeli government and settler groups—the current (August 2004) dispute between Israeli settlers and the Sharon government over plans for the withdrawal of settlements from Gaza illustrates is only the latest such conflict—and can even occur within governing coalitions (for example the Gaza withdrawal plan has exacerbated political fissures both within Sharon's coalition government and within the Likud party).

One can extend this further to note that standard theories of bureaucratic behavior would suggest that the operation of competing rule sets will be the norm rather than the exception in political behavior. For example, Islamic military groups and the Israeli military might be engaging in high levels of conflict, while simultaneously one gets externally mediated negotiations between Israel and individuals representing the Palestinian Authority (for example the U.S.-mediated "road map" process in the summer of 2003) and, at the very end of the series, the independent "Geneva Accord" negotiations between non-governmental elites from both Israel and Palestine (December 2003). A potential strength of the pattern-based approach would be the ability to explicitly model these multiple agendas.

If pattern recognition is the basis of human understanding of human behavior, then while one can specify rules that govern human behavior, it will be impossible to know for a surety in advance all of the consequences produced thereby. *Many* consequences can be known, but never all. As a result, there is, as Wolfram puts it, a "computational irreducibility" about rule-governed human behavior. This means that there is a limit to prediction in any theoretical science of social phenomena. In dealing with complex phenomena such as social behavior, a theorist will have to readjust his sights: specification of the rules, and an understanding of less than all of the consequences thereof, will now be his aim. Wolfram puts it this way:

> When viewed in computational terms most of the great historical triumphs of theoretical science turn out to be remarkably similar in their basic character. For at some level almost all of them are based on finding ways to reduce the amount of computational work that has to be done in order to predict how some particular system will behave. . . . If one views the evolution of a system as a computation, then each step in this evolution can be thought of as taking a certain amount of computational effort on the part of the system. But what traditional theoretical science in a sense implicitly relies on is that much of this effort is somehow unnecessary--and that in fact it should be possible to find the outcome of the evolution with much less effort. . . . In traditional science it has usually been assumed that if one can succeed in finding definite underlying rules for a system then this means ultimately that there will always be a fairly easy way to predict how the system will behave. . . . But now computational irreducibility leads to a much more fundamental problem with prediction. For it implies that even if in principle one has all the

> information one needs to work out how some particular system will behave, it can still take an irreducible amount of computational work actually to do this. . . .And this, I believe, is the fundamental reason that traditional theoretical science has never managed to get far in studying most types of systems whose behavior is not ultimately quite simple. [A]t an underlying level this kind of science has always tried to rely on computational reducibility, [s]o when computational irreducibility is present it is inevitable that the usual methods of traditional theoretical science will not work. And indeed I suspect the only reason that their failure has not been more obvious in the past is that theoretical science has typically tended to define its domain specifically in order to avoid phenomena that do not happen to be simple enough to be computationally reducible. (Wolfram, 2002, 737-742)

Our modified aims will then modify our definition of causality when attempting to understand human behavior. The act of imputing causality *is the act of identifying rule-based patterns in the phenomena we study*, with the caveat that the complete consequences of the rules specified are probably not going to be knowable in advance. Wolfram states, "whenever computational irreducibility exists in a system it means that in effect there can be no way to predict how the system will behave except by going through almost as many steps of computation as the evolution of the system itself" (Wolfram, 2002, 739). In general, then, there are no valid shortcuts to take, for we are not operating in a context of computational reducibility (generally speaking) in the social sciences.

In summary, in our quest to move towards this new methodological approach, we need to confront several challenges in devising a plausibility probe:

- do we have time stream data of human behavior in IR that we could use for a test?
- can we create a system of visualizing that human behavior?
- can we specify a small set of rules understood to be used by the human agents involved?
- can patterns and meta-patterns be discerned in this way, thereby accounting for the observed behavior?
- can we demonstrate that these patterns are not simply the result of chance alignments of events?

Pattern-Based Rules: A Prototype

Hudson, Schrodt and Whitmer (2004) was an initial descriptive validation of the potential of this approach. Since no one had looked for patterns in this fashion before, we first needed to demonstrate that we could find them, and that the patterns had some plausible correspondence to our underlying qualitative understanding of the situation we were analyzing. In that research, we developed a web-based tool for exploring pattern-based rules; this can be found at `http://ep.jhax.org`. That site includes a number of data sets from the Kansas Event Data System (KEDS) project, and provides a number of well-documented facilities for recoding the data, specifying rules, and visualizing event data as discrete patterns rather than scaled aggregations. In particular, the inputs titled "patterns" and "display" allow a researcher to have the capability to perform discrete pattern transformations on the graphic output. One can also

experiment with possible rules, then display whether those patterns account for any of the behavior in the set.

In our initial probe of the approach, we specified some very simple rules and then ascertained how well they accounted for the behavior in the Israel-Palestine dyad. These rules were chosen from a combination of the general theoretical literature and a qualitative assessments of what some experts in the field assert are the rules these actors do use (e.g. Bickerton and Klausner 1998, Gauss 1998, Gerner 1994, Goldstein et al 2001, Tessler 1994).

Wolfram himself provides encouragement that the rules need not be many, and neither do they need be complex. For example, he states, "Simple and definite underlying rules can produce behavior so complex that it seems free of obvious rules" (Wolfram, 2002, 752) and then goes on to elaborate that in his years of experience analyzing complex systems,

> But when in general does complexity occur? [I]f the rules for a particular system are sufficiently simple, then the system will only ever exhibit purely repetitive behavior. If the rules are slightly more complicated, then nesting will also often appear. But to get complexity in the overall behavior of a system one needs to go beyond some threshold in the complexity of its underlying rules. The remarkable discovery that we have made, however, is that this threshold is typically extremely low. [I]t ultimately takes only very simple rules to produce behavior of great complexity. . . . Instead, once the threshold for complex behavior has been reached, what one usually finds is that adding complexity to the underlying rules does not lead to any perceptible increase at all in the overall complexity of the behavior that is produced. (Wolfram, 2002, 105-6)

Indeed, Wolfram found that the most complex behavior could be obtained with the use of approximately three rules. We feel that there is reason to believe that the set of rules being employed by the Israelis and Palestinians in enacting what they feel to be meaningful behavior toward one another is also not very large, nor very complex. Signaling between organized human collectives, especially those in conflict, almost mandates that only a small set of simple rules be used in order to maximize the chances that the other group will understand the meaning intended by the action.

Furthermore, because international politics is a complex problem solving environment, heuristics—simple rules used to partially solve complex problems—are of particular importance. Purkitt observes:

> To cope with limited cognitive capabilities, individuals selectively process information and use a limited number of heuristics or mental rules of thumb as cognitive aids in their effort to manage information. This apparently universal reliance on intuitive heuristics to solve all types of problems seems to be due to the need to compensate for the limitations of short-term memory and information processing capabilities. By using intuitive mental heuristics, people can develop a problem attack plan which permits them to develop a subjectively acceptable problem solution. (Purkitt 1991,43)

For example, rational choice and balance of power theories are both heuristics in the sense that they are relatively simple; they come with a complex set of side-conditions; and they are intended as general rules to guide decision-making, without providing a complete specification of actions to be taken. To the extent that an heuristic is shared by the decision-makers in a political

system—for example balance of power in 19th century European diplomacy or the Chicken game in 20th century nuclear deterrence—it reduces uncertainty and becomes self-validating.

In our exploratory exercise (Hudson, Schrodt and Whitmer 2004), we endeavored to come up with a small set of fairly simple rules that could be justified on the basis of scholarship concerning Israeli and Palestinian actions. The first rule we used was the classic "tit-for-tat" (TFT) approach immortalized by Rapoport and, more recently, Axelrod (1984). Country experts have asserted that the Israelis and Palestinians consciously use this rule; and it has long been known that reciprocity is one of the strongest patterns in event data (for example Dixon 1986, Ward and Rajmaira 1992, Goldstein and Freeman 1992, Goldstein and Pevehouse 1997). The second rule we used was one that we have labeled the "olive branch": one side responds to a period of conflict with cooperation rather than reciprocating the conflict. The olive-branch rule is the standard gambit for breaking out of the mutually-destructive DD/DD/.../DD sequence in the classical prisoners' dilemma game. Finally, we looked at four more complex "meta-patterns" that involved patterns-of-patterns—that is, complex patterns that were built out of the occurrence of simpler pattern. These meta-patterns were designed to tap into escalation and de-escalation behavior that was more complex than the simple "olive branch."

This analysis produced a rich set of results. For example, we found three general results on TFT, the simplest of our rules. First, the TFT behaviors are generally, but not totally, symmetric in the dyad—generally when one side is engaging in TFT, whether cooperative or conflictual, the other side is doing so as well. There is no reason that this must be the case, but the fact that we observe it suggests that the two antagonists are implementing a classical TFT solution to the prisoners' dilemma game. Unsurprisingly, give our qualitative understanding of the conflict, they are far more likely to be playing DD than CC.

Second, most of spikes in the conflictual TFT correspond to periods of substantial violence such as the first and second *intifadas* and Israel's 1982 invasion of Lebanon. The outbreak and decline of the first *intifada* from December 1987 to August 1990 shows the same exponential-decay shape that is seen in Goldstein-scaled data for the period (Schrodt and Gerner 1994). Similarly, the negotiations following the Oslo agreement in September 1992 and prior to the outbreak of the second *intifada* in September 2000 are evident.

The most surprising aspect of the TFT analysis was the juxtaposition of TFT conflict *and* cooperation during the post-Oslo period. We cross-checked this against the qualitative record and found that pattern to be a good illustration of the utility of objective events patterns over vaguely remembered narratives: While the Oslo period (1994-2000) saw nowhere near the levels of violence seen in the second *intifada,* there were periods of substantial conflict, such as the four suicide bombings in Tel Aviv and Jerusalem and subsequent Israeli reactions to these in the spring of 1996, shortly after Israel's military withdrawal from Palestinian urban areas. Conversely, negotiations have continued at both the official and unofficial levels (e.g. the December 2003 Geneva Accords between Israeli and Palestinian citizen elites) during the second *intifada*.

One of our concerns when we embarked on the analysis was whether we would posit plausible patterns and find nothing in the data. Our experience has, instead, been the opposite— the problem is not that we are finding too little, but we are still finding too much. When one combines the remarkably rich set of patterns that can be constructed using the quite simple methods aggregation methods available in the pattern-specification language with the ability to rapidly construct colorful, web-based displays at a very fine time interval, it is difficult to figure where to go next

with the analysis. On the other hand, with a few exceptions, we are finding very credible "patterns in the patterns"—these do not occur at random, but instead their rise and fall generally tracks changes in the political situation which we know about from qualitative narratives.

Israel-Palestine Event Data

In this paper, we will continue to explore the possibilities and pitfalls of Wolfram's approach to understanding human behavior in the arena of international politics. As before, we are using event data on the Israel-Palestine conflict. This dyad involves actors whose behavior is highly reactive one to another and has been the focus of sufficient media attention that we can be confident that the event data are a reasonably accurate description of the actual behavior in the system. The dyadic relationship between the Israelis and Palestinians, while certainly affected by the initiatives of third parties, is nevertheless quite internally reactive, as many scholars have noted (see for example Bickerton and Klausner 1998, Gauss 1998, Gerner 1994, Goldstein et al 2001, Tessler 1994).

News reports on the interactions between Israel and Palestine were coded into the WEIS scheme (McClelland 1976) using TABARI, a computer program from the Kansas Event Data System (KEDS) project that creates event data from machine-readable text.[1] The events were coded from Reuters News Service lead sentences obtained from the NEXIS data service for the period April 1979 through May 1997, the Reuters Business Briefing service for June 1997 through December 1998, and *Agence France Presse* from January 1999 to December 2004.[2] The data were run through a "one-a-day" filter to eliminate duplicate reports of the same event by allowing only one instance of any source-event-target combination in a day. As noted below, we used two different actor coding configurations—these will be discussed in the sections on the individual applications. The coding software, coding dictionaries and data are available at the KEDS web site, `http://www.ku.edu/~keds`.

For the event counts, we use the following categories based on the WEIS two-digit cue categories:

material cooperation: WEIS categories 01, 06, 07

verbal cooperation: WEIS categories 02, 03, 04, 05, 08, 09, 10

verbal conflict: WEIS categories 11, 12, 13, 14, 15, 16, 17

material conflict: WEIS categories 18, 19, 20, 21, 22

This reduces the number of distinct event categories that can be used as independent variables to a manageable amount and eliminates the problem of three-digit WEIS categories that have very low frequencies. It is also likely to reduce the effects of coding error somewhat: Several of the

---

[1] Discussions of machine coding can be found in Gerner et al. (1994), Schrodt and Gerner (1994), Huxtable and Pevehouse (1996), and Bond et al. (1997), Subramanian and Stoll 2004, and King and Lowe 2004. While the analyses in this paper use the WEIS coding scheme, in the near future, we will be switching the project over to the new CAMEO framework (Gerner et al 2002), which is optimized for automated coding,

[2] The second analysis is done with an older version of the KEDS Levant data set where the Reuters to AFP transition occurs in October 1999. In the process of working on this paper, we discovered that some of the 1999 data in this set were based on a set of texts that under-represented Israel-Palestine events; subsequent work with be based on the corrected set.

"verbal conflict" codes in WEIS are ambiguous even for human coders, and the automated coding probably generates some misclassification within those categories.

While we will be using event data in this analysis, one could use this approach on almost any information on human behavior over time. One could look at the time stream of memoranda that comprises *The Pentagon Papers*, for example. One could look at market behavior over time. One could look at negotiation moves between the parties involved in the North Korean talks. And one need not only look at monads or dyads, but could examine N-ads, as well. Any human behavior, or artifact thereof, that can be laid out in a time stream can be viewed from this perspective. The data need not be at any level of measurement precision beyond categorical. And one can combine types of data; one could look at patterns made by time streams composed of behavior found in presidents' speeches and currency values, for example. Unlike mathematics-based methods where data must be at the same or nearly the same level of measurement precision to be combined, there is no such stricture in this method.

Application 1: Differential Event Streams in Sub-state actors

The principal difference between the coding for NKSS project and that done previously by the KEDS project will be the emphasis on sub-state actors. Our expectation is that sub-state actors will be far more important in an pattern-based framework than it is in the traditional interval-level analytical methods, since the pattern-based methods do not require the aggregation used in interval-based methods.

CAMEO Sub-state Actor Coding

Over the past three years, the KEDS project has developed a systematic scheme for coding sub-state actors in conjunction with the CAMEO framework.[3] The motivation for this was two-fold. First, almost all of the behavior that the KEDS project had been coding involved conflicts that did not fit the classical state-to-state Westphalian model. For example, in the Israeli-Palestinian conflict, sometimes the Palestinians (or their political representatives such as the Palestine Liberation Organization or the post-Oslo Palestinian National Authority) are treated as a state by Israel or other state actors, sometimes they are not. Israel's military interactions in the territory of Lebanon usually (but not always) involve the non-state actor Hizbollah rather than the Lebanese state per se (and Lebanon, meanwhile, must contend with Syrian forces on its territory). Even within Israel—which generally exercises strong state control compared to that in Lebanon and Palestine— the Israel "settlers" in the West Bank and Gaza frequently (and vocally) undertake actions nominally in defiance of Israeli government policy, up to and including assassinating Israeli Prime Minister Rabin in 1995 following his signing of the Oslo agreement. Sub-state actors matter.

Because the WEIS event coding framework (and related framework such as COPDAB and BCOW) were developed during the Cold War, codes were limited to state actors and a few long-lived non-state actors that were conspicuous in media reports, typically international organizations such as the UN, IMF, and Red Cross/Red Crescent, or nationalist movements such

---

[3] The CAMEO sub-state actor coding framework has been developed primarily by Deborah Gerner, Dennis Hermrick, Bradley Lewis, Ömür Yilmaz and other coders on the KEDS project. As of March 2005 the KEDS group are are still actively refining this system in conjunction with a separate project, and the description given here should be taken as tentative rather than definitive.

as the PLO, Irish Republican Army, and South Vietnam's communist National Liberation Front. With the increased intensity of sub-state (and failed-state) conflict following the Cold War, it was not clear how these should be systematically coded.

To use a particularly problematic example from outside the Middle East, during the 1990s both the KEDS project and an NSF-funded project of Goldstein and Pevehouse (1997) were coding event data on the conflict in the former Yugoslavia. The antagonists in this conflict were primarily defined in ethnic terms, but the geography (and legal status of the participants) were primarily defined by the former Yugoslavian republics, for example Bosnia-Herzegovina, Croatia, and Serbia.[4] If one used **BOS** as a code for "Bosnia" and **SER** as a code for Serbia", it was not clear whether a "Bosnian Serb"—that is, someone of Serbian ethnicity living in territorial Bosnia—should be coded **BOSSER** or **SERBOS**. The KEDS project used one system; Goldstein and Pevehouse the other.

The new CAMEO system attempts to standardize this by implementing a 9-character, three-level coding system with consistent rules. Codes have the form **AAABBBCCC** with the following uses

Primary code (**AAA**): This is the primary geographical (for states) or role (for non-state actors) designator. State codes conform to the ISO 3166-1 Alpha-3 standard 3-character codes maintained by the UN Statistical Division, so for example Palestine is no longer **PAL** but instead is **PSE** (see http://unstats.un.org/unsd/methods/m49/m49alpha.htm).[5] Non-state roles are general types such as IGO (inter-governmental organization), NGO (non-governmental organization) and **NGI** (non-governmental individual, for example Jimmy Carter).

Secondary code (**BBB**): This is the secondary designator for a geographical location (typically a state, province or city), the organizational identity for an IGO, NGO or NGI, or either the role or ethnicity for an individual or group. For example, **PSEGZS** is the Gaza Strip; **ISRGOV** is the Israeli government, **PSEREB** is a Palestinian militant group (**REB** is the generic code for any non-state actor that regularly engages in military actions), and **ISRPSE** is an ethnic Palestinian living in Israel.

Tertiary code (**CCC**): This provides identifying information about specific groups, sub-groups or individuals. For example **PSEREBHMS** is the Hamas group; **PSEREBISJ** is Islamic Jihad.

In order to preserve at least some mnemonic value, the tertiary codes are not unique: **ISRPOLLAB** could refer to the Labor Party in Israel while **GBRPOLLAB** could refer to the Labour Party in Great Britain. The primary and secondary codes are unique—**PSE** is always "Palestinian"; **GOV** is always "government", **MIL** is always "military" and so forth.

---

[4] As those familiar with the conflict are aware, this was also contested: for example "Serbia" remained legally linked with the former Yugoslavian state of Montenegro, and contained within Serbia was the province of Kosovo which was not recognized as distinct in Yugoslavia but which had a distinct ethnic separatist movement. The Yugoslavian state of Macedonia was, due to objections by Greece, known to NATO states as FYROM—"Former Yugoslavian Republic of Macedonia" (see also "The Artist Formerly Known as Prince") but had a significant ethnic population of "Kosovar Albanians." Suddenly the Middle East seemed simple.

[5] Alas, these are subject to their own set of political constraints, notably in the absence of a code for the Republic of China (Taiwan).

It is [very] important to note that this is a *hierarchical* coding scheme, where the meaning of a field is dependent on the elements that came before it, rather than a *rectangular* coding scheme where the meaning of a field is solely a function of the position of the code. Consequently Jimmy Carter is **USAGOVCAR** when he is president of the United States but **NGICAR** in his post-presidential role as an independent international mediator. When thinking about the logic behind this system, a good analogy is the Library of Congress cataloguing system for books, which is also hierarchical and role-dependent: the [say] 5th number in an LC designator has no particular meaning, but instead is dependent on the numbers and symbols that came before it (and is dramatically different, for example, depending on whether a book or journal is cataloged). If we had used a rectangular system, we would have had to include a null indicator for irrelevant information (for example Mr. Carter might be **NGI---CAR**) and, for more critically, a very large number of fields (e.g. five separate fields depending on whether the secondary designator was a region, organization, individual, role, or ethnicity), leading to codes of unwieldy length that primarily contained null fields.

This coding system is still a work-in-progress, but we expect it to provide at least three advantages. First, it standardizes existing codes where these are available—for example in addition to using UN country codes, we've used the PANDA/IDEA substate codes and HURIDOCS religion codes—and provides a systematic guide for the creation of new codes. Second, it unambiguously resolves the **BOSSER** versus **SERBOS** problem. Third, the hierarchical structure allows for straightforward aggregation: using "*" to mean "wildcard", **PSE*** refers to all cases of Palestinian actors , **PSEREB*** refers to all cases of Palestinian military actors, and **PSEREBHMS** refers specifically to Hamas.

Sub-state Actor Event Counts

While the KEDS project has [unsystematically] coded sub-state actors for quite some time, almost all of its analysis has been done with 3-character primary codes, typically **ISR** (Israel), **PAL** (Palestinian) and **LEB** (Lebanon). These are aggregated by simply using a wildcard to get all codes with the same initial characters.

The NKSS web site also allows for wildcards, but makes it equally easy to look at groups of codes (for example **PSEGOV** and **PSEPLO**) or wildcards at any level (**PSEREB***). Intuitively, we would expect that by looking at sub-state actors, one would find different patterns than one would find with aggregated actors. For example, a persistent problem for the Palestine National Authority (PNA) during the Oslo period has been the fact that Islamic militant groups reject the legitimacy of the Oslo process and at times work at cross-purposes to the PNA. There is a similar problem—albeit of lesser magnitude—with respect to the Israeli "settler" movement—which seeks to establish Israeli-controlled towns and villages in all of the territory occupied by Israel in the 1967 War—and the Israeli government, which is committed through the Oslo process to some yet undefined "land for peace" that would result in Palestinian sovereignty over most of that area. In order to assess whether these differences would be present in the event data, we looked at weekly event counts for actions initiated by the following groups, and directed towards targets with the primary code of the opponent (so, for example, the "militant" category has counts with **PSEREB*** as the source and **ISR*** as the target).[6]

---

[6] Due to time limitations that prevented immediate posting of the new data set with CAMEO-coded actors, these weekly totals were actually compiled using a little C program rather than using the web site tool; the source code

Group	Codes	
	Palestine	**Israel**
All	**PSE**	**ISR**
Government	**PSEGOV** **PSEPLO**	**ISRGOV**
Military		**ISRMIL**
Settlers		**ISRSET**
Militants	**PSEREB**	
West Bank	**PSEWBN**	
Gaza Strip	**PSEGZS**	
Hamas	**PSEREBHMS**	

At this point it is important to note that the specific code assigned to an incident is entirely dependent on the phrasing of the news report. For example, a demonstration by Hamas supporters in Gaza City might be reported as

```
Palestinians demonstrate against Israeli closures
Gaza City demonstration protests Israeli closures
Hamas organizes demonstration in Gaza against Israeli closures
```

These three sentences would have the source codes **PSE, PSEGZS** and **PSEREBHMS** respectively. Consequently our analysis involves not just a study of the pattern of the events themselves, but also the characteristics of the reporting by Reuters and AFP.

Tables 1 and 2 show the results of this analysis. The tables show the correlations for all of the actors with the **ISR*** and **PSE*** counts, and also show combinations of sequences that *do not* have a correlation that is significant at the 0.0001 level. The reported number is the Pearson product moment r; the number in parentheses is the p-value (if not reported, $p < 0.0001$). We ran the analysis on the complete series (N = 1250) and also for the Oslo period (September 2003 to December 2004, N = 587). Calculations were done with the Stata *pwcorr* command.

The Israel case (Table 1) is the more straightforward and completely confirms our expectations. In general, the actions of the government and military are highly correlated with the aggregate on all measures of behavior. However, as we expected, the actions of the settlers diverge, and this diverge consistently becomes more pronounced (that is, the correlations are lower) in the post-Oslo period when the settlement movement has had major disagreement with both the Israeli government and the Israeli military.

---

for that program is available on request. However, the previous week we had used the web-based tool to do some exploratory work, and it really is easy to use. Honest.

The Palestinian case is more complicated, though this was also expected given the fact that the strength of the Palestinian proto-state is dramatically less than that of Israel. While almost all of the series correlate significantly with the aggregate **PSE*** measure (Gaza on post-Oslo material cooperation and verbal conflict being the exception), the measures show considerable divergence between each other.

These differences are generally consistent with two sources of distinct behaviors within Palestinian politics. The first is the difference between the traditional Palestinian political leadership headed until recently by Yassir Arafat—the Palestinian Liberation Organization and the post-Oslo Palestine National Authority—and militant Islamic groups such as Hamas and Islamic Jihad. The second is the distinction between the very poor, densely populated Gaza Strip and the relatively wealthier West Bank. The Islamic groups had more of a base in Gaza, while Arafat's political base (and in the post-Oslo period, residence) was more in the West Bank. These tendencies are reflected in the correlations.

The one counter-intuitive finding is the low correlation between Hamas activity and that in Gaza. This may be a function of the tendency of reports to emphasize Hamas—that is, if Hamas is involved in an action in Gaza, the PSEREBHMS code will be picked up rather than a PSEGZS code—or it may be due to the fact that the current actor coding dictionary has relatively little geographical information about Gaza (it does not, for example, include the cities of Khan Yunis and Rafah, whereas the PSEWBN codes does contain Bethlehem, Hebron, Jenin, Jericho, Nablus and Ramallah[7])

Finally, we would note two caveats to this analysis. First, keep in mind that the **ISR*** and **PSE*** counts *include* that counts of the various sub-state behaviors, which will bias the counts towards correlating. This effect probably has a particularly high impact on the material conflict and verbal cooperation measures since these activities tends to be undertaken by the military/militants and government respectively. These are in fact the highest correlations anywhere in the tables, reaching the level of 0.95 in the case of the Israeli military and material conflict, and in the range of 0.7 to 0.8 for governments and verbal activity. It would be relatively straightforward to do a pair-wire comparison of series where the relevant substate actors had been removed; this would presumably reduce the correlations further.

Second, the AFP data (1999 to the present) are substantially denser than the Reuters data. This is partly an effect of the events on the ground because the second *intifada*, which began in September 2000, involved far more intense military activity than had been experienced earlier in the conflict. However, there may also be some differences in the level of coverage between the two news services—AFP has generally had far more stories from the region than Reuters had. One of the future objectives within this project will be trying to find a way to reconcile these two sources.

[7] This oversight can be readily corrected—recoding the entire 1/4-million texts requires only about five minutes on a 350 Mhz G3 and should be even faster once we get TABARI operating on the much faster G5 machines.

Table 1: Correlations of ISR* events with Israeli Sub-state Actor Events

	1979-2004 (N=1250)	Post-Oslo (N = 587)
Material Cooperation		
Government	0.5414	0.4981
Military	0.6791	0.6755
Settlers	0.1263	0.1034 (0.012)
Set x Gov	0.0340 (0.2296)	0.0276 (0.5050)
Set x Mil	0.0144 (0.6101)	-0.0070 (0.8659)
Verbal Cooperation		
Government	0.8032	0.7350
Military	0.5604	0.5176
Settlers	0.2411	0.1647
Set x Gov	---	0.0787 (0.0567)
Set x Mil	---	0.0437 (0.2901)
Verbal Conflict		
Government	0.7552	0.7312
Military	0.6020	0.5918
Settlers	0.2126	0.1578
Set x Gov	---	0.0544 (0.1879)
Set x Mil	0.0758 (0.0073)	0.0358 (0.3860)
Material Conflict		
Government	0.4272	0.3777
Military	0.9561	0.9571
Settlers	0.2911	0.2013
Set x Gov	0.0365 (0.1978)	-0.0377 (0.3618)
Set x Mil	---	0.1188 (0.0039)

Table 2a: Correlations of PSE* events with Palestinian Sub-state Actor Events

	1979-2004 (N=1250)	Post-Oslo (N = 587)
Material Cooperation		
Government	0.5521	0.5226
Militants	0.4020	0.4067
Mil x Gov	0.0618 (0.0289)	0.0339 (0.4130)
West Bank	0.3636	0.3580
WB x Gov	-0.0153 (0.5899)	-0.0440 (0.2871)
WB x Mil	0.0825 (0.0035)	0.0731 (0.0769)
Gaza	0.1407	0.1328 (0.0013)
Gaza x Gov	-0.0186 (0.5108)	-0.0351 (0.3964)
Gaza x Mil	---	0.1320 (0.0013)
Gaza x WB	-0.0091 (0.7475)	-0.0166 (0.6887)
Hamas	0.3003	0.2981
Hamas x Gov	0.0688 (0.0149)	0.0473 (0.2524)
Hamas x WB	0.0358 (0.2058)	0.0250 (0.5460)
Hamas x Gaza	-0.0079 (0.7800)	-0.0155 (0.7076)
Verbal Cooperation		
Government	0.7863	0.6958
Militants	0.3987	0.3602
Mil x Gov	---	0.0911 (0.0274)
West Bank	0.3074	0.2370
WB x Gov	---	0.0430 (0.2988)
WB x Mil	0.0742 (0.0087)	0.0320 (0.4391)
Gaza	0.2368	0.1563
Gaza x Gov	---	0.0036 (0.9304)
Gaza x Mil	---	0.1125 (0.0064)
Gaza x WB	0.0101 (0.7202)	-0.0356 (0.3894)
Hamas	0.3710	
Hamas x Gov	---	0.0836 (0.0430)
Hamas x WB	0.0758 (0.0073)	0.0399 (0.3344)
Hamas x Gaza	---	0.0914 (0.0267)

Table 2b: Correlations of PSE* events with Palestinian Sub-state Actor Events

	1979-2004 (N=1250)	Post-Oslo (N = 587)
Verbal Conflict		
Government	0.7757	0.7296
Militants	0.5868	0.5545
West Bank	0.2783	0.3177
WB x Gov	---	0.1200 (0.0036)
WB x Mil	0.0897 (0.0015)	0.1013 (0.0141)
Gaza	0.1030	0.0494 (0.2319)
Gaza x Gov	-0.0042 (0.8822)	-0.0651 (0.1151)
Gaza x Mil	0.0262 (0.3548)	-0.0072 (0.8611)
Gaza x WB	-0.0054 (0.8489)	-0.0454 (0.2718)
Hamas	0.5679	0.5384
Hamas x WB	---	0.1079 (0.0089)
Hamas x Gaza	0.0221 (0.4342)	-0.0101 (0.8068)
Material Conflict		
Government	0.4456	0.3981
Militants	0.6749	0.6507
West Bank	0.5546	0.5358
WB x Gov	---	0.1210 (0.0033)
Gaza	0.4032	0.3689
Gaza x Gov	---	0.0835 (0.0431)
Gaza x WB	---	0.1020 (0.0134)
Hamas	0.6017	0.5775

Application 2: Differential Event Patterns in Israeli Governments

In this section, we will use the three basic patterns we used in our first paper; tit-for-tat, olive branch, and the four meta-rules (Hudson, Schrodt, Whitmer, 2004) in order to investigate differences in Israeli-Palestinian interaction parsed per Israeli government. That is, was signaling between the two groups different under Peres, as versus Shamir or Barak or Sharon?

Analysis of the First Paper

Here we remind the reader of these three basic patterns. Tit-for-tat (Axelrod, 1984) looks at reciprocal series of events: conflict by one side after conflict by the other; cooperation by one side after cooperation by the other. Tit-for-tat is a common signaling tactic used in adversarial situations where noise in the system may reach high levels. In our first paper, we found tit-for-tat

was a common strategy used in Israeli-Palestinian interaction, the incidence of which but increased over time as noise also increased.

Olive branch is a pattern wherein conflict by one side is met with cooperation by the other. What we found in our first analysis is that olive branches were often extended by each side in the context of simultaneous conflict. That is, olive branches were usually held out in the midst of a tit-for-tat exchange of conflict. How this played out is that one side would engage in conflict, and then the other side would return with both conflict and cooperation. The signal became, "You have the choice about which of our actions to reciprocate. You can reciprocate the violence, or you can reciprocate the peace. And then we will follow suit." In our previous paper, we found that the Israelis used the olive branch tactic far more than the Palestinians, but that the entire Oslo period can be viewed as a long olive-branch-while-striking-back-also episode. Many lay observers saw the Oslo period as one of mainly peace, but a more detailed examination showed that violence continued alongside the peace effort until agreements were formalized. And, unfortunately, even that period of greater calm did not last.

The four meta-patterns investigated identified whether the period in question was characterized more by one-sided violence (red), both-sided violence (black), violence and cooperation mixed (purple), or cooperation-but-no-appreciable-violence (yellow). In the early years of the data set (1979-early 1993), red predominates, followed by black, punctuated by occasional bursts of yellow. In this earlier period, we are seeing asymmetric conflict. The two sides are not engaging each other directly most of the time, but rather one side is striking out at one period of time, and the other side is striking out at a different period of time. Even during the period of the first intifada, this was primarily the pattern seen. Also noticeable is that the Israelis appeared to be trying to get in the last "punch" in these exchanges.

Starting in early 1993, purple grows. What this means is that both violence and cooperation permeated Israeli-Palestinian interaction as the Oslo process unfolded. Before the second intifada, purple is punctuated primarily by red. When the second intifada begins, purple is punctuated primarily by black. Subsequent to the second intifada's initiation, noise in the system becomes so great that there appears to be one years-long episode of tit-for-tat. The utility of the tit-for-tat signaling is arguably reduced to nothing more than background noise itself.

Analysis of Each Prime Minister's Tenure

In this paper, we extend this analytical effort by examining the different tenures of the various Israeli prime ministers since 1979 when the events data begin. The time periods include

Menachem Begin, 20 June 1977 to 10 October 1983 (two governments)

Yitzhak Shamir, 10 October 1983 to 13 September 1984

Shimon Peres, 13 September 1984 to 20 October 1986 (Unity government)

Yitzhak Shamir, 20 October 1986 to 22 December 1988 (Unity government)

Yitzhak Shamir, 22 December 1988 to 13 July 1992 (two governments)

Yitzhak Rabin, 13 July 1992 to 22 November 1995

Shimon Peres, 22 November 1995 to 18 June 1996

Benjamin Netanyahu, 18 June 1996 to 18 May 1999

Ehud Barak, 6 July 1999 to 7 March 2001

Ariel Sharon, 7 March 2001 to present (two governments)

Using tit-for-tat, olive branch, and the four meta-patterns, some interesting differences emerge from the data for the various Israeli prime ministers. Unfortunately for our analysis of Begin, the data begins in the middle of his tenure in office as prime minister, and thus we cannot say how the "conversation" between Begin and the Palestinians began. But we can say certain things about how it developed over time. First, until early 1982, the majority of episodes of Material Conflict were initiated by the Palestinians. Furthermore, these episodes seemed very temporally contained, being more isolated strikes than a coordinated plan of attack. Israeli responses to these strikes are also short retorts. There is also a period of relative quiescence and even cooperation until early 1982. Starting in early 1982, tit-for-tat violence begins to increase between the two sides and episodes of violence are much more drawn out temporally. Apparently wanting to de-escalate, both sides offer an olive branch toward the middle of 1982. Subsequent to those matching olive branches, the Israelis ratchet down their tit-for-tat responses to the Palestinians considerably, and do so far more than the Palestinians. Begin's tenure actually ends with relative calm.

Shamir's first brief tenure in 1983-1984 sees the Palestinians giving him a brief honeymoon, during which Shamir initiates several episodes of conflict without a significant Palestinian response. In the weeks preceding his government's collapse, the Israelis cease this initiation of conflict episodes.

The Palestinians appear to give Shimon Peres a several-month long honeymoon as he takes office in late 1984. After a short tit-for-tat conflict between the two sides at the very end of 1984, the Israelis conduct no significant conflict for six months. During this six-month period, the Palestinians engage in only very brief conflict episodes. An escalation of conflict then occurs, during which Peres offers both tit-for-tat conflict and an olive branch. When the Palestinians do not respond to the olive branch, Israel initiates a fairly extended period of conflict, after which the Palestinians do extend an olive branch. A period of relative calm then ensues for about a month, after which sporadic violence breaks out in asymmetric, temporally short episodes. Both sides also experiment with offering olive branches and responding with periods of calm to such offers. The offering of olive branches reliably brings about a month of calm by the other side in each case when it occurs.

In Shamir's second tenure, even before the first intifada Israel steps up its non-tit-for-tat (i.e., pretty much unprovoked) conflict behavior. Interestingly, during this time period, we see the Palestinians offer several olive branches to the Israelis, none of which are "taken up." As the first intifada begins, tit-for-tat conflict escalates tremendously. What is interesting is that during the early months of the first intifada, we initially see three episodes where both sides are offering olive branches fairly simultaneously, but none of these prevent subsequent violence. About a year into the first intifada, the Israelis are still repeatedly offering olive branches, but the Palestinians neither reciprocate nor offer any more olive branches at all (except for one in fall 1988).

In Shamir's third term, we apparently see a man trying to reestablish some intelligible signaling between his government and his adversaries that could lead to a de-escalation by the other side. He tries escalating his non-tit-for-tat violence and for a time stops his offering of olive branches. Then in early spring of 1989, he tries a different signal: ceasing conflict and offering a stand-

alone olive branch. When that is not taken up, he reverts to a strategy of offering both violence (tit-for-tat and non-tit-for-tat) and olive branches at the same time. This actually leads to a nearly month-long cessation of significant violence by both sides. Even after the calm is broken by the Palestinians, the first response by Shamir is an olive branch without accompanying violence. When that is not taken up, Shamir begins tit-for-tat violence against the Palestianians. It then appears that it is the Palestinians turn to figure out how to signal effectively to the Israelis. For almost four months, from October 1989 to early spring 1990, the Palestinians offer olive branch after olive branch (virtually without simultaneous conflict on their part) to an unrelenting cascade of non-tit-for-tat violence by the Israelis. It isn't until the Palestinians begin adding violence to the context of their olive branches that the Israelis budge, moving to offer some olive branches of their own. We get a strange series of patterns indicating alternating cooperation-only meta-patterns with asymmetric-violence meta-patterns. It almost appears as if the timing of the Israeli and Palestinian olive branches are unfortunately out of phase during this period: just when one side decides olive branches would work, the other side has concluded olive branches don't work. And then that shifts and reverses as both are surprised. Apparently in very later fall 1991, the two sides get their signaling together, and olive branches are finally followed by a several month lull in the violence by both sides. By the end of Shamir's tenure in office, the asymmetric violence has crept in again. Short asymmetric episodes are eventually overcome by longer violent episodes, incorporating both tit-for-tat and non-tit-for-tat dynamics.

Yitzhak Rabin appears to come into office determined to prove his ability to be "tough" with the Palestinians. The Palestinians refuse to take the bait, offering him a short honeymoon, but after several weeks, respond with violence—and with an olive branch at the same time. After a period of mis-matched offerings of olive branches, something seems to move the olive branches into phase with one another. Though there is some accompanying violence, olive branches are reciprocated, and then reciprocated again. In the middle of 1994, there is actually a period of very little violence on either side. Though violence does reappear after that time, it is at a lower level than before, and is more temporally bounded. But what is noticeable is that after the high point for peace of mid-1994, the Palestinian side largely abandons the offering of olive branches, while the Israelis do continue to offer them.

The short post-assassination tenure of Shimon Peres is very hard to interpret. The Palestinians strike without Israeli response in the first few months of Peres' tenure. After that, there are a few Israeli counter-strikes, but also olive branches offered by each side. These months end with a series of non-tit-for-tat conflict by the Palestinians in the face of repeated Israeli olive branches.

The tenure of Benjamin Netanyahu is a study in contrasts. There appear to be several distinct periods where Netanyahu tried different approaches in communicating with the Palestinians. It is unclear whether any of these different types of communication were more successful than others. If one judges Israeli success by the lowering of Palestinian conflict behavior after a signaling attempt, then Netanyahu must have felt fairly confused, as no reliable pattern of Israeli behavior matches periods of lowered Palestinian violence. Netanyahu first forbears to use violence against unprovoked Palestinian conflict. The next time the peace is broken, he has apparently decided on a new approach: violence with olive branches. The next time violence begins again, we get a period of mismatched olive branches in the context of sporadic violence from late 1996 to early 1997. In mid-1997, we do get matched olive branches, after which violence peters out on both sides until late summer of 1998. At that point, Netanyahu reverts to his first strategy of not responding in kind to increased Palestinian unprovoked conflict, and instead offering olive

branches that are repeated every 10 days or so. This sustained olive-branching without concomitant violence by Israel does appear to usher in a period of calm before the next election.

Ehud Barak is given an amazingly long honeymoon by the Palestinians, lasting until about April 2000 (the better part of a year after he is elected). The resumption of escalated violence after that time is met by a long string of Israeli olive branches without simultaneous violence. However, when Ariel Sharon goes to the Temple Mount, all meaningful signaling between the two sides disappears in a paroxysm of violence. It is true that at the beginning of this second intifada, olive branches are offered repeatedly by both sides. But the overwhelming noise of tit-for-tat violence drowns out the usefulness of such offers. This pattern, or non-pattern, of interaction continues throughout the Sharon years, until the data set ends in fall of 2003, though there begins to be an absolute lessening of the number of conflict incidents beginning in later 2002.

Comparisons of the Prime Ministers

Some interesting comparisons arise from the above analysis. First, the Palestinian side always signals at the beginning of a new prime minister's tenure. Usually, this is in the form of a honeymoon, or cessation of violent activity. Long honeymoons were given to Israeli prime ministers that seemed to offer the best chances for negotiation: thus, for example, Ehud Barak is given the longest honeymoon of all. However, it appears that the Palestinians also made a judgment as to whether a prime minister might be influenced by their opening signal to him, despite the fact that the prime minister might not seem a good negotiating partner. It does appear that the Palestinians thought they could influence Benjamin Netanyahu by an opening honeymoon. But the signaling between the two sides during Netanyahu's tenure was too confusing to provide a solid basis for communication. Of course, some prime ministers get no honeymoon at all, Ariel Sharon being an excellent case in point.

Another phenomenon also seems to emerge from the analysis; except for the period of the second intifada, there does seem to be a lull in the violence by both sides as an Israeli election comes to pass. This could be an attempt by each side to influence the election. This pattern is tempered somewhat in two cases: at the end of Peres' first tenure in 1986, he actually steps up conflict against the Palestinians while the Palestinians are lowering conflict. And when Rabin is assassinated, the Palestinians step up violence even as the Israelis are forbearing to use violence.

Still a third point to make is that Israeli prime ministers change their signaling over time. Some change more than others. In particular, Yitzhak Shamir and Benjamin Netanyahu seemed to skip around from use of one rule to use of another rule over time. They would respond to the same stimuli in different ways over time. Other prime ministers were much more predictable, such as Begin and Peres. The same stimuli would be met with largely the same response time and again. Impressionistically, it did seem as though the mixed signaling of Shamir and Netanyahu did not result in tangible progress. But perhaps their willingness to experiment with new reactions set the stage for their successors, Yitzhak Rabin and Ehud Barak, respectively.

Fourth, it does appear that communication can completely break down. The second intifada is a period where no signaling—tit-for-tat, non-tit-for-tat, olive branch—can be regarded as a signal. There is simply too much noise. All of these rules become background context and no longer can be regarded or responded to as meaningful signals. This leads us to the supposition that cessation of rules is as important to their meaning as their continuation. Unless one pauses, how can there be a dialogue?

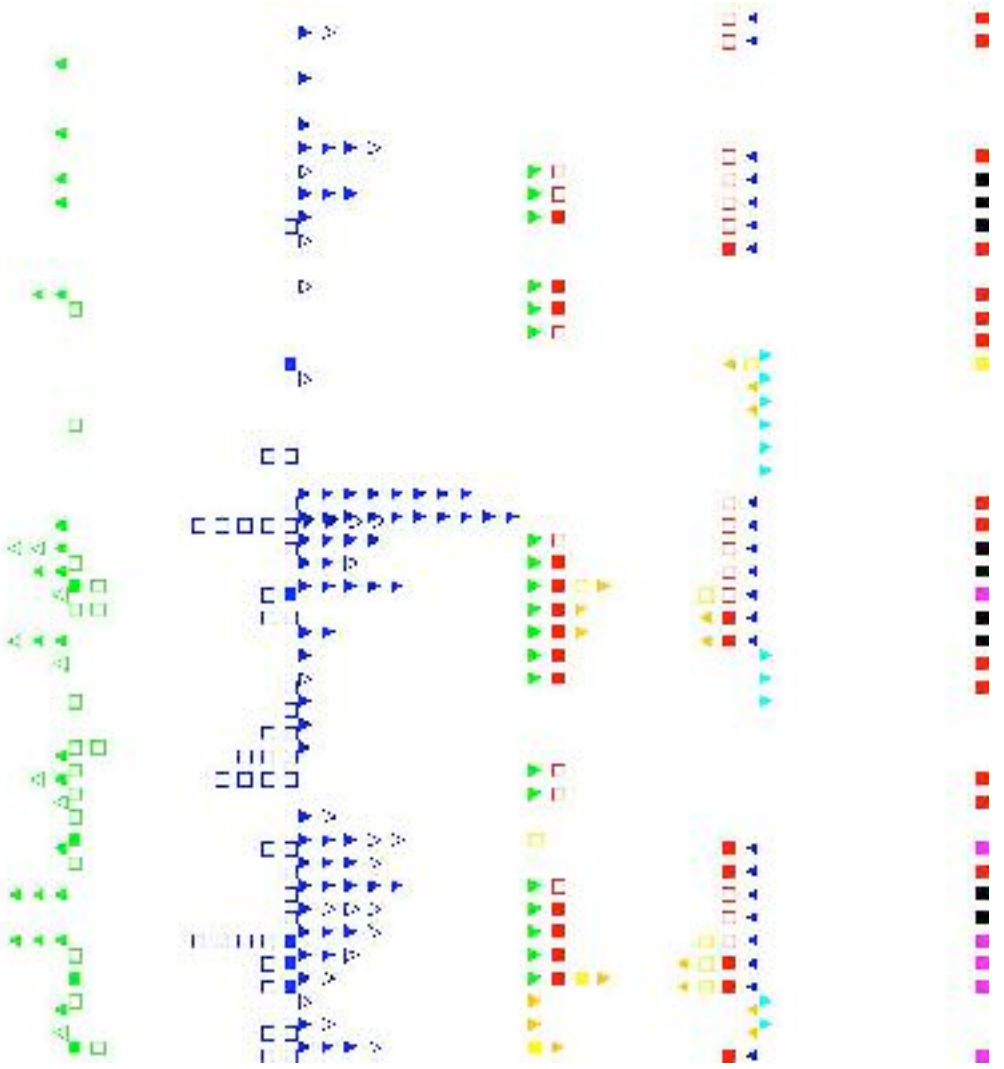
Fifth, it does appear that the Israeli side is better at controlling their message than the Palestinian side (at least prior to the second intifada). We see attempts by the Israelis to repeat a signal, pausing for a time between repetitions to make sure the message gets across. We see this especially with the olive branch rule. On the Palestinian side, the message is a bit less clear and becomes increasingly less clear as the years go by. This may have to do with the proliferation of subnational actors on the Palestinian side, each with their own slightly different agenda. A future analysis will reveal whether Palestinian behavior is clearer when each subnational actor is examined in isolation. However, it should be noted that the present analysis does omit Hamas, Islamic Jihad, and Hezbollah from the list of Palestinian actors/target examined. This was done to increase the likelihood that we could see coherent signaling by the Palestinian side.

We are currently in the process of checking the concordance between the phenomena noted through use of the pattern recognition technology and scholarly chronologies of the same time period. Such concordance would help determine the face validity of the observations made through observance of patterned behavior.

Application 3: Revealing New Patterns in Israeli-Palestinian Interactions in Sequential Fashion

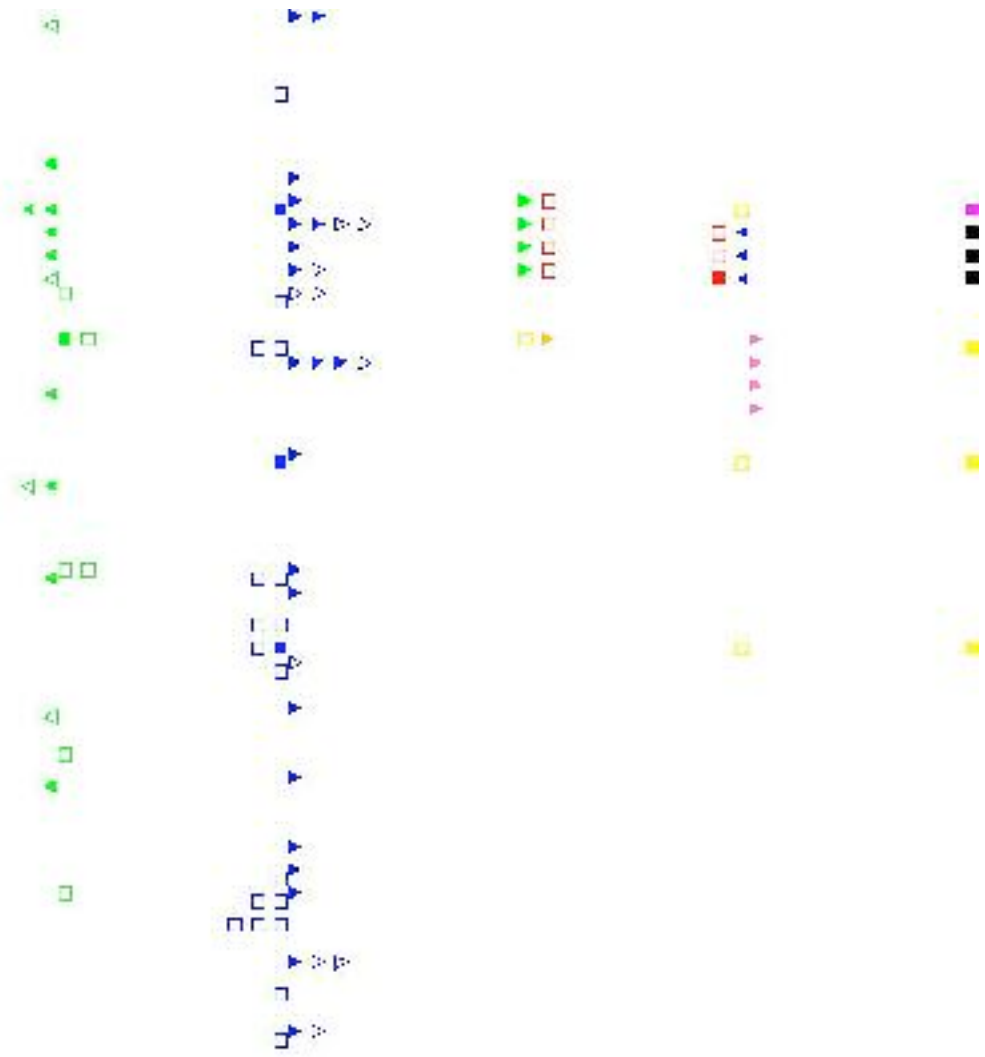
To this point, we have relied on only three patterns to view Israeli-Palestinian behavior: tit-for-tat (and non-tit-for-tat), olive branch, and the four meta-patterns. In this section, we want to push the idea of patterns and rules a bit further. Can we "see" more in the data than just these three sets of rule-based behaviors?

For example, we noted in the previous prime minister analysis that olive branches followed by pauses in conflict by the olive-branch-offerer tended to hold more meaning than olive branches offered while accompanied by violence on the part of the offerer. Here is one example from spring 1982:

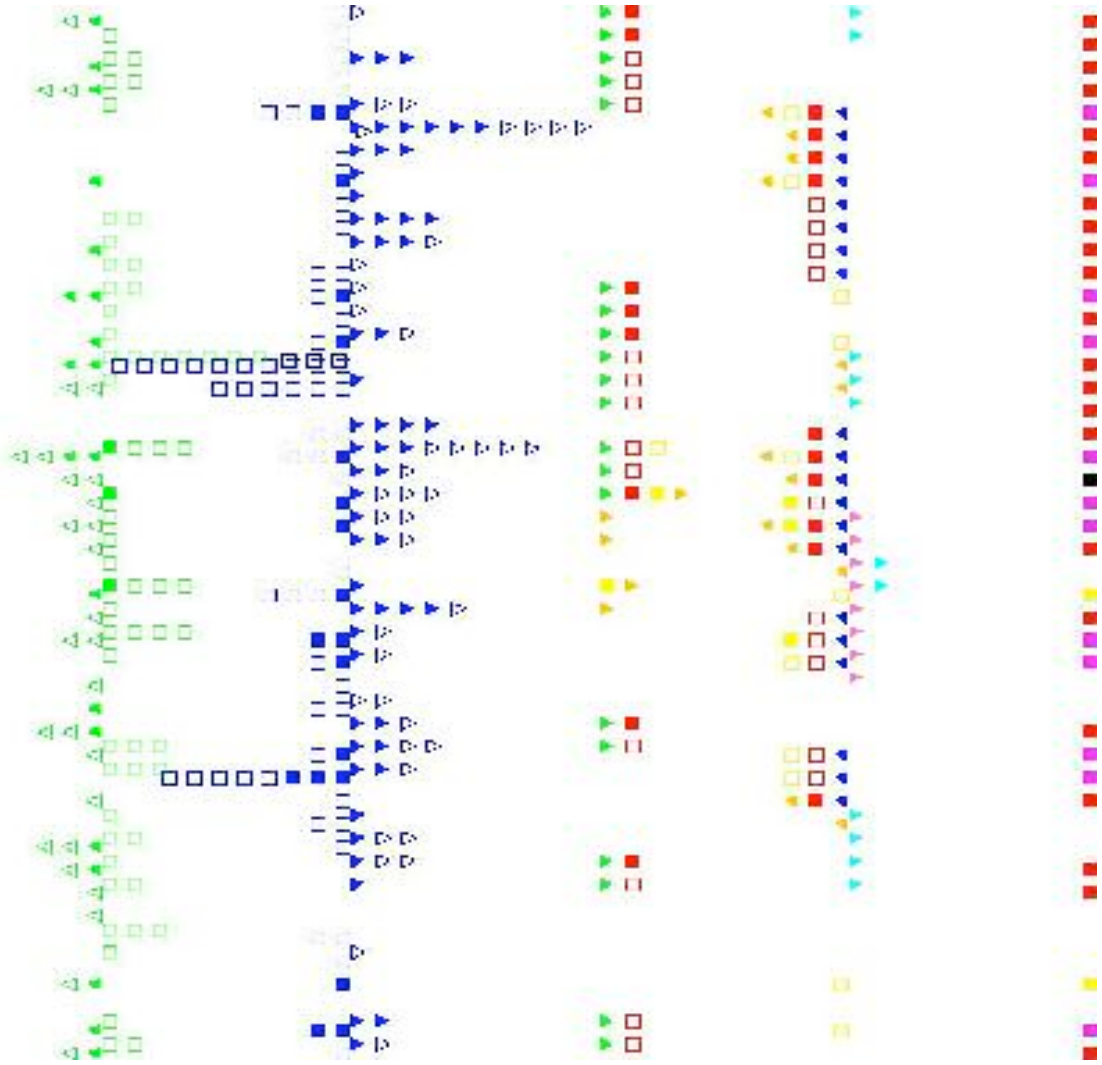


Notice the turquoise arrows in the second column from the right. These identify the use of the Israeli pause. Note how the signal is repeated three times, with 2-3 weeks of interval between. This is apparently a technique to lift the signal higher than the background noise level in the event stream.

Let us now turn to the Palestinians' use of the pause, denoted by a lavender arrow in the second column from the right. Here we see in spring 1980 an effective pause leading to a period of considerable calm between the two sides. Notice that the Israeli response does not include offering an olive branch, but does lead to significant decrease in conflict by their side:

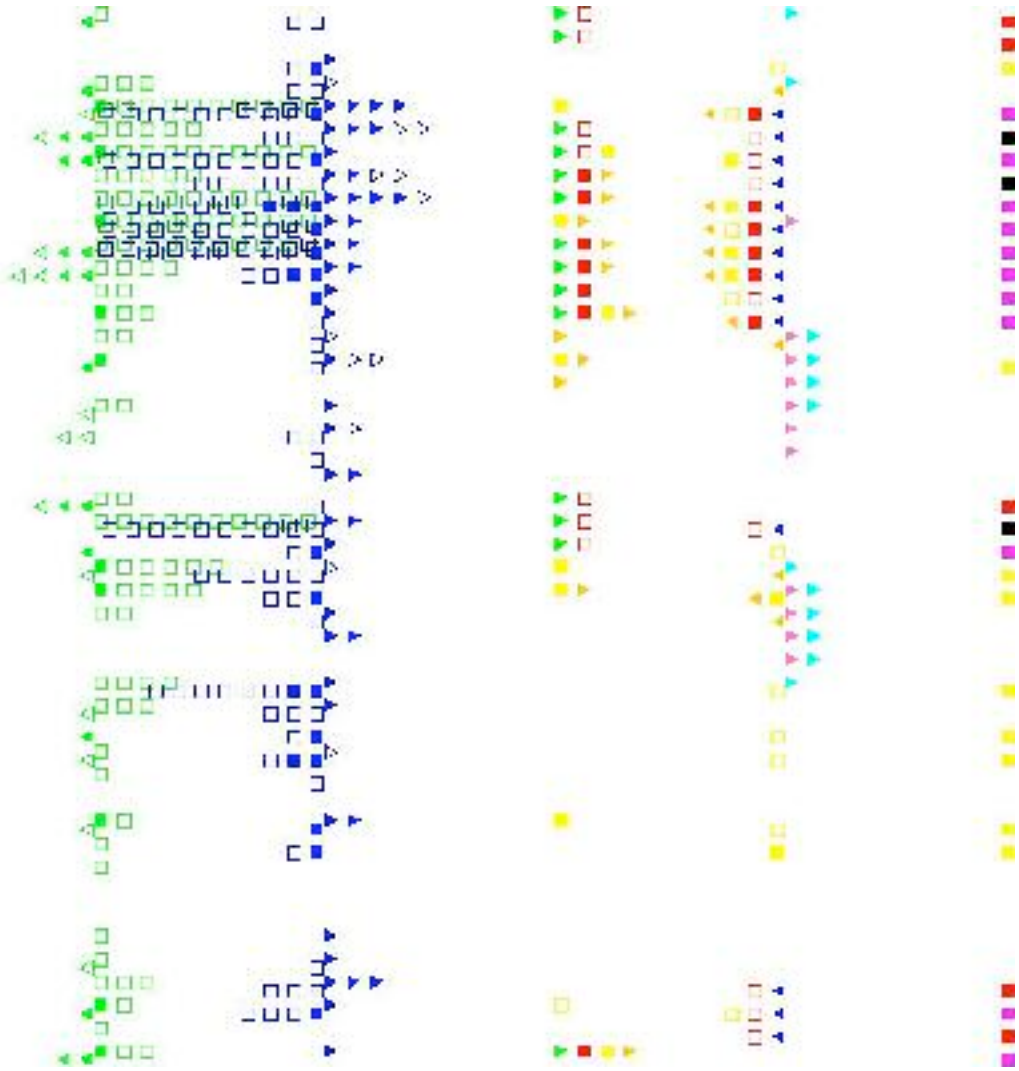


It is also interesting to observe how the use of pauses by each side is orchestrated. For example, note this display from mid-1997:

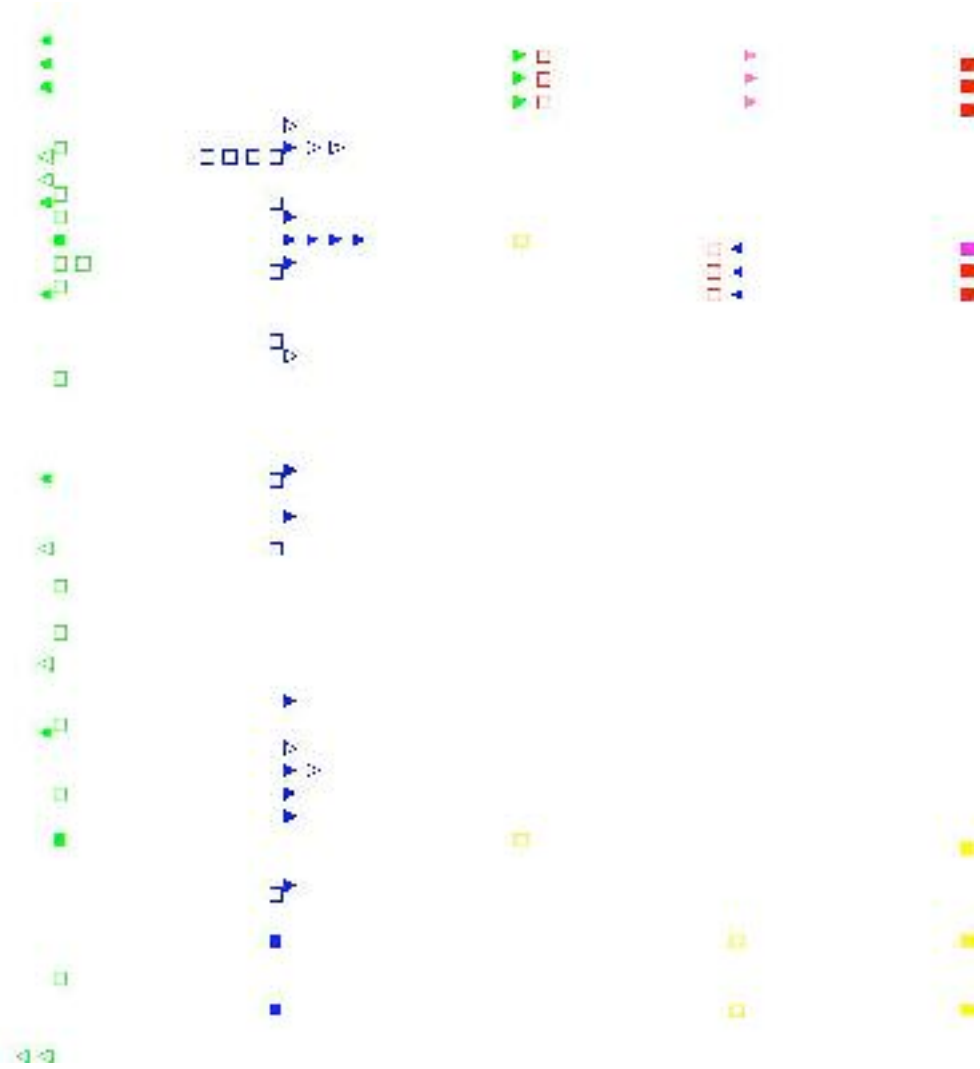


[display continues on next page]

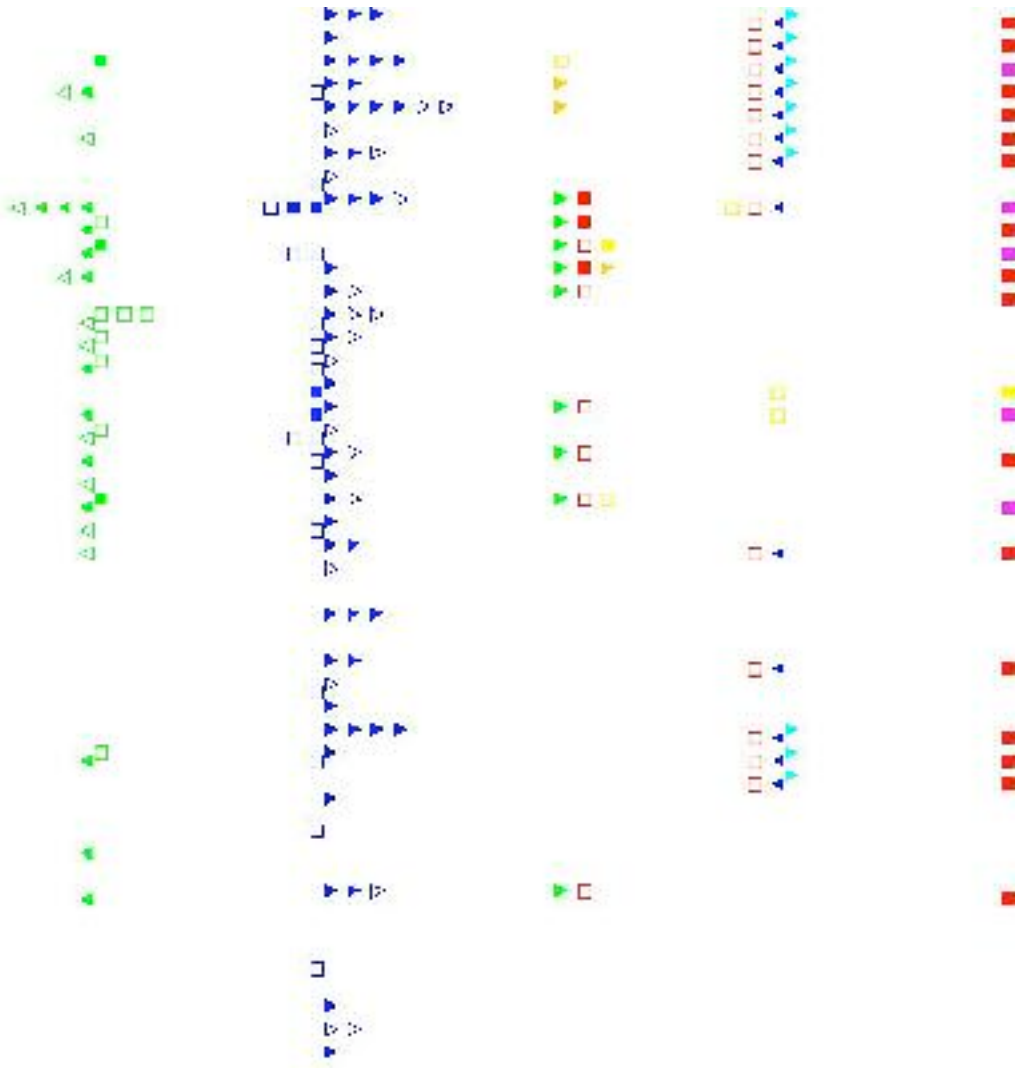
Tracking the turquoise and lavender arrows, we see a pause by the Israelis reciprocated by a Palestinian pause. Despite subsequent non-tit-for-tat Palestinian conflict, the Israelis repeatedly signal with pauses. However, when these are not reciprocated, the Israelis begin a long episode of non-tit-for-tat conflict, just as the Palestinians are significantly lowering their level of conflict. A more hopeful interaction of matched pauses takes place as the Oslo process take off, and ends a particularly virulent period of escalating violence:



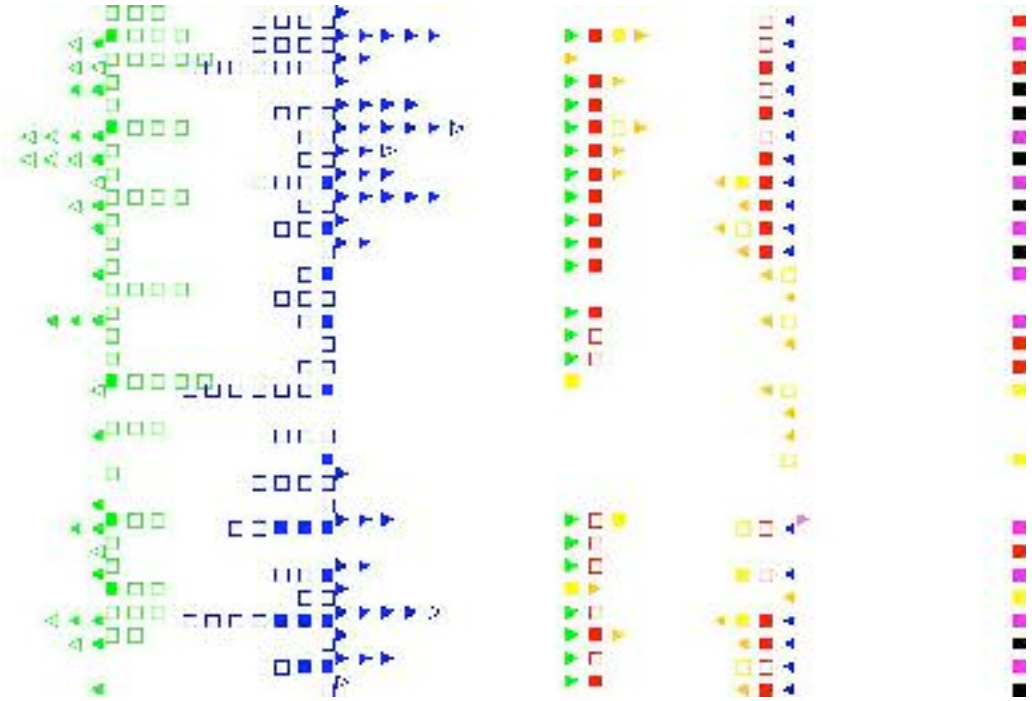
A second new pattern that we look at in this paper is the pattern of provocation—the initiation by one side of new hostilities after the other side has not reached their threshold for material conflict for over a week. Provocation is used more often by the Palestinians than the Israelis. However, there are two interesting phenomena apparent in the data. First, over time the Israelis appear to "learn" provocation from the Palestinians. And, second and quite counterintuitively, provocation often precedes a period of relative calm. That is, the other side may briefly strike back, but then both the victim and the provocateur cease conflict for a time. Perhaps this is a way of testing the resolve of one's adversary. Here is an example from late 1982:



There is also an apparent organizational difference in ability to respond speedily to a provocation. Unsurprisingly, it appears that it takes the better part of a week or more for a Palestinian response to an Israeli provocation. But Israeli reaction to a Palestinian provocation comes much more swiftly, often 2-3 days. Below is a Palestinian reaction to an Israeli provocation in spring 1990. In this case, the turquoise arrows represent Israeli provocation:



Now compare the above to Israeli response to Palestinian provocation, from late 1993; the lavender arrow is representing Palestinian provocation:



After a significant lull on the Israeli side, we see a Palestinian provocation, which is immediately answered by the Israelis.

To conclude this section, then, this exercise of developing two new patterns, pause and provocation, has allowed us to "see" in an even more detailed fashion than before the interaction that the Palestinians and the Israelis are co-creating. We can see learning, we can see forbearance, we can see differences in organizational capacity. As we move forward with this project, we hope to extend our sense of sight even further.

Future Work

As we note at the beginning of this paper, we are only in the initial phases of this project. Our ISA 2004 paper, Hudson, Schrodt and Whitmer (2004), was essentially a "proof of concept" effort albeit one that was fortunately sufficient for us to secure NSF support for further work. That funding began only on 1 February 2005, and consequently we have only had limited time and resources to push the approach further. In this final section, we will outline where we see this project heading over the next two years.

Enhancements to the www.nkss.org software environment

The software in Hudson, Schrodt and Whitmer (2004) established a basic framework for pattern-based analysis. We are currently in the process of re-deploying this on a couple of dedicated Web servers. The `http://www.nkss.org` site will be mirrored on dual-processor Apple G5

XServe servers at the University of Kansas and Brigham Young University, which should significantly increase the response time and allow for multiple users to work simultaneously. This site will be accessible to the general research community with passwords that provide ability to store data and rule sets; we would also provide general access to the site (with appropriate security against hackers) for individuals who want to experiment with the available data sets.

Like all first efforts, the `www.nkss.org` tools do not encompass everything that one might want to do with event patterns—though frankly, we also realize that we haven't even begun to use all of the potential present even in the existing capabilities—and is somewhat awkward to use. Under NSF funding, we anticipate adding the following capabilities.

1. User-friendly methods of entering patterns. In the original system, patterns were specified algebraically using numerical operations. While this in fact allows for a great deal of flexibility, the syntax is not natural and a great deal of translation is required to go from the pattern one has in mind to the algebraic expressions required to implement it.

   In the past month, the system has been enhanced with numerical *if-then* statements. However, the "engine" that underlies the program is in fact far more powerful, and is based on a more general proprietary pattern-recognition system that Whitmer has been developing for use with legal software. We anticipate bringing in various aspects of this system into `www.nkss.org` on an experimental basis, and then once we have determined which characteristics are appropriate for the event data analysis, those can be implemented in a simpler, open-source framework.

   Finally, we anticipate at some point implementing the ability to specify event patterns using the regular expressions of Unix (Friedl 2002). Regular expressions have become much more widely used in recent years due their centrality to the perl text-processing language, and for at least some analysts, regular expressions may be the most intuitive method of constructing patterns:

   > One of Perl's key features as a language is regular expressions; in fact, Perl has probably done more to evolve regular expressions than any other language. If you are not familiar with regular expressions, think of them as the ultimate string manipulation tool for serious string processing. *Regular expressions are to strings what math is to numbers.*
   > Andrew Clinick, Program Manager, Microsoft Corporation, January 22, 1999 (http://msdn.microsoft.com/workshop/languages/clinic/scripting012299.asp; accessed 18 December 2000)

   There are now several different libraries that allow regular expressions to be evaluated in the environment of general-purpose languages such as Java and C++, and we expect to be able to implement this as an option.

2. Improved interface with the data, We expect to eventually develop `www.nkss.org` into a general platform for hosting event data sets, for example with built-in subsetting capabilities, scaling and aggregation routines, and the ability to output data in several formats. Our model here is the EUGene system (Bennett and Stam 2004; http://www.eugenesoftware.org/), which began as a project-specific software tool but has evolved as a general platform for hosting cross-sectional time-series data sets.

3. Tools for evaluating and possibly inducing rules. At the minimum this will involve the computation and display of conditional probabilities (see discussion below). We also would like to have the ability to easily check for the logical consistency of rules and allow for the chaining of rules (that is, circumstances where one rule's consequent is another's antecedent, or close to it). We would also add the ability to restrict the application of rules to specific time periods.
4. Alternative visualization methods: we anticipate that the final system would provide several different options for the display of data, and a researcher could switch easily between these. As with the specification of patterns, the current system actually has a great deal of flexibility in this regard but the syntax is awkward and needs to be made more user-friendly.

Assessment of the Stochastic Characteristics of Event Patterns

The work we have done to date has only looked at the presence of rules, not their statistical characteristics. As part of the new research, we will develop a number of measures based in conventional probability theory to assess the stochastic characteristics of rules. This work includes the following components:

1. Evaluation of actual rules against random data and random rules against actual data: what is the probability that we are simply finding these patterns by chance? These assessments are comparable to the probabilities of Type I and Type II error in statistical analysis. Specifically, we want to assess
    a. What is the probability that rules we have specified based on the qualitative and theoretical literature will be found in a sequence of events generated randomly? This assessment can be done on various sets random data sharing increasing levels of structure with the true data, for example by using Monte Carlo methods to generate data sets with the same marginal distribution with respect to the number of events by dyad but with a uniform distribution across event types; then adding the additional restriction that the marginal distribution of event types correspond to the actual data; then adding the additional restriction that the marginal distribution of complementary event pairs correspond to the actual data and so forth.
    b. What is the probability that randomly generated rules will be found in the actual data? In other words, to what extent are there "rules" in any data set? This is a somewhat more difficult problem since it requires developing the concept of a "random rule" but by modifying Wolfram's methods for specifying a space of discrete rules, it should be possible to do this systematically.
2. Development of increasingly complex rules. We will start with tit-for-tat and various other game-theory-derived strategies (e.g. brinksmanship; escalation; ultimatum), and assessing of how frequently these are found. We would initially look at these with respect to fairly simple consequents such as the presence of conflict versus cooperation), but we should also be able to scale up to more complex consequents such as escalation and de-escalation sequences.
3. Conditional probability assessment. Letting X be the antecedent and Y the consequent, we are interested in looking at
    a. Predictive rules: $P(Y|X) >> P(Y)$
    b. Null rules: $P(Y|X) = P(Y)$

c. Incorrect rules: P(Y|X) << P(Y)

d. Dormant rules: P(X) -> 0

e. Comparison of rules: P(Y*|X) ? P(Y|X)

(This approach follows, but considerably extends, the analysis in Mintz and Schrodt 1988). We are also interested in identifying the time periods when the antecedents of rules are encountered with a high frequency (P(X)) as distinct from situations where P(Y|X) is high—that is, distinguishing between whether a rule might be invoked because the requisite antecedent conditions are present from situations where the rule was "correct"—both the antecedent and consequent were found. The frequency and conditional probabilities are two different measures and there might be some interesting relationship between. We are also interested in rules that are encountered with a low frequency: for example we would not be surprised to find that behavior involves a combination of high-frequency "standard operating procedures" that account for most behavior and low-frequency "crisis behavior" that also occurs predictably but only in exceptional circumstances.

In the process of discussing this possibility, however, we have also encountered another issue: when is a rule "interesting?" That is, there are undoubtedly a number of trivial rules that have high predictive conditional probabilities, but predict behaviors that are routine either in the sense that they occur frequently in the data set, or they are uninteresting for substantive reasons. "Interesting" rules, in contrast, probably involve a combination of novelty (the rule predicts a pattern that has not occurred frequently earlier in the data set) and substantive utility (the rule predicts events with a clear theoretically-relevant interpretation, for example the escalation or de–escalation of the conflict, rather than something pattern that is rare but has no obvious meaning.)

4. Rule substitution over time. As we have observed in the analyses presented in this paper, we would expect to see changes in rules over time. This occurs for at least two reasons. First, as demonstrated in the analyses we have done in this paper, we find different rules employed when there is a regime change in an established government (e.g. Labour, Likud, and Unity governments in Israel) or a major event such as the Oslo Agreement. Second, we expect to see some co-evolution of strategies by the antagonists. .

5. Comparison of the high frequency/probability patterns with the qualitative textual record: to what extent are the actors being explicit about the rules they are following? The same rich textual base of news reports used to produce the event data can also be assessed qualitatively to see whether pattern-based rules are being invoked implicitly. We know of at least one instance where this was clearly the case—the TFT of Palestinian suicide bombings and Israeli assassinations of Palestinian militants in 2003-2004—and we expect to find others. We will also consult the extensive case study literature on these crises in analyzing these rules.

6. Cross-source calibration and scale-invariant pattern recognition. Two closely related problems in contemporary event data analysis are the lack of comparability across news sources (notably between Reuters and *Agence France Presse*, which nominally should provide similar coverage of important world events: see Huxtable and Pevehouse 1996, Schrodt, Gerner and Simpson 2001, Davenport and Galaich 2002), and the problem of geographical and temporal scaling: a general phenomenon such as the Palestinian *intifada* or the Serbia-Bosnia conflict is actually composed of a large number of small scale encounters. Historically event data analysis has largely ignored these issues because it was dealing data

coded from only a single source at a very high level of aggregation (typically nation-years). The problems become more critical at the low levels of aggregation we are dealing with, and we expect that pattern-based modeling will provide a variety of new methods for dealing with these issues.

The work we have done so far is still tentative and has only begun to explore the possibilities of a pattern-based approach to event-data analysis. Nonetheless, we find even these first steps to be very promising: the data show patterns that are credible from the perspective of our qualitative and theoretical understandings of the conflict, but also enable us to characterize the event stream in a more systematic fashion than we could with other tools. Automated coding has allowed us to generate far more detail on sub-state actors than was found in earlier, human-coded data, and this in turn should give us greater insights into the nuances of this and other conflicts.

Bibliography

Abelson, Robert P. 1973. "The Structure of Belief Systems." In *Computer Models of Thought and Language*, edited by R.C. Schank and K.M. Colby. San Francisco: Freeman.

Allison, Graham T. 1971. *The Essence of Decision*. Boston: Little, Brown.

Anderson, John R. 1983. *The Architecture of Cognition*. Cambridge: Harvard University Press.

Andriole, Stephen J. and Gerald W. Hopple. 1988. *Defense Applications of Artificial Intelligence*. Lexington MA: Lexington.

Axelrod, Robert. 1984. *The Evolution of Cooperation*. New York: Basic Books

Beck, Nathaniel, Gary King, and Langche Zeng. 2000. "Improving Quantitative Studies of International Conflict: A Conjecture," *American Political Science Review* 94, 1: 21-36.

Bennett, D. Scott and Allan C. Stam. 2004. *The Behavioral Origins of War*. Ann Arbor, MI: University of Michigan Press.

Bercovitch, Jacob, ed. 1996. *Resolving International Conflict: The Theory and Practice of Mediation*. Boulder, CO: Lynne Rienner Publishers.

Bercovitch, Jacob, and Jeffrey Z. Rubin, eds. 1992. *Mediation in international relations : multiple approaches to conflict management*. New York: St. Martin's Press.

Bickerton, Ian J. and Carla L. Klausner. 1998. *A Concise History of the Arab-Israeli Conflict*. (3rd edition) Upper Saddle River, NJ: Prentice-Hall.

Bond, Doug, J. Craig Jenkins, Charles L. Taylor, and Kurt Schock. 1997. "Integrated Data for Events Analysis (IDEA): An Events Typology for Automated Events Data Development." *Journal of Peace Research* 40: 727-745.

Bond, Doug, Joe Bond, J. Craig Jenkins, and Charles L. Taylor. 2003. "Mapping Mass Political Conflict and Civil Society: The Automated Development of Event Data." *Journal of Conflict Resolution* 41: 553-579.

Bond, Joseph, Sean O'Brien, Vladimir Petroff and Doug Bond. 2004. "Hidden Markov Modeling of Conflict Processes with Events Data." Paper presented at the International Studies Association, Montreal, March 2004.

Brandt, Patrick T. and John R. Freeman. 2004. "Testing Democratic Peace Theory: A New Approach with Application to The Israeli-Palestinian Conflict." Paper presented at the International Studies Association, Montreal, March 2004.

Bull, Hedley. 1966. "International Theory: The Case for a Classical Approach." *World Politics* 18:361-377.

Carbonell, Jaime G. 1978. "POLITICS: Automated Ideological Reasoning." *Cognitive Science* 2:27-51.

Chase, W.G. and H.A. Simon. 1973. "Perception in Chess." *Cognitive Psychology* 4:55-81.

Cyert, R. M. and J. G. March. 1963. *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice-Hall.

Davenport, Christian and Glen Galaich. 2002. "When a Blind Eye Turns: Using International Media Sources for Creating Human Rights Violations." Paper presented at the American Political Science Association, Boston.

Dixon, William J. 1986. "Reciprocity in United States-Soviet Relations: Multiple Symmetry or Issue Linkage." *American Journal of Political Science* 30:421-45.

Friedl, Jeffrey E. F. 2002. *Mastering Regular Expressions*, 2nd ed. Sabastopol, CA: O'Reilly and Associates.

Fullbrook, Edward, "A Brief History of the Post-Autistic Economics Movement," November 21, 2001, http://www.paecon.net. Accessed 14 March 2004

Gaddis, John Lewis. 1992. "International Relations Theory and the End of the Cold War." *International Security* 17:5-58.

Gause, F. Gregory. 1999. "Systemic Approaches to Middle East International Relations." *International Studies Review*1,1:11-32.

Gerner, Deborah J. 1994. *One Land, Two Peoples: The Conflict over Palestine*. (2nd ed.) Boulder, CO: Westview Press.

Gerner, Deborah J., Philip A. Schrodt, Ronald A. Francisco, and Judith L. Weddle. 1994. "The Machine Coding of Events from Regional and International Sources." *International Studies Quarterly* 38: 91-119.

Deborah J. Gerner, Philip A. Schrodt, Ömür Yilmaz and Rajaa Abu-Jabr. 2002. "Conflict and Mediation Event Observations (CAMEO): A New Event Data Framework for the Analysis of Foreign Policy Interactions." Paper presented at the American Political Science Association, Boston, August 2002.

Gilovich, Thomas. 1981. "Seeing the Past in the Present: The Effect of Associations to Familiar Events on Judgments and Decisions." *Journal of Personality and Social Psychology* 40:797-808.

Goldstein, Joshua S., and John R. Freeman. 1990. *Three-Way Street: Strategic Reciprocity in World Politics*. Chicago: University of Chicago Press.

Goldstein, Joshua S., and Jon C. Pevehouse. 1997. "Reciprocity, Bullying and International Cooperation: A Time-Series Analysis of the Bosnia Conflict." *American Political Science Review* 91,3: 515-530.

Goldstein, Joshua S., Jon C. Pevehouse, Deborah J. Gerner, and Shibley Telhami. 2001. "Dynamics of Middle East Conflict and US Influence." *Journal of Conflict Resolution* 45, 5: 594-620.

Green, Donald and Ian Shapiro, 1995. *Pathologies of Rational Choice Theory: A Critique of Applications in Political Science*. New Haven, CT: Yale University Press, 1995

Hogarth, Robin M. and Melvin W. Reder, eds. 1987. *Rational Choice: The Contrast between Economics and Psychology*. Chicago: University of Chicago Press.

Holland, John H., Keith J. Holyoak, Richard E. Nisbett and Paul R. Thagard. 1986. *Induction: Processes of Inference, Learning and Discovery*. Cambridge: MIT Press.

Hudson, Valerie, ed. 1991. *Artificial Intelligence and International Politics*. Boulder: Westview

Hudson, Valerie M, Philip A. Schrodt and Ray D. Whitmer "A New Kind of Social Science?: Applying Wolfram-Like Models to the Analysis of International Behavior." Paper presented at the International Studies Association, Montreal, March 2004.

Huxtable, Phillip A., and Jon C. Pevehouse. 1996. "Potential Validity Problems in Events Data Collection." *International Studies Notes* 21, 2: 8-19.

Khong, Yuen Foong. 1992. *Analogies at War*. Princeton: Princeton University Press.

King, Gary and William Lowe. 2004. "An Automated Information Extraction Tool for International Conflict Data with Performance as Good as Human Coders." *International Organization* 57,3: 617-642.

Kohonen, T. 1984. *Self-Organization and Associative Memory*. New York: Springer-Verlag.Newell,

Margolis, Howard. 1987. *Patterns, Thinking and Cognition: A Theory of Judgement*. Chicago: University of Chicago Press.

Majeski, Stephen J. 1987. "A Recommendation Model of War Initiation: The Plausibility and Generalizability of General Cultural Rules." In *Artificial Intelligence and National Security*, edited by Stephen Cimbala. Lexington, MA: Lexington Books.

McClelland, Charles A. 1976. *World Event/Interaction Survey Codebook*. (ICPSR 5211). Ann Arbor: Inter-University Consortium for Political and Social Research.

Mefford, Dwain. 1991. "Steps Toward Artificial Intelligence: Rule-Based, Case-Based and Explanation-Based Models of Politics." In *Artificial Intelligence and International Politics*, edited by Valerie Hudson. Boulder: Westview.

Mintz, Alex and Philip A. Schrodt. 1988. "A Conditional Probability Analysis of Regional Interactions in the Middle East." *American Journal of Political Science*. 32,1: 217-230.

Newell, Allan and Herbert Simon. 1972. *Human Problem Solving*. Englewood Cliffs, NJ: Prentice-Hall.

Political Psychology. 2003. "Special Issue: Neuroscientific Contributions to Political Psychology." *Political Psychology* 24,4.

PS. 2003. "Special issue: Methodological Pluralism." *PS* 36,2.

Purkitt, Helen E. 1991. "Artificial Intelligence and Intuitive Foreign Policy Makers Viewed as Limited Information Processors." In *Artificial Intelligence and International Politics*, edited by Valerie Hudson. Boulder: Westview.

Reber, Arthur S. 1993. *Implicit Learning and Tacit Knowledge*. New York: Oxford University Press.

Schrodt, Philip A., and Deborah J. Gerner. 1994. "Validity assessment of a machine-coded event data set for the Middle East, 1982-1992." *American Journal of Political Science* 38: 825-854.

Schrodt, Philip A. 2000. "Pattern Recognition of International Crises using Hidden Markov Models." In *Political Complexity: Nonlinear Models of Politics*, ed. Diana Richards. Pp. 296-328. Ann Arbor: University of Michigan Press.

Schrodt, Philip A., Deborah J. Gerner, and Erin M. Simpson. 2001. "Monitoring conflict using automated coding of newswire sources: a comparison of five geographical regions." Paper presented at the PRIO/Uppsala University/DECRG High-Level Scientific Conference on Identifying Wars: Systematic Conflict Research and Its Utility in Conflict Resolution and Prevention, Uppsala. June 2001.

Schrodt, Philip A. and Deborah J. Gerner. 2004. "An Event Data Analysis of Third-Party Mediation." *Journal of Conflict Resolution* 48,3: 310-330.

Schrodt, Philip A. 2004. "Detecting United States Mediation Styles in the Middle East, 1979-1998." Pp. 99-124, in Zeev Maoz, Alex Mintz, T. Clifton Morgan, Glenn Palmer and Richard J. Stoll, eds. *Multiple Paths to Knowledge in International Relations*. Lexington, MA: Lexington Books.

Sniderman, Paul M., Richard A. Brody and Philip E. Tetlock. 1991. *Reasoning and Choice*. Cambridge: Cambridge University Press.

Subramanian, Devika, and Richard J. Stoll. 2004. "Computer Generated Events Data from Online Sources: Some Assembly Required." Paper presented at the International Studies Association, Montreal, March 2004.

Sylvan, David, Stephen Majeski and Jennifer L. Milliken. 1991. "Theoretical Categories and Data Construction in Computational Models of Foreign Policy." In *Artificial Intelligence and International Politics*, edited by Valerie Hudson. Boulder: Westview.

Sylvan, Donald A., Ashok Goel and B. Chandrasekran. 1990. "Analyzing Political Decision Making from an Information Processing Perspective: JESSE." *American Journal of Political Science* 34:74-123.

Sylvan, Donald A. and Steve Chan, 1984. *Foreign Policy Decision Making: Perception, Cognition and Artificial Intelligence*. New York: Praeger.

Simon, Herbert A. 1982. *The Sciences of the Artificial*. Cambridge: MIT Press

Tessler, Mark. 1994. *A History of the Israeli-Palestinian Conflict*. Bloomington, IN: Indiana University Press.

Thorson, Stuart and Donald A. Sylvan. 1982. "Counterfactuals and the Cuban Missile Crisis." *International Studies Quarterly* 26:537-71.

Ward, Michael and Sheen Rajmaira. 1992. "Reciprocity and Norms in U.S.-Soviet Foreign Policy." *Journal of Conflict Resolution* 36,2: 342-368.

Walt, Stephen M. 1999. "Rigor or Rigor Mortis? Rational Choice and Security Studies,"*International Security* 23, 4: 5-48

Weinberg, Gerald M. 1975. *An Introduction to General Systems Thinking*. New York: John Wiley and Sons.

Wolfram, Stephen. 2002. *A New Kind of Science*., Champaign, IL: Wolfram Media

Yee, Albert S. 1996 "The Effects of Ideas on Policies," *International Organizations* 50, 1: 69-108