Hierarchical Modeling of Relational Event Data

Nicole Pierski[1], Chris DuBois[2], Carter T. Butts[1,3], Dan McFarland[4]

1. Department of Sociology, 2. Department of Statistics, 3. Institute of Mathematical Behavioral Science | University of California Irvine
4. School of Education | Stanford University

Motivation

How can we study the mechanisms driving relational dynamics in large populations of heterogeneous subgroups? How can we identify the extent to which different individuals' characteristics, or properties of the network setting, influence behavioral tendencies within and across groups?

Overview

Modeling group structure within networks as well as dynamic networks is a topic of continuing substantive and methodological interest. Here, we analyze relational event data collected by McFarland (2001) by applying a hierarchical extension of the relational event model (Butts 2008) to explore how these mechanisms vary across observed sequences.

Data

The data, collected by Dan McFarland of Stanford's School of Education, consists of sequences of classroom observations among high school students and teachers. Data was also collected on course content, teaching style, student demographics, and classroom dynamics such as seating charts and student friendships. The sequences of interactions analyzed here involve conversation dynamics–turn-taking and reciprocity–within 316 classroom sessions, involving 162 teachers and 3167 students, taking place over varying times and days of the week as well as in various class topics. The following describe the classroom sessions in general.

	Average
Number of individuals per session	20.28
Number of interactions per session	284.42
Percentage Female	0.54
Percentage White	0.79

Relational Event Data

Conversation Dynamics

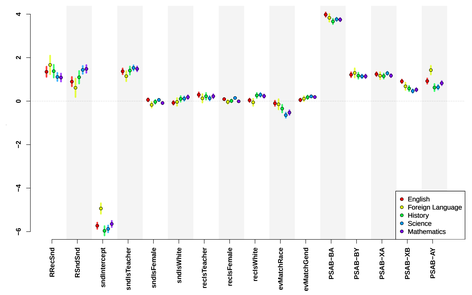


Figure: Population-level estimates of mean coefficients by interaction mechanism and class subject. Coefficients reflect the direction and strength of each effect in the group-level model; *Y* axis shows expected coefficients for new classes from the same population, as estimated by 2-stage WLS based on group-level posterior mode analysis. Analysis shows that interaction mechanisms are highly stable across classrooms, but that small differences do exist by educational context (class subject).

Core Mechanisms

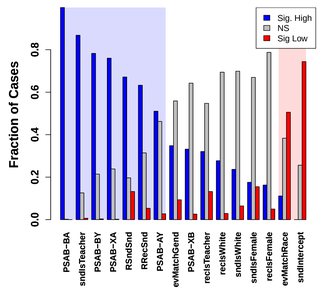


Figure: For each interaction mechanism, fraction of classrooms showing positive, negative, and non-significant coefficients. (Significance assessed at 2 posterior standard deviations from 0.) Core conversational mechanisms such as turn-taking (PS*), recency (R*), and teacher initiation (sndIsTeacher) are enhanced in most classrooms (blue shading); overall density (sndIntercept) and racial homophily (evMatchRace) are systematically suppressed (red). Mechanisms involving gender, race differences in participation, and teacher-targeted speech are not reliably significant, although they do appear in some classes.

A Closer Look at Interaction Across Subjects

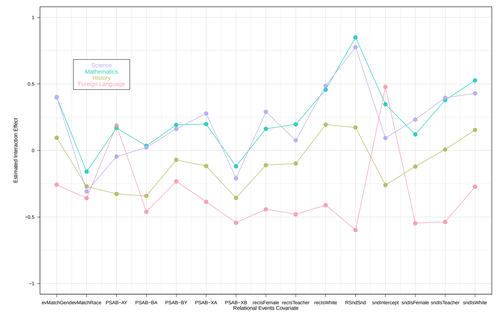


Figure: Interaction effects for class subject by mechanism type, controlling for subject and mechanism main effects. Overall, foreign language classes show the least structured conversation (low coefficients on driving mechanisms), with math and science classes showing the most structure; history is intermediate. Hierarchical analysis allows us to uncover contextual effects that may drive how group behavior unfolds.

Correlation between Coefficients

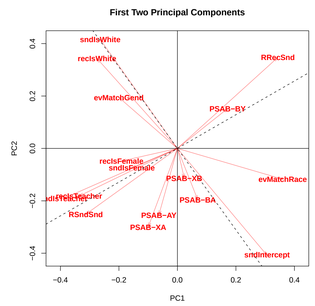
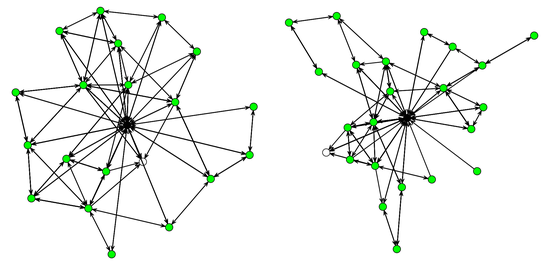
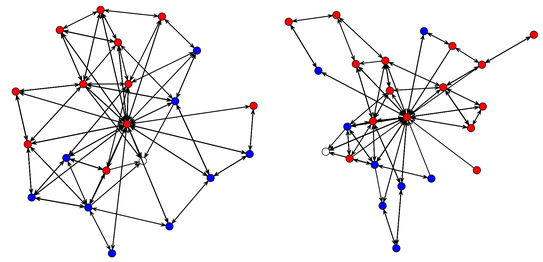


Figure: Two-dimensional PCA of estimated coefficients, with varimax rotation (dotted axes). Two primary dimensions in the interaction mechanisms are (1) a contrast between tendencies towards disproportionate participation by white students coupled with gender homophily versus greater overall communication, more turn-taking reciprocity, and greater race matching; and (2) a contrast between greater teacher and female participation and conversational persistence, versus greater turn-passing and long-term reciprocity. While mechanisms are similar across classes, deviations show systematic patterns.

Example Classrooms



These two networks are examples of a classroom session. Interactions are aggregated over time and individual are colored according to role - student or teacher. Black nodes indicate teachers and green nodes indicate students.



Here we show the same two classroom sessions colored by gender. Red nodes are females and blue nodes are males.

Conclusion

Hierarchical analysis lets us identify both similarities and differences in relational dynamics across groups. We find here that basic mechanisms such as turn-taking, recency, and role effects are reliable predictors across settings, with some residual variation associated with contextual covariates such as course content.

References

[1] Butts, Carter T. "A Relational Event Framework for Social Action." Sociological Methodology, 38(1):155-200. 2008.

[2] McFarland, Daniel A. "Student Resistance: How the Formal and Informal Organization of Classrooms Facilitate Everyday Forms of Student Defiance." American Journal of Sociology 107 (3): 612-78. 2001.

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Scalable Methods for the Analysis of Network-Based Data