A New Kind of Social Science:

Analyzing Israeli-Palestinian Event Data Using Reverse Wolfram Models

by

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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 produce discrete patterns. This paper reports some initial findings from a new NSF-funded project (NSF SES-0455158) designed to apply this pattern-based method to political event data. We believe that a variation on Wolfram's approach that we call "reverse Wolfram modeling" can provide a new methodology that is capable of preserving the agential basis of social interaction, capable of analyzing the rules behind such purposive behavior, capable of tracking multiple agents as they enact rules through behavior directed at one another, and capable of capturing the evolution of such interaction over time. The core of this project is a new, publicly-accessible web-based tool designed for the visualization and analysis of event data patterns (www.nkss.org). Using data on the Israel-Palestine conflict generated by the TABARI automated coding program for the period 1979-2004, we identify patterned behavior for which specific rule use can be imputed. We then examine several agent-based rules, plus four "meta-rules" to parse Israeli-Palestinian interaction over time, paying particular attention to the tenure of each Israeli prime minister. The qualitative record is examined to assess face validity for the patterns noted, and good concordance is found. Several empirical applications are demonstrated, including moving totals and increasingly complex sequences of rule enactment that go well beyond the simple variations on tit-for-tat responses

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 Newtonian 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 to fit poorly with the types of questions we would like 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 some aspects of 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 for the study of human behavior, it seems difficult access the validity of a particular historical or constructivist account. And since the findings of the social sciences aim to inform social practice and policy, which may have profound impact on the lives of individuals, some minimal falsifiability seems morally imperative, as well as being theoretically imperative to the extent that the social sciences are following norms sets by the natural sciences.

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 assessments 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 the amino acids coded by a strand of DNA, and then the patterns of those amino acids combine to produce the patterns formed by collections of proteins. Though the patterns in the DNA are simple in themselves, they can ultimately produce highly complex organisms, including human beings.

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 explore 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 very common response is to simply ignore these issues 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 the uniform 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-Aqsa 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 allowable interactions and usually involve a simple quantitative 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 simple introspection will show 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). The non-continuous nature of much of social reality 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 this fact 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.

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 that 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 the 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, the actions of an individual chess player, 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 to replace the 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, often as not 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 Hopple 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 organization's 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, for 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. Thus, the pattern-based approach to social science is applicable not only at the level of individuals, but also at the levels of groups, organizations, and bureaucracies.

Some of these rules are implicit, or buried deep within an organization's internal processes where they are not seen in the public record. However, many of the rules will be accessible. Since human understanding involves matching observed events to a pattern, the function of political discourse is to provide sufficient information 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 competition between the Yasser Arafat's Fatah Party and Islamic militant groups is one conspicuous example of this problem. Conflicts have also occurred between the Israeli government and settler groups, as seen in the 2004-2005 dispute between Israeli settlers and the Sharon government over the evacuation of settlements from Gaza illustrates is an example—and can even occur within governing coalitions. For example the Gaza withdrawal plan exacerbated political fissures both within Sharon's coalition government and within the Likud party, leading to the establishment of the Kadima Party.

One can extend this further by noting 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 with each other, but one could simultaneously get externally mediated negotiations between Israel and the Palestinian Authority. An example of this occurred with the U.S.-mediated "road map" process in the summer of 2003 and 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.

Social Science and Computational Irreducibility

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 a sense, then, we aim to implement *reverse* Wolfram modeling. Where Wolfram would posit rules and then observe resulting patterns, we are observing patterns that are the result of rules and we intend to postulate what those rules are. This is a much more intuitive approach to social science explanation than is currently possible using standard statistical-mathematical techniques, and it is an approach that preserves, rather than obliterates, the agential nature of social interaction.

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 interaction behavior in IR that we could use for a test?
- can we create a system of visualizing that interaction 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?

Reverse Wolfram Modeling: A Prototype

The answer to the first question, "do we have time stream data of interaction behavior in IR?" is yes. Event data provides precisely the type of interactional time series needed for our plausibility probe. Though there are certainly many controversial issues surrounding event data, contemporary events data sets are far superior to what they were in the early days of Foreign Policy Analysis. Furthermore, machine coding allows for much more rapid and reliable coding than ever before. We will be using data produced by the TABARI automated coding program (Schrodt 2006) for our analysis.

The second requirement for this project was to create a way to visualize event data streams, and simultaneously enable visualization of imputed behavioral rules that would produce such streams. The result was EP (Event Patterns) Tool, a web-based methodology that permits recoding of data, visualizing of events, and imputation of agent-based rules for interaction. EP Tool currently resides at http://www.nkss.org . That site includes a number of data sets from the Kansas Event Data System (KEDS) project, and provides several 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 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 first experiments with reverse Wolfram modeling using EP Tool, we specified some very simple rules and then ascertained how well they accounted for the behavior in the Israel-Palestine dyad. We required a dyad whose behavior was highly active 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). After choosing a dyad on which to experiment, the next step was to devise a set of interaction rules whose use could be investigated.

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 sets 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 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.

For our initial experimentation, we selected a set of rules that we believed were enacted between the Israelis and Palestinians. 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).

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). We examined both TFT conflict and TFT cooperation episodes in the data.

Delineating TFT exchanges also enabled us to examine a second subset of rules--non-tit-for-tat (NTFT) interactions, where one side will offer conflict in a fairly peaceful context (what we term "provocation"), or cooperation in a fairly conflictual context (what we term "olive branch"). 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. Provocation, of course, is its complement in escalation.

Third, we examined the strategic use of non-action, or what we term "pause." Pauses make communication more intelligible, especially in interaction contexts characterized by considerable noise. Pause is often used to accentuate what action is taken after the end of the pause, because the non-action sets the subsequent action apart from the continual give-and-take of the unfolding

relationship. It can also be used to signal the sincerity of a change in policy that follows the pause, because action after a pause is scrutinized more carefully.

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 rules followed by a particular side in the interaction. These meta-patterns are "state" variables that characterize the status of the dyadic relationship. We delineated four meta-rules that would produce distinct patterns: one-sided conflict, mutual conflict, mutual cooperation, and cooperation/conflict combined. The rules examined in this initial analysis are summarized in Table 1:

Name of Rule	**Characterization of Rule**
TFT Conflict	Tit-for-tat conflict; above-threshold material conflict on one side followed by above-threshold material conflict on the other
TFT Cooperation	Tit-for-tat cooperation: above-threshold material cooperation on one side followed by above-threshold material cooperation on the other
Provocation	Non-tit-for-tat material conflict: no above-material conflict on the one side, followed by above-threshold material conflict on the other side
Olive Branch	Material cooperation by one side, preceded by material conflict on the other side
Pause	Material cooperation followed by below-threshold material conflict on one side, which was preceded by above-threshold material conflict on the other side
Meta-rule: Asymmetric Conflict	No material cooperation from either side; only one side is expressing material conflict
Meta-rule: Mutual Conflict	No material cooperation from either side; both sides are expressing material conflict
Meta-rule: Mutual Cooperation	No material conflict from either side; both sides are expressing material cooperation
Meta-rule: Mixed Cooperation and Conflict	Material conflict form either or both sides and material cooperation from either or both sides.

Table 1: Rules Examined in the Initial Empirical Analysis

Empirical Investigations

• Israel-Palestine Event Data

News reports on the interactions between Israel and Palestine were coded into the WEIS scheme (McClelland 1976) using TABARI.[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 in the patterns 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 "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

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[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 will be based on the corrected set.

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: Graphic Representation of Raw Events

One obvious application of this approach is the visualization of raw events data in a symbolic form that the mind can be trained to understand. Such a technique is very useful for data exploration and abduction at the early stages of analysis. In the display below, we see raw material conflict data for the autumn of 1995; the Palestinian material conflict behaviors are to the left and pointing left, and the Israeli to the right pointing right. Each succeeding row of symbols corresponds to a subsequent two-day period of time; thus the top row corresponds to late September, and by the bottom of the display, we are in late October.

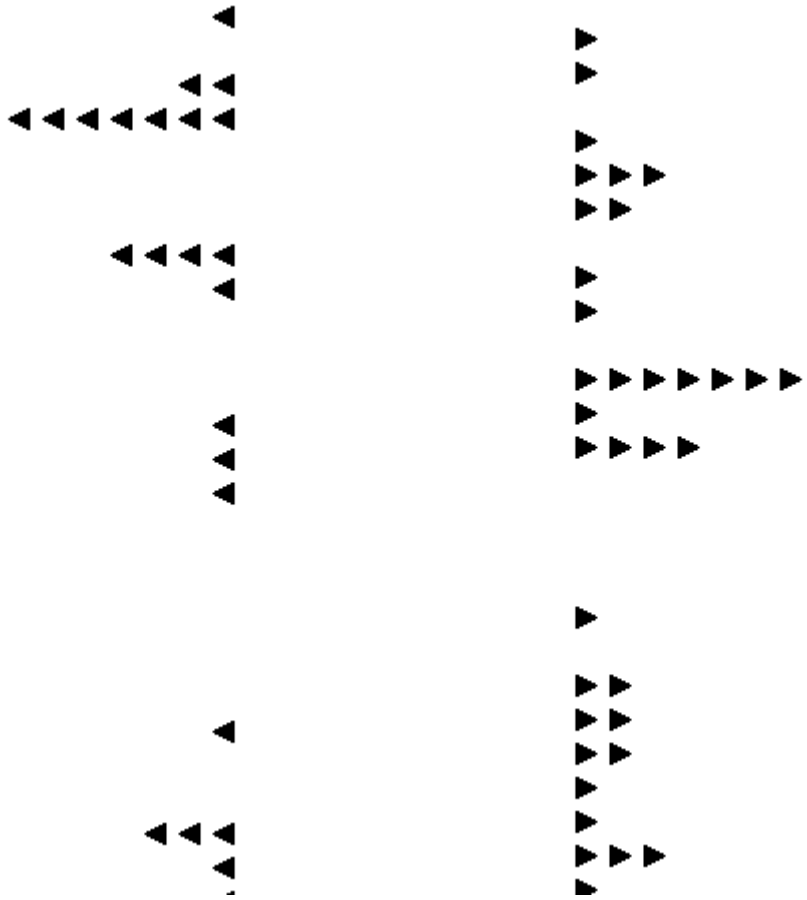

Figure 1: Palestinian-Israeli Material Conflict Events, Autumn 1995

Suppose now we were interested in seeing both material conflict and material cooperation simultaneously; an example of such a view would be in Figure 2, where outlined arrows on the left pointing to the left are Palestinian material cooperation behavior, and to the right pointing right for Israeli material cooperation behavior. The time period pictured is the outbreak of the second *intifada* in late 2000/early 2001. Notice that this period is characterized not only by an

upsurge in violence, as expected, but it is also characterized by repeated instances of limited material cooperation on each side, which is not part of our conventional view of the time. This resulted from the fact that the cooperative arrangements between Israel and the Palestinian Authority did not abruptly end, and in the initial stages of the second *intifada*, efforts continued to limit the outbreak of violence. Any event categorization scheme conceptualized by the researcher can be made into a visual display by EP Tool.

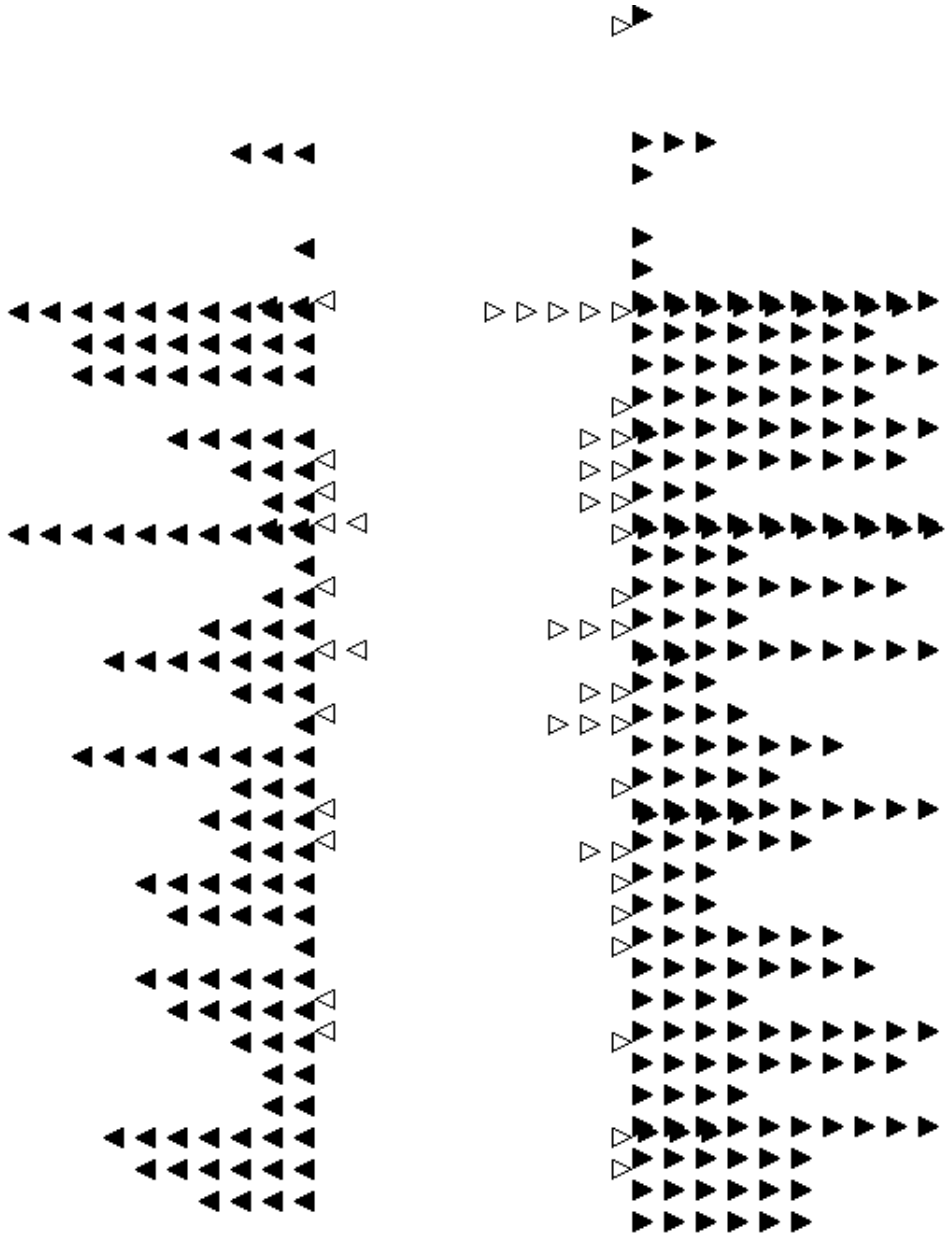

Figure 2: Palestinian/Israeli Material Conflict and Material Cooperation Behavior at the Outbreak of the Second Intifada

While examination of the raw data in chronological visual view is a natural starting point, the most intuitive next step is to generate hypotheses about the rules governing the interactions that we are seeing in these raw data displays. It is to that subject we now turn.

• Rules and Thresholds

One of the first issues faced is how to instruct EP Tool to find instances of rule enactment in the event data. In this initial analysis, we decided to confine ourselves to material conflict and material cooperation, as versus verbal interaction, with the rationale that actions do indeed speak louder than words in the intractable Israeli-Palestinian conflict. The surer signaling should be through material action, not verbal rhetoric, and consequently we would expect the patterns to be more distinct in that domain of behavior.

Second, it became clear that we would need to establish thresholds of conflict. That is, there is chronic conflict in the Israeli-Palestinian dyad, and it is necessary to distinguish between this "background noise" of constant material conflict and a clear new signal that indicated a change in the pattern of conflict. From the graphic representation of raw events, we induced a threshold of four Israeli material conflict events in a six day period below which no signaling would be apparent to the other side; and for the Palestinians, a threshold of two material conflict events in a six day period would distinguish background noise from signal. Material cooperation was sufficiently rare in the interaction data that no threshold was set for those events.

Given these thresholds, coding of the rules in Table 1 was fairly straightforward. For example, TFT conflict rule enactment for, say, the Israelis, would "fire" if the Israelis exceeded their material conflict threshold in the current time period where the Palestinians had exceeded their material conflict threshold in the prior time period. Olive branch would "fire" for Israel if the Israelis had engaged in material cooperation in the current period where the Palestinians had exceeded their threshold for material conflict in the previous time period. Specification of time periods can be adjusted by the researcher: we used a standard time period of six days' duration for this exercise.

• Application 2: Rule Enactment Moving Averages

In order to track the patterns over a long period of time, the indicators were downloaded from the EP Tool web site using the "Text" option, and then read into MS-Excel. The TFT, olive branch, and meta-rules were examined by graphing moving averages of the frequency with which the patterns occur.

Because there are 4485 points in the complete data set (15 April 1979 to 31 December 2003 in two-day intervals), it was necessary to construct some means of summarizing the results. The figures below give 32-day moving totals of the number of times that a pattern was matched: this measure has the value of 16 if the pattern matched in every one of the two-day periods in the 32-day interval. The values for Israel and Palestine are "mirrored" across the X-axis, with the counts for Israel above the axis and Palestine below.

As we anticipated, there is a very large discontinuity in all of the graphs following 1999. Unfortunately, this is likely due to two factors, one involving the situation and one involving the data. The situational discontinuity was the outbreak of the second Palestinian *intifada* in September 2000. The level of violence during this period was substantially greater than that experienced during the first *intifada* in 1988-1991, and consequently the number of reports of violence is objectively higher. In addition, the Palestine Authority had achieved some degree of international legitimacy following the Oslo peace agreement, and the international response in to the second *intifada* was more sustained and open than that during the first *intifada*, where the

U.S. in particular engaged in negotiations with the Palestinians very reluctantly. Objectively, one would expect the two periods to appear different.

However, we also have a change in data sources at this point, with Reuters prior to October 1999 and Agence France Presse (AFP) following that period. As discussed in Schrodt, Gerner and Simpson (2001), AFP generally has a much higher density of coverage of the Israel-Palestine conflict than Reuters has in the periods where we can examine the coverage of both sources. Consequently some of the increased intensity of coverage is, in all likelihood, due to the change in data sources.

Whatever the cause, the net effect of these two changes is that the data during the period 2000-2003 generally overwhelm our indicators, which either spike to their maximum values for the entire period or go to zero. Because we frequently see this occurring for measures of *both* conflict and cooperation, it seems more likely to be an artifact of the increased coverage of AFP. The solution to this problem would be to use higher thresholds for the AFP data; we intend to experiment with this adjustment at a later date.

Tit for Tat Analysis

Figures 3 and 4 show the 32-day moving totals for incidences of conflictual and cooperative tit-for-tat, which were compiled separately (i.e. conflictual TFT refers to a period of material conflict by one side followed by a period of material conflict by the other). Several characteristics are evident in these displays.

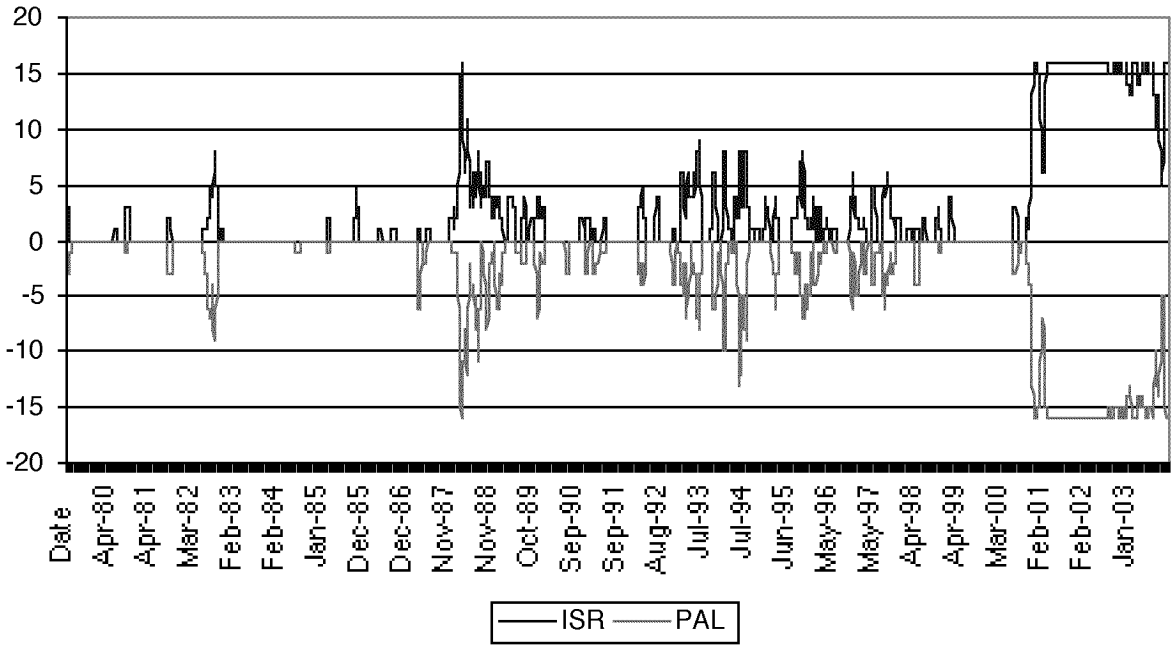

Figure 3. Tit-for-tat conflict

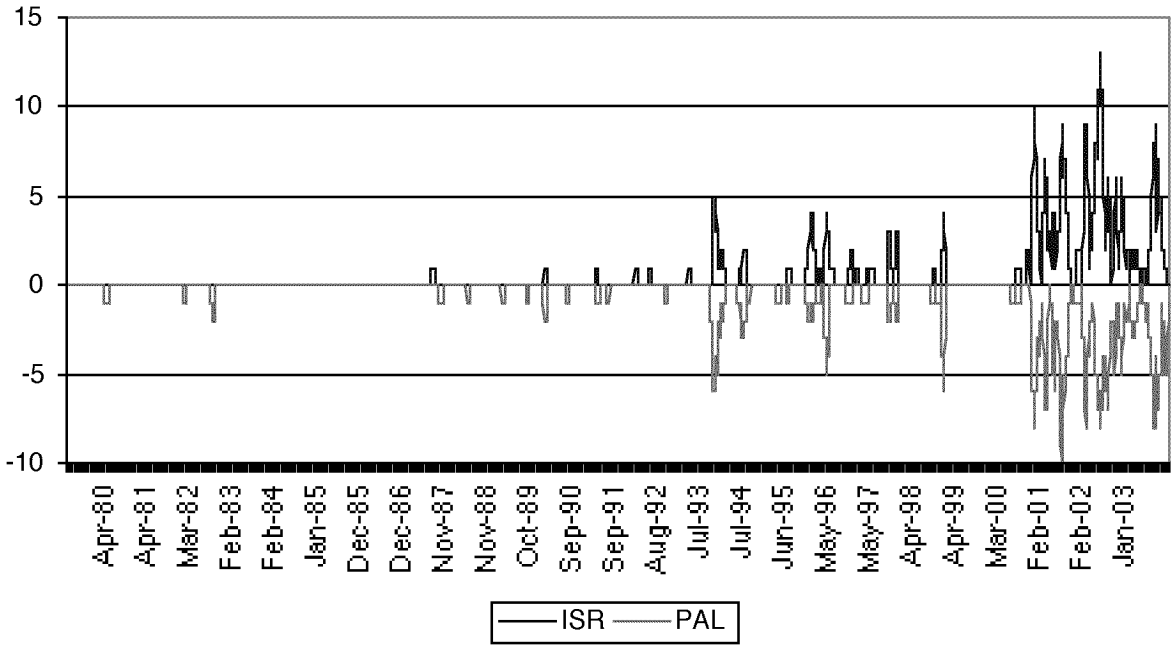

Figure 4. Tit-for-tat cooperation

First, the behaviors are generally, but not totally, symmetric—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 understand 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 surprising aspect of these two graphs is the juxtaposition of TFT conflict *and* cooperation during the post-Oslo period. This is not an error and is an illustration of the utility of objective events patterns over vaguely remembered narratives: one tends to forget that while the Oslo period 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 continued at both the official and unofficial levels (e.g. the Geneva Accords between Israeli and Palestinian citizen elites) during the second *intifada*

Olive Branch Rule

The second set of rules we looked at were the "olive-branch"—instances where one side engaged in cooperation despite having experienced conflict from the other side. These instances are shown in a 32-day moving total in Figure 5.

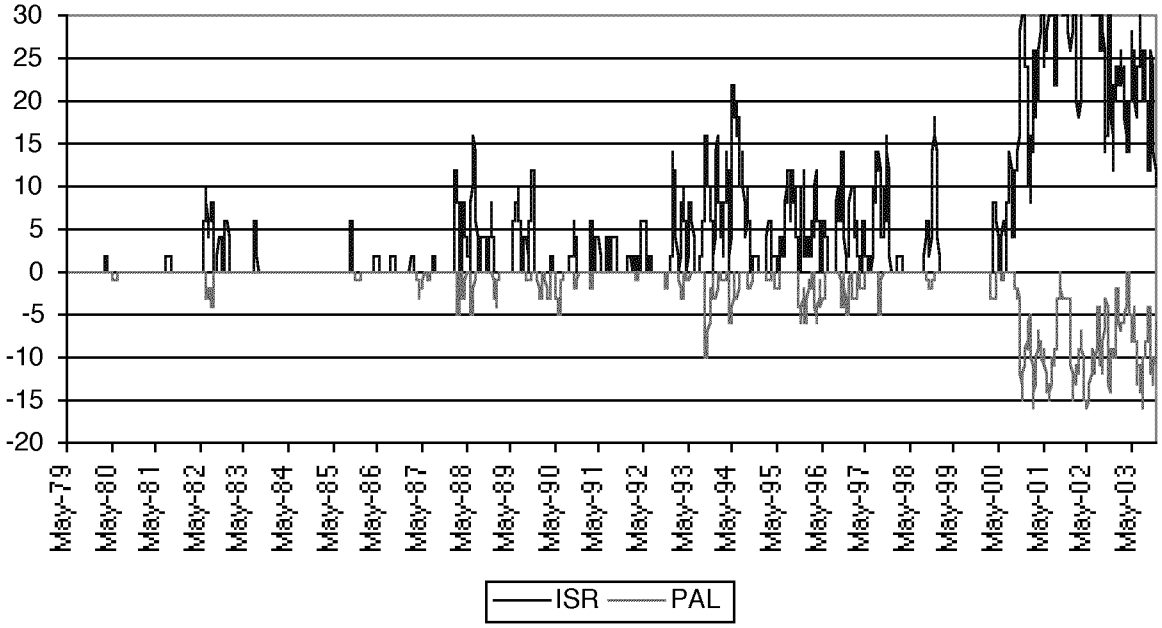

Figure 5. Olive branch pattern

The olive-branch pattern turns out to be far better than the cooperative TFT pattern at delineating the Oslo period. Like cooperative TFT, one also sees olive-branches occurring during the second *intifada*, but we believe that this is consistent with the narrative record. It is also interesting to note that one sees a number of olive-branch instances following the outbreak of the first *intifada*, and continuing in a sporadic pattern until the Oslo agreement. This would appear to be consistent with changes in Israeli policy as they experimented with a variety different levels of response to the *intifada*, and to international pressure for a resolution of the dispute following the first Iraq war in 1991. The qualitative record indicates that the Israeli response to the first *intifada* was indeed marked by shifts in strategy. As the violent response to the unrest in the territories proved to be ineffective, it became clear to Israeli leaders that a more "political" solution was required (i.e., the offering of olive branches to effect a long-term solution to the conflict) (Morris 2001, 587, 589).

The olive-branch patterns show substantially less symmetry than was seen in the TFT graphs, even in the post-Oslo period. Some of this may be a calibration issue: events with Israel as an actor are consistently reported more frequently than events with Palestine as an actor. However, this is unlikely to be the only explanation, given the symmetry for the TFT rules. A more likely explanation is that the Palestinians, as the weaker party, are more likely to be the follower than the leader in offering cooperation. This story is also consistent with the pattern seen in the cooperative TFT graph prior to Oslo: there are a number of instance when the Palestinians

engaged in cooperative TFT—that is, cooperated following cooperative behavior by Israel—but this was rarely reciprocated, as seen by the absence of spikes above the X-axis. This might have led the Palestinians to become less inclined to initiate olive-branches, since their experience is that unilateral cooperation would not be reciprocated. A final possible explanation may simply be the fact that Israel has a major stronger and cohesive state structure and is therefore better able to implement policy shifts. Prior to the Oslo process the Palestinians had very little to offer the Israelis in terms of material cooperation. It was not until the establishment of the Palestinian Authority in 1993/4 that Israel had a negotiating partner that it considered to be a legitimate representative of Palestinian interests. Also, the refusal on the part of Israel throughout most of the period prior to Oslo to negotiate with the PLO would have rendered negotiations (and thus Palestinian material cooperation) virtually impossible, as the PLO was the closest thing to a Palestinian representative that existed before the PA.

An interesting example of the olive-branch pattern in the display can be seen in Figure 6 below. We selected this because it was a frame that "jumped out" when the display as a whole was being scanned—suddenly a long series of left-filled X's (the olive-branch indicator) appear on the Israeli side (on the right), with some limited reciprocity on the Palestinian side (right-filled X's appearing on the left).

This appeared sufficiently unusual that we went back to the original source texts to see what was going on. As the figure caption indicates, this was the period of U.S.-mediated negotiations at the Wye Plantation conference center that attempted to get the Oslo process back on track amid a deteriorating security situation. As the negotiation were presented in the press reports, Israel—under U.S. pressure—was offering a number of concessions, while the Palestinian negotiators were generally considering that the U.S. was taking a position that favored Israel's interests and did not consider these offers to be adequate implementation of Oslo. While the display obviously does not provide all of that information, it does signal that something interesting is going on, and in this instance, we were alerted to this by the display.

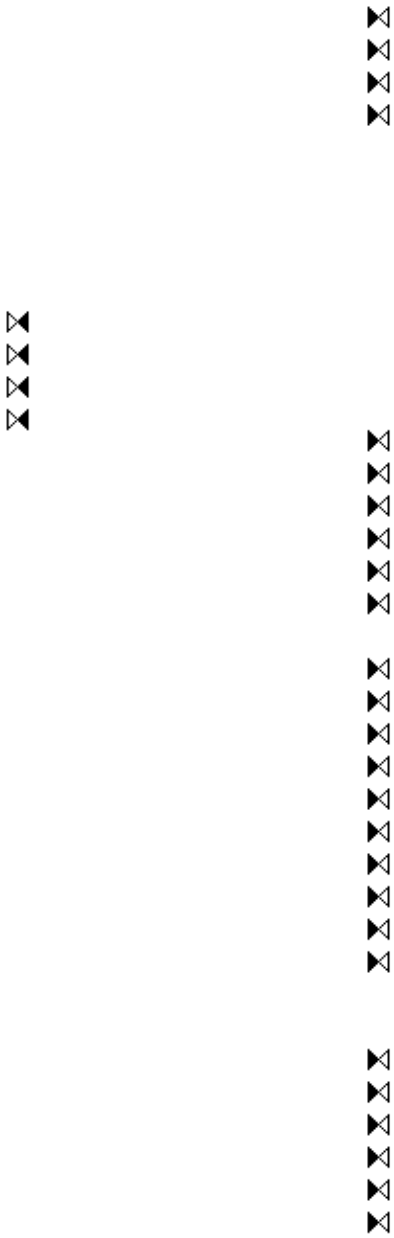

Figure 6: Olive Branches by the Palestinians and Israelis during the Wye Plantation negotiations

One of the interesting conclusions from this initial analysis is the meaning behind olive branch rule enactment. Remember that olive branch is a pattern wherein conflict by one side is met with cooperation by the other. What we found in our initial 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." There was no logical necessity for the rule to have this meaning, but it took on that meaning in the context of Israeli-Palestinian relations. It is indeed nearly impossible to find in the qualitative record an instance where an olive branch that received a violent response was followed by another olive branch.

In fact, the failure to meet post-olive branch violence with a firm (i.e., violent) response proved to be a politically costly action for those involved in the conflict. The preeminent example is the failure of Shimon Peres to respond firmly to four suicide bombings in early 1996, which followed an Israeli olive branch, the Israeli military withdrawals from major Palestinian metropolitan areas as part of Israel's initial implementation of the Oslo Accords. Peres responded to these bombings. The suicide bombings—at the time a novel tactic—were themselves a tit-for-tat response by Islamic militants to Israel's assassination of Hamas bomb expert Yahya Ayyash in early January 1996. Peres responded with closures of the Palestinian cities and a major attack on southern Lebanon, but nonetheless narrowly lost to the Likud's Benyamin Netanyahu in the June 1996 general elections (Morris 2001, 636-638).

This example illustrates some of the difficulties in following the threads of action and reaction in a conflict with multiple sub-state actors. The suicide bombings were an explicit tit-for-tat response to the assassination of Ayyash, but the first attack—nearly simultaneous bus bombings in Jerusalem and Askelon—occurred almost two months after Ayyash was killed, a much longer period than we are tracking. Peres's efforts to show readiness to use force following the bombings were primarily directed at *Lebanon*, and involved a widely-condemned attack by Israeli artillery on the UN compound at Qana that resulted in more than one-hundred civilian deaths. Peres's narrow defeat was at least partly attributable to Israeli Arabs—who would have been expected to support Peres over Netanyahu—refusing the vote for Peres as a protest over events at Qana.

Meta-Rules

A further set of experiments dealt with looking at the incidence of "meta-rules." These were implemented as four boxes of different colors at the right-hand edge of the display, and were intended to detect both the level of escalation and de-escalation in the activities, as well as its consistency. The four rules are

Red box	Meta-rule 2: no cooperation in previous period; only one side using conflict
Black box	Meta-rule 1: no cooperation in previous period; both sides now using conflict
Purple box	Meta-rule 3: no conflict in previous period; currently mixture of conflict and cooperation
Yellow box	Meta-rule 4: no conflict in previous period; currently cooperation only

In essence, the red and black boxes represent *escalation*; the purple and yellow *de-escalation*. If none of the meta-rules apply, the final column is left blank.

Making sense of the meta-rules has thus far proven more difficult than we anticipated, in part because they fluctuate quickly. Graphs similar to those used for tit-for-tat and the olive-branch rules are not particularly informative, so instead we spent some time simply looking through the entire display and trying to determine patterns using that highly sensitive pattern recognition

device, the human visual cortex. Using this method, two trends in the meta-patterns seem to be evident.

First, to use Wolfram's phrasing, "purple grows." In the parts of display prior to the Oslo Agreement in 1993, signals are usually unambiguous: there is either conflict or the absence of conflict, and the meta-boxes are either black, red, or absent (mutual cooperation unaccompanied by conflict is rare during this period, as we saw in Figures 3 and 4). In the post-Oslo period, in contrast, purple becomes more and more dominant, indicative of mixed conflict and cooperation.

This is, in all likelihood, a reflection of a critical change in the situation: the rise of Islamic militant groups to challenge the legitimacy of the Palestinian Authority and the Palestine Liberation Organization as the sole "voices" of the Palestinian opposition to Israel. A second factor that may also be contributing to this is the increase in visible international mediation, particularly by the United States and Europe, who until recently strongly encouraged talks between Israel and Palestinian representatives even there was a high level of violence on the ground. Prior to Oslo, when there was no mutual recognition between the two sides, talks (if present at all, and they usually weren't) were in secret or through intermediaries, whereas following Oslo both sides have to respond to public calls for negotiations even in times of conflict.

The second meta-pattern that we have noted is that the majority of the meta-boxes are red: following a period of no cooperation, conflict is initiated by one side or the other, rather than simultaneously. Lest this seem obvious, one should note that this is quite a different pattern than one sees in a conventional war, where the normative pattern would be that the two sides "meet on the field of battle" and engage in conflict simultaneously. In the Israel-Palestine conflict, the dominant pattern is instead *asymmetric* conflict incidents, typically in the form of brief Israeli military raids and even shorter small-scale Palestinian attacks such as violent demonstrations, attacks on Israeli settlements, and (following 1996, when the tactic was introduced) suicide bombing. While generally these occur in a tit-for-tat fashion, there is a significant time lag between the stimulus and response and this therefore triggers a red meta-rule. The qualitative record confirms that it is often the case that periods of tit-for-tat violence are clearly initiated by either side in an asymmetrical fashion that appears unprovoked in the time frames we are considered. For example, even though the violence of the first *intifada* was winding down in late 1991-early 1992, Israel engaged in unilateral violent action (the assassination of Hamas and Islamic Jihad leaders) that ultimately provoked further violence. As noted above, the Hamas retaliation to the assassination of Yahya Ayyash did not occur for almost eight weeks.

A couple of other patterns appear to suggest themselves, but we need to do further systematic analysis to determine whether these are actually occurring at a level beyond that expected by chance. First, it appears that in the pre-Oslo period, Israel tends to get the "last word" in a period of extended conflict—that is, it is an Israeli action that triggers the last occurrence of a red meta-box. Following Oslo, these shift over to the Palestinians. If this shift is in fact real, it may be another manifestation of the decentralization of Palestinian militant activity following Oslo.

The other general change between the pre- and post-Oslo pattern—and this involves an overall assessment of the display, not just the meta-rules—is the increase of material cooperation (typically, agreements) by the Palestinians. Prior to Oslo, "cooperation" by the Palestinians was simply the absence of conflict; following Oslo we start to see cooperation events, even during periods of conflict. Again, much of this can be explained by the fact of mutual recognition that

came with Oslo—prior to Oslo, the two sides had no public arena in which to cooperate. Israel, as the occupying power, could engage in unilateral concessions to the Palestinians (for example easing restrictions), but there could be no parallel official Palestinian response. This situation changed following the Oslo agreement.

• Application 3: 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 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 4 January 2006 (two governments)

In this section of the analysis, as in the previous section, we are interested in whether the patterns and changes in patterns seen through the use of EP Tool correspond with the qualitative historical record of the time. Does the record support or contradict what we are seeing? Note that this is not necessarily a one-way process. The record can correct our understanding of the visualized patterns produced by EP Tool, and this section employs that approach. However, it is also possible to use the patterns produced by EP Tool to round out accepted understandings of the historical record. For example, the Oslo negotiations are conventionally understood as a peace-oriented episode in the Israeli-Palestinian conflict. But viewing the events of that period through EP Tool reminds us that both sides were simultaneously engaged in material conflict above their threshold levels throughout the negotiations. Thus, we can correlate the record produced by historians with the record produced through a technique like EP Tool in bi-directional fashion.

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 recorded in the event data 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, reflecting, no doubt, the worsening situation in Lebanon. However, conflict activity by the Israelis outside of Lebanon appears to abate as the Israelis become preoccupied elsewhere. It should be noted, however, that, though less frequent in occurrence, the episodes of Palestinian violence outside of Lebanon found during this period were nevertheless laden with political significance. For example, a Jewish terrorist attack against students at the University of Hebron in July 1983 was a rallying point for the nascent Palestinian nationalist movement that would later manifest itself as the first *intifada*. The attack contributed directly to the growth of the Palestinian wing of the Muslim Brotherhood, Hamas (Morris 2001, 569).

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. Shamir instigated a crackdown on militant activity by the Muslim Brotherhood early in his tenure as prime minister, most notably by orchestrating a June 1984 raid by the General Security Serivices (GSS) on a mosque where the Brotherhood was stockpiling weapons. As the Palestinian nationalist movement was still in its early stages at the beginning of Shamir's tenure, the violence was mostly one-sided (Morris 2001, 574). In the weeks preceding his government's collapse, the Israelis cease 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. The olive branch likely represents the Israeli release of 1150 Palestinian prisoners in May 1985 (Morris 2001, 574). 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

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. While the violence on the part of the Palestinians was at a relatively low level at this point, the attacks that did take place were significantly provocative to increase Israeli conflict behavior (e.g., firefights with Islamic Jihad members on 1 and 6 October 1987). On 15 October 1986 (and the end of the Peres tenure) Islamic Jihad and Fatah jointly carried out a grenade attack during an IDF swearing-in ceremony at the Western Wall In Jerusalem. In May 1987, several Islamic Jihad members escaped Gaza Prison and sparked the beginning of a new guerilla campaign, marked for example by the killing of an IDF commander in Gaza on 8 August 1987. Thus, Israeli conflict activity during this period can be understood as TFT responses to Palestinian violence (Morris 2001, 571). There is also evidence of asymmetric conflict on the part of the Palestinians (i.e., conflict behavior not met with a significant Israeli response). On 31 May 1987, there was a major uprising in the Balata refugee

camp outside Nablus in the West Bank. The IDF attempted to quell the violence, but eventually gave up rather than fire on the crowd and provoke further violence (572-573).

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. The qualitative record echoes these observations: the "official" beginning of the *intifada* came in December 1987, the period from October to December was also marked by a significant increase in TFT conflict that ultimately reached very high levels (Morris, 2001, 571-573). 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. A possible olive branch on the part of the Palestinians is the explicit PLO prohibition of terrorist attacks against Israeli civilians. Following the findings from the pattern analysis, this prohibition did not prevent attacks by Hamas and Islamic Jihad (583). 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).

The offering of olive branches by Israel is a reflection of the conclusion voiced by Defense Minister Yitzhak Rabin in January 1988 (early in the *intifada*) that the Israeli response would have to be a "political" one. There was strong hesitance on the part of Israeli political figures (especially Shamir and Rabin) to utilize extreme military measures such as the use of battlefield weapons—a common occurrence in the more highly militarized second *intifada*—to extinguish the uprising. For example, on 23 February 1988 Israel discontinued the use of the "beatings policy" that it had been using (unsuccessfully) to quell violent demonstrations. Such restraint can be understood as a reflection of the Israeli realization that political olive branches would be the best way to deal with the Palestinians (587-590).

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. In January 1989, following intense mediation by the United States and various European intermediaries, Shamir gave his blessing to offering of a peace proposal to the Palestinians (headed by the PLO), following Arafat's renunciation of terrorism on 15 December 1988. The PLO rejected the proposal (Morris 2001, 608-609). With that rejection, Shamir reverts to a strategy of offering both violence (tit-for-tat and non-tit-for-tat) and olive branches at the same time. On 14 May 1989 the cabinet approved a Shamir peace plan that would be offered to the Palestinians. This marked the beginning of the ongoing Israeli attempts to deal with the conflict by offering concrete political solutions, a process that culminated with the Oslo process. The ongoing i*ntifada* is responsible for the TFT and non-TFT violence accompanying these olive branches (609).

Cabinet approval of the Shamir peace plan actually leads to a nearly month-long cessation of significant violence by both sides. Even after the calm is broken by the Palestinians with their abortive beach raid south of Tel Aviv on 20 June 1989, 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 Palestinians. The olive branch here was a "revised" version issued by hardliners in Shamir's Likud Party in July 1989. The new proposal placed heavy conditions on the proposal offered in May. The conditions (including, for example, explicit Israeli

commitment to further settlement expansion in the territories) seemed to make clear the unwillingness of certain elements in Israel to make any concessions to the Palestinians, and the plan was accordingly rejected by the PLO. Following this half-hearted olive branch, the Labor Party left the Unity Government in March 1990, and Shamir put together a hard-line rightist government in June. The collective effect of the Israeli move to the right was a return to a more military response to the *intifada* that was marked by TFT and non-TFT violence. The move back to violence rather than olive branches seems to have begun after the PLO rejection of the final hard-line Likud peace proposal (May-June 1989). However, the eventual departure of Labor from the government pushed Israel even further in the direction of violence (Morris 2001, 609-610).

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 late 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. Both the in-phase olive branches and the lull in violence can likely be explained by Shamir's agreement on 1 August to participate in the Madrid Peace conference as the result of outside pressure from the United States and other Middle Eastern leaders (Morris 2001, 614). 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. The qualitative record shows that in late 1991-early 1992 Israel resumed a policy that it had used early in the *intifada* to deal with Islamic Jihad and Hamas. IDF troops in the territories hunted down and killed suspected leaders of the *intifada*, which may account for the one-sided violence during this period. It was also the case that the overall violence levels were lower during this period, as the *intifada* was beginning to wind down (Human Rights Watch 1991, 1992).

Yitzhak Rabin appears to come into office determined to prove his ability to be "tough" with the Palestinians. Though Rabin began his term promising toughness in dealing with the Palestinians (likely as the result of both political necessity and personal temperament), his tenure would mark a significant shift in the character of the conflict that ultimately precipitated the Oslo peace process. Rabin had come to the conclusion that the violence experienced during the *intifada* would be the norm unless Israel were to conclude some sort of territorial settlement with the Palestinians. The end of the Cold War also provided a unique window of opportunity, as the disappearance of the Arab world's Soviet sponsors, along with the isolation of the Palestinians by many Arab states in response to Arafat's support of Saddam Hussein's invasion of Kuwait, left the Palestinians in a particularly vulnerable political position that might force them to be pliable in negotiations. Rabin's time as prime minister was marked by the contrast between short- and long-term solutions to the Palestinian problem (Morris 2001, 616). The Palestinians nevertheless offer Rabin a short honeymoon, but after several weeks, respond to Rabin's "tough

approach" with violence—and with an olive branch at the same time. In late 1992 the GSS began a campaign to round up Palestinian fundamentalists in the West Bank in response to terrorist activity originating there. Israel took the additional step of closing the territories in March 1993 in response to terrorist attacks in Jerusalem and Tel Aviv. Thus, both ongoing TFT conflict and the nascent peace process (i.e., mutual olive branches) marked this period (617-618, Human Rights Watch 1993).

After a period of mis-matched offerings of olive branches, something seems to move the olive branches into phase with one another. The qualitative record shows that from May to August 1993 the Israelis and Palestinians began serious negotiations in which both sides offered concessions, which would explain the in-phase olive branches during this period (Morris 2001, 620-621). 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. It is important to note that by this point, the distinction between Islamic militant groups, who rejected the Oslo Agreement, and the PLO, which accepted it, begins to become critical: what we are probably seeing in much of this record is increased Israeli cooperation with the PLO, while Islamic militants continue with attacks that are designed to thwart that cooperation. In the future we intend to do analyses that will disaggregate these subnational actors.

Comparing these observations with the historical record, some TFT violence took place in early-mid 1994, beginning with Israeli settler Baruch Goldstein's massacre of Palestinians at the Tomb of the Patriarchs in Hebron on 25 February. Violent attacks by Palestinians groups following the incident were met with a violent response by Israel. As 1994 wore on, the overall violence did seem to lower in intensity, despite a rash of Islamic Jihad/Hamas suicide bombings inside Israel throughout 1994 and early 1995 (626). Israel offered some significant olive branches during this period: the agreement to a small number of international monitors in Hebron, as well as agreeing to the eventual transfer of a measure of sovereignty in Hebron to the Palestinian Authority (PA) and the release of some Palestinian prisoners. These Israeli olive branches were not met with similar overtures by PA leadership, perhaps because the Palestinians had little to offer at this point. Also, Yasser Arafat was still hesitant to be too accommodating toward Israel because of internal political pressures, the threat of civil war posed by Islamic Jihad and Hamas opposition to the peace process, and the continued closure of the territories (625-626, Human Rights Watch 1994).

Rabin was assassinated in November 1995. 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 Palestinian militant groupss in the face of repeated Israeli olive branches directed towards the new Palestinian Authority as part of the early implementation of the Oslo Agreements. The qualitative record shows that in February-March 1996 Hamas and Islamic Jihad carried out a series of spectacular suicide bombings inside Israel. Interestingly, these followed an Israeli olive branch: the removal of Israel military control from most major Palestinian cities in the West Bank.

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 historical record shows that the Israeli side of the conflict was relatively quiet until September 1996, when Netanyahu approved the opening of an exit of archaeological tunnel that runs the length of the Western Wall of the Temple Mount in Jerusalem. Rabin had been hesitant to open the tunnel exit because of it sensitivity, and it seems to be the case that Netanyahu took this action to establish that he would be dealing with Israeli-Palestinian issues in a more aggressive fashion. Not surprisingly, massive violence erupted in the main towns of the West Bank and Gaza as a result (Morris 2001, 641-642).

The next time violence breaks out, we get a period of mismatched olive branches in the context of sporadic violence from late 1996 to early 1997. The mismatched olive branches likely took place in the context of the troubled negotiations between Netanyahu and Arafat from October 1996 to January 1997. The two sides were only able to reach very contingent and tenuous agreement on a few issues, such as IDF redeployment in the West Bank, PA control of Hebron, and the status of the Oslo process. The negotiations took place against a backdrop of sporadic violence (Morris 2001, 642-643). In mid-1997, we do get matched olive branches, after which violence peters out on both sides until late summer of 1998. The historical record generally confirms this interpretation: though the aforementioned negotiations were rocky, they did result in some mutual concessions (i.e., matched olive branches): Israel agreed to withdraw from parts of Hebron, although Israeli settlements in the center of the city remained, and the PA agreed to more actively suppress terrorist activity and networking ability in its territory. There was less violence overall during this period, but there were two major suicide attacks in Jerusalem in July and September 1997 (643-646).

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. The qualitative record suggests that the period from 1998 to 1999 was one of the quietest in the conflict. There is evidence that while Israel did not respond in the typical TFT manner to Palestinian violence during this period, it did take aggressive measures in response to attacks, such as widespread house demolitions (Human Rights Watch 1999). The olive branches during this period took place in the context of the Wye River negotiations in late 1998. The offers made by Israel were much more limited and contingent than those offered in earlier negotiations (e.g., Oslo), which is perhaps remarkable given the low level of violence during this period. Both sides ended up reneging on the promises made at Wye, and the failure of the process ultimately led to the downfall of the Netanyahu government (Morris 2001, 646-651).

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. The

low violence level and the repeated Israeli olive branches found during this period reflect the Sharm ash Sheikh and Camp David negotiations ongoing during the early part of Barak's tenure. Israel offered more unilateral concessions during these meetings than it had at any point since Oslo. Indeed, Barak's strong desire to propel the peace process forward informed his political strategy from the beginning of his brief time as prime minister. This desire was most clearly illustrated by the tortuous negotiations in which Barak engaged in order to patch together a coalition that would be amenable to the peace process. The failure of the negotiations was largely due to Arafat's failure to respond in kind with olive branches of its own, since Arafat felt that the agreements offered in 2000 did not go even as far as what had originally been promised in Oslo seven years earlier. There seems to be a direct relationship between the failure of the negotiations, the subsequent destabilization of the Barak government, and the buildup of violent tension in the territories that was to explode in September 2000 (Morris 2001, 652-654, 658-660).

When Ariel Sharon goes to the Temple Mount in that month, 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. Despite the chaos that marked the commencement of the second *intifada*, an olive branch does appear in the historical narrative. Israel, the PA, and the leaders of several Arab states met in October 2000 in an unsuccessful bid to bring an end to the violence (Morris 2001, 669). This pattern, or lack of pattern, of interaction continues throughout the Sharon years, until our 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, which is consistent with Palestinian hopes for a meaningful resumption of the Oslo process under a Labor government, following the general hostility to Oslo expressed by Netanyahu's Likud government. 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. Barak's tenure offers counterfactual evidence supporting the contention that the use of violence by the Palestinians is causally related to the prospects of the peace process. As it became more and more apparent that the Sharm ash Sheikh and Camp David negotiations in 1999/2000 would be unsuccessful—or if successful, only under terms unacceptable to Hamas and Islamic Jihad—Palestinian groups began preparing for violence.

Thus, the failure of negotiations during this period is likely responsible for the buildup of tension that was to become the second *intifada* (Morris 2001, 666). It does appear that the Palestinians thought they could influence Benjamin Netanyahu into continuing the Oslo process 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. The period following Netanyahu's election in June 1996 was largely free of Palestinian attacks, perhaps due in part to an Israeli crackdown in the territories following a rash of attacks in February-March 1996. Alternatively,

militants may have decided that they had retaliated sufficiently to avenge the death of Ayyash. Another likely factor was the desire on the part of elements on both sides to rescue the peace process following the tumult of Rabin's assassination and the Peres tenure. The "honeymoon" came to an end with the tunnel opening in the Old City of Jerusalem and the resulting violence (641). Of course, some prime ministers get no honeymoon at all, Ariel Sharon being an excellent case in point. It was, after all, Sharon's visit to the Temple Mount on 28 September 2000 that instigated the violence that was to mark much of the Sharon tenure that would follow, and Sharon, architect of the 1982 invasion of Lebanon, had been intensely unpopular with Palestinians for years.

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. During the period of the National Unity Government (1984-1988) the Israelis adopted a hard-line stance with regard to the Palestinians, which was referred to as the "iron fist" policy. It is not surprising, then, that the tenure of Peres (and Shamir after him) would be marked by increased one-sided conflict with the Palestinians. And when Rabin is assassinated, the Palestinian militant groups step up violence even as the Israelis are redeploying troops away from West Bank urban areas.

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, in part because so many autonomous actors were engaged in the conflict, particularly on the Palestinian side. 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 is also certainly due to the proliferation of subnational actors, with very different agendas on core issues such as the Oslo Accords. A future analysis will reveal whether Palestinian behavior is clearer when each subnational actor is examined in isolation.

The preceding comparisons of visualized event patterns with the actual historical record for the tenures of the various prime ministers are instructive. It has been gratifying to discover that an

examination of the qualitative historical record has for the most part confirmed the patterns and changes in patterns that we are identifying through reverse Wolfram modeling using EP Tool. Such comparisons provide an important measure of face validity for the overall approach.

- ## Application 4: Analyzing Pause and Provocation in Israeli-Palestinian Interaction

To this point, we have relied on only three pattern: tit-for-tat, olive branch, and the four meta-rules. 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. If we operationalize the "pause rule" as on in which one side offers material cooperation behavior accompanied by a relative lack of material conflict for several days, are such pauses used in Palestinian-Israeli signaling? Figure 7 illustrates one example from late 1982, following Israel's invasion of Lebanon, an operation directed against the PLO. Notice the filled boxes in the column to the right. These identify the use of the Israeli pause, a signal that 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. Notice also how the Palestinians do begin to reciprocate the syncopated pause (filled diamonds in the left column), in what is presumably an attempt to begin and maintain a de-escalatory sequence with the Israelis.

Figure 7: Palestinian and Israeli Pauses, late 1982

Let us now turn to the Palestinians' use of the pause, denoted by a black diamond in the first column. Here we see in mid-1980 an effective Palestinian use of the pause leading to a period of considerable calm between the two sides. Notice that the Israeli response does not include offering any material cooperation (no filled boxes appear), but the Palestinians' pause does lead to significant decrease in conflict by the Israeli side. The outlined points indicate relative lack of violence (i.e., violence below the thresholds of the respective sides); the filled points on the Israeli side indicate material conflict above their threshold.

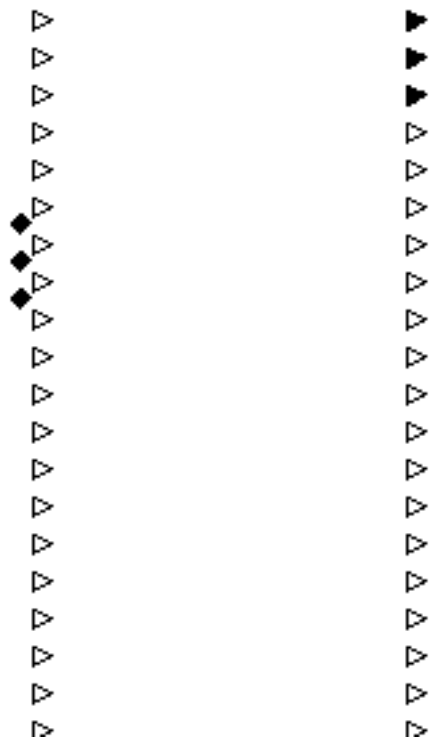

Figure 8: A Palestinian Pause in mid-1980, leading to a period of calm on both sides

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

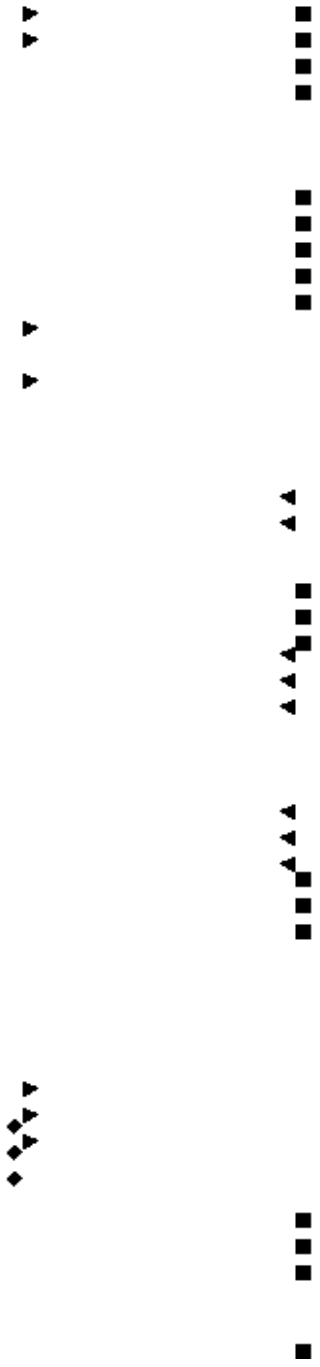

Figure 9: Late 1997 Sequence of Pauses and Escalation between the Israelis and Palestinians

Tracking the diamonds (Palestinian pauses) and filled boxes (Israeli pauses), we see first see a pause by the Israelis. Despite subsequent non-tit-for-tat Palestinian conflict (filled points facing right in the left column), the Israelis repeatedly signal with pauses. However, when these are not reciprocated, the Israelis begin a long episode of non-tit-for-tat conflict punctuated by pauses,

just as the Palestinians are significantly lowering their level of material conflict. The Palestinians finally offer a pause (after an episode of escalatory material conflict), which the Israelis then reciprocate, and the sequence ends with relative calm on both sides.

Do both sides ever pause at the same time? Yes, and the inauguration of matched pauses actually delineated the Oslo period. These matched pauses do ratchet down the violence between the two sides as well, though it does not eliminate it by any means. Here are some matched pauses from the end of 1993:

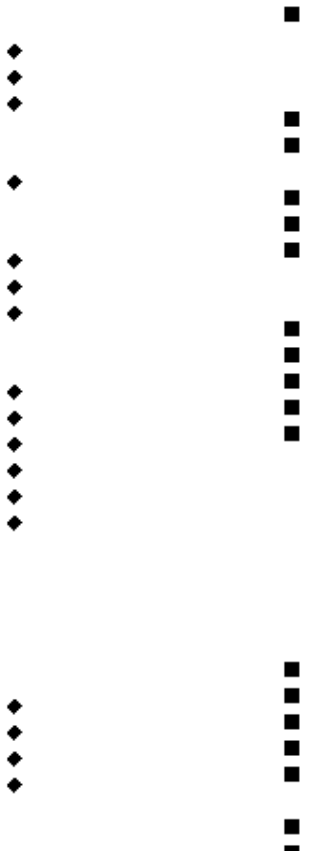

Figure 10: Matched Palestinian-Israeli Pauses at the Start of the Oslo Process

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, though this may partly be a function of the slower response of the Palestinians to earlier Israeli actions. 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 counter–intuitively, 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, or make mark the end of a tit-for-tat: there is an action, a retaliation, and then the situation is temporarily resolved. Here is an example from early 1983, with filled arrows to the left representing Palestinian provocation, and filled arrows to the right representing Israeli provocation:

Figure11: Provocation by Palestinians then retaliatory provocation by Israelis, followed by relative calm; early 1983.

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 mid-1990. In this case, the right-facing arrows are Israeli provocation, while left-facing arrows are the Palestinian conflictual response (remember each row is equivalent to two days). Thus, it takes the Palestinians at least two weeks to revenge the Israeli provocation. Over time, however, the Palestinian response time shortens considerably; by the end of the dataset (2004), revenge to a provocation comes almost as swiftly as the Israelis' capability to respond.

Figure 12: Response Time by the Palestinians to an Israeli provocation, mid-1990

Now compare the above to Israeli response to Palestinian provocation, from late 1980; the left-facing arrow is the Palestinian provocation after a period of general calm, and the right-facing arrow is the immediate Israeli retaliation for the provocation:

Figure 13: Palestinian provocation, with immediate Israeli retaliation, late 1980

There appears to be a clear difference in organizational ability for retaliation between the Israelis and Palestinians, which narrows over the time span of the dataset.

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

Enhancements to the www.nkss.org software environment

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 are in the process of adding the following capabilities.

1. 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.
2. Tools for evaluating and possibly inducing rules. At the minimum this will involve the computation and display of conditional probabilities (Schrodt, Hudson, and Whitmer, forthcoming). 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.
3. 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 could stand 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. Further 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 by the actors involved. 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.

Conclusion

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.

Event data have been employed in the analysis of international behavior for over four decades, but arguably we are still trying to learn how to use them effectively. This type of data—a nominal time series—is rarely encountered in other fields such as economics and industrial process control that make extensive use of statistical methods, and consequently there are relatively few places from which we can borrow techniques. Instead we must invent our own.

This paper has been an initial foray into the realm of using discrete patterns similar to those pioneered by Wolfram as a tool for event analysis. Our work here has been primarily a

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. A comparison of the visualized patterns produced by reverse Wolfram modeling and the qualitative historical record indicates a fairly robust level of face validity for the overall approach.

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 aggregation methods available in the pattern-specification language with the ability to rapidly construct colorful, web-based displays at a very fine time interval, the possibilities for interaction analysis increase substantially. 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.

If social science can develop new methodologies that are capable of preserving the agential basis of social interaction, capable of analyzing the rules behind such purposive behavior, capable of tracking multiple agents as they enact rules through behavior directed at one another, and capable of capturing the evolution of such interaction over time, it will possess the capabilities necessary to move past the current stage of relative methodological anomie. We believe that reverse Wolfram modeling may reasonably be expected to be part of that emerging tool set.

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