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Markov Chain Models of Negotiators' Communication

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Negotiators' communication can be analysed at several levels: the frequency with which strategies are used, how negotiators sequence strategies and how strategies evolve over time. Each level of analysis provides us with different kinds of information about the negotiation process. An important difference between these approaches is that analyses focusing on how often negotiators use a specific strategy assume that the negotiation process is static over time whereas analyses that focus on sequences or phases allow for the possibility that, as negotiators learn about each other, they redefine the negotiation and change their strategy preferences. (See also Encyclopedia entry on Quantitative Coding of Negotiation Behavior by Weingart and Olekalns.) The analysis of sequences enables us to answer questions that cannot be answered by focusing solely on the frequency with which negotiators use particular strategies. By analyzing sequences, we are able to assess how negotiations unfold over time and how negotiators influence each other and transform the negotiation. Understanding how the negotiation is transformed is especially important because it helps us to identify the most important mechanisms for building mutually beneficial solutions across a range of questions. In this entry, we describe the use of Markov Chain models to represent and analyse strategy sequences (Bakeman & Gottman, 1986; Smith, Olekalns & Weingart, 2006; Thomas, 1985).

At its simplest, a strategy sequence describes an action-reaction pattern which represents the strategy used by one negotiator (Negotiator A) and the response from the other negotiator (Negotiator B). Thus, a basic sequence looks like this: $\text{strategy}_{\text{Negotiator A}} \rightarrow \text{strategy}_{\text{Negotiator B.}}$ Researchers might start by asking about the basic structure of sequences: do negotiators match or mismatch each others' strategies? At this level of analysis, sequences can be described as reciprocal, complementary or structural. When negotiators reciprocate, they match each other's strategies exactly ($\text{threat}_{\text{Negotiator A}} \rightarrow$

threat$_{\text{Negotiator B}}$). However, they may also loosely match each others' strategies, maintaining a broad strategic approach in which they respond with similar, but not identical, strategies. (threat$_{\text{Negotiator A}}$ $\rightarrow$ argumentation$_{\text{Negotiator B}}$). Finally, negotiators may mismatch strategies, so that a cooperative behaviour is followed by a competitive one, or vice versa (threat$_{\text{Negotiator A}}$ $\rightarrow$ problem-solving$_{\text{Negotiator B}}$). Although some research questions may be answered by focusing on this very general categorization of sequences, it is more revealing to focus on both the form and content of sequences. This allows researchers to answer questions such as: What is the likelihood that cooperative tactics will be reciprocated? Is the reciprocation of cooperative tactics related to the quality of negotiated outcomes? Does the relationship between integrative reciprocity and outcome quality hold irrespective of the negotiating context?

Data Preparation.

Answers to these kinds of questions require that we first decide on the number of strategies to be included in the analysis. We may choose to use a very broad classificatory scheme, for example, by coding strategies as either 'integrative' or 'distributive'; or we may choose instead to undertake a more fine-grained classification of strategies, breaking down the broad integrative-distributive categories into more distinct behaviours such as process management, priority information, argumentation, proposal management and contention. Once the strategies are coded, we construct a contingency table that summarizes the number of strategy sequences of each kind in the negotiation. At its simplest, the sequences can be represented in a 2 x 2 contingency table in which one dimension, or margin, of the table shows Negotiator A's strategy (cooperative or competitive) and the other dimension shows Negotiator B's response (cooperative or competitive). The entries in the table represent the frequency of each of the possible strategy-response pairs, that is, of each possible strategy by Negotiator A followed by each possible response by Negotiator B.

Contingency tables become more complex as we add dimensions for variables such as negotiators' outcomes and the negotiation context. We may, for example, create a 4-dimensional contingency table to represent each negotiator's strategy (cooperative or competitive), their joint outcome (low, moderate, high) and the level of power within a dyad (equal or unequal). As we add dimensions to a contingency table, the number of cells rapidly increases, creating very sparse data for subsequent analysis. For this reason, it is important to consider how many categories will be used to code the data. Choosing broad categories has the advantage that, in subsequent analyses, researchers have many observations in each cell of their contingency table. However, they may miss subtle nuances in negotiators' interactions. Conversely, using many categories creates sparse tables with many empty cells. In our analyses, we have found that using between 4 and 7 strategy clusters creates sufficiently well-populated contingency tables while adequately capturing the emerging negotiation process.

Markov Chains.

Markov chain analyses are based on a representation of the negotiating dyad as a system, which can be in one of a finite number of states at any time, each with some probability. The states describe the propensity or disposition of each member of the dyad to use each of the strategies available to them. The sequencing of strategies, conceived of as a sequence of transitions between states, is described by a simple probability model. Markov chain analyses recognize that, at any given time, negotiators can choose to use one of several strategies. The probability that they will prefer one strategy over others is determined by their opponents' preceding strategy. Specifically, Markov chain models allow us to determine the probability that Negotiator B will use a particular strategy from the set of strategies we have defined, based on the strategy used by Negotiator A: If Negotiator A uses a cooperative strategy, what is the probability that negotiator B will respond with a cooperative strategy or a competitive strategy?

An important question is how far back in the negotiation do we need to look in order to determine the probability that Negotiator B will at this point in time choose a specific strategy, X_n. Is it sufficient to know Negotiator A's immediately preceding strategy or do we need to trace the process back through several turns. The Markov assumption states that the probability of X_n (Negotiator B's strategy choice at *this* point in time) depends on only a fixed number of the set of preceding X values (strategies). How far back in time do we need to go determine the level (order) of the Markov chain. If we need to look only at the preceding strategy used by Negotiator A to predict Negotiator B's strategy choice, we are representing the sequence as a *first-order* Markov chain, $X_{n-1} \rightarrow X_n$. It may, however, be that Negotiator B's current strategy choice is predicted by both Negotiator A's immediately preceding strategy and Negotiator B's own earlier strategy. To predict Negotiator B's strategy we need to go back two steps in time and represent the sequence as a *second-order* Markov chain, $X_{n-2} \rightarrow X_{n-1} \rightarrow X_n$. As well being important conceptually, the question of the order of a Markov chain is important statistically. The order of the chain determines the minimum size of the contingency table needed to render successive parts of a sequence of strategies conditionally independent of one another. Conditional independence is required in order to analyze the data using widely available loglinear models. In our research, we have found that second-order Markov chains are usually sufficient to capture the structure of negotiation. To represent the dependencies between consecutive strategies, we construct a transition matrix from our contingency table. The transition matrix expresses the conditional probability that each of the set of possible strategies will be reciprocated by each of the others. The simplest analysis that we can conduct is to code strategies as either cooperative or competitive and to restrict our analysis to first-order Markov chains, that is, sequences of two strategies, $X_{n-1} \rightarrow X_n$. In this case, a transition matrix might look like this:

		Time n	
		Cooperative	Competitive
Time n-1	Cooperative	0.6	0.4
	Competitive	0.3	0.7

This table shows that the probability of reciprocating a cooperative strategy is 0.6, whereas the probability of reciprocating a competitive strategy is 0.7.

Loglinear Analysis of Markov Chain Models.

Because the data are a multi-way contingency table, loglinear analysis provides a convenient and readily accessible technique for analysing Markov chain models (Agresti, 1990). A difference between other applications of loglinear models and their application to Markov chains is that the unit of analysis changes from the individual to the strategy or speech act. The first step in using loglinear models is the creation of a contingency table. In this table, the margins are formed by strategies at consecutive steps in time. Again, the simplest model would be 2-dimensional, cross-classifying the strategies used at Time N and Time N-1 ($X_{n-1} \rightarrow X_n$). The number of dimensions in the contingency table is thus determined by the expected order of the underlying Markov chain. A 2-dimensional table is required to represent a first-order Markov chain whereas a 3-dimensional table is required to represent a second-order Markov chain, and so on. In this analysis, sequential dependencies appear statistically as interactions between strategies: A first order chain emerges as an interaction between strategies at Time N and Time N-1 (X_{n-1} *X_n), whereas a second-order chain would appears as an interaction between strategies at Time N, Time N-1 and Time N-2 (X_{n-2} *X_{n-1} *X_n).

To understand which sequence structure best captures the underlying data, we use the likelihood ratio test statistic, G^2, to test for model fit. Typically, we start by testing whether an independence model, comprising simple frequencies with no interactions, fits the data. We do this in the largest non-sparse contingency table we can form using the available data. We then add model terms of increasing complexity (two-way interactions for first order chains, followed by three-way interactions for second order chains, and so on), testing whether the inclusion of these terms improves the fit of the model to the data. To test this, we look for significant changes in G^2 at each step.

Adding Dimensions

So far, we have described relatively simple models that will help us answer the question "Can we predict Negotiator B's strategy at a given point in time, if we know what Negotiator A (and negotiator B) did in the immediately preceding moments of the negotiation?" While this question is interesting in its own right, we are able to ask considerably more complex questions that increase our understanding of the negotiation process by adding other variables to the model. We might choose to compare different subgroups based, for example, on their goals. We might compare negotiating dyads or groups who both have cooperative goals to dyads with competitive or mixed goals (i.e., one negotiator has a competitive goal, the other has a cooperative goal; see Brett, Weingart, Olekalns & Smith, 2007). This *prospective* classification of our sample allows us to compare how negotiators' goals shape the strategy sequences that dominate a negotiation. In past research, researchers have tested how negotiators' goals, tactical knowledge (present/absent) and power (low/high) affect the emergence of dominant strategy sequences. Alternatively, we might *retrospectively* classify subgroups based on their outcomes (for example, low, moderate and high joint gain.) This kind of classification allows us to ask whether there are unique sequences that are associated with each kind of outcome. Past research has shown that negotiators who use competitive-competitive sequences are more likely to obtain low joint gain whereas those who use cooperative-cooperative sequences are more likely to obtain high joint gain. A different kind of retrospective classification is based on time. By subdividing the negotiation into halves (or even smaller units), we can examine whether negotiators use different sequences in difference stages of a negotiation. Any one of these classifications (goals, outcomes, time) adds another dimension to the contingency table. We can expand the contingency table further to ask even more complex questions, linking prospective and retrospective classifications of negotiation strategies. Examples of such complex models can be seen in Olekalns and Smith's (2003) research linking negotiators' goals, strategies sequences and outcomes.

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Key Terms

Negotiation processes, Markov chains, strategy sequences, reciprocity

Biographies

Mara Olekalns (PhD, University of Adelaide) is a Professor of Management (Negotiations) at the Melbourne Business School, University of Melbourne. Her research examines the factors that shape strategy choices in negotiation, including trust, power and outcome goals. She also researches how gender stereotypes affect negotiators' trustworthiness and outcomes.

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Laurie R. Weingart is Professor of Organizational Behavior at the Tepper School of Business, Carnegie Mellon University. Her research focuses on negotiation processes in dyads and group and conflict and innovation within interdisciplinary teams. She is currently President of the Interdisciplinary Network for Group Research and is past-president of the International Association for Conflict Management.

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