Meta-analysis of SIENA Stochastic Actor-Oriented Model Estimates

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What is SIENA?

Simulation Investigation for Empirical Network Analysis
- Software developed by Snijders and colleagues
- Estimates stochastic actor-oriented models
- Models change in social network panel data
Network function

\[ f^X_i(\beta, x) = \sum_k \beta^X_k s^X_{ki}(x) \]

\( f^X_i(\beta, x) \): Network function for network \( x \)
- Log odds of each actor \( i \)'s possible choices for tie changes

\( s^X_{ki}(x) \): Network processes, or “effects”

\( \beta^X_k \): Estimated statistical parameters
- Indicate strength of \( k \) network effects
Behavior function

\[ f_i^Z(\beta, x, z) = \sum_k \beta_k^Z s_{ki}^Z(x, z) \]

\( f_i^Z(\beta, x, z) \): Behavioral function for behavior \( z \)
- Log odds of the potential behavior choices for actor \( i \)

\( s_{ki}^Z(x, z) \): Effects that predict change in the behavior

\( \beta_k^Z \): Estimated statistical parameters
- Indicate the strength of the \( k \) behavior effects
What if you have multiple networks?

Several options for combining estimates:
1) One large network
2) SIENA “multi-group”
3) Meta-analysis
One large network

Structural zeroes:
- Indicate that ties between actors are not permitted
- Essentially demarcate the individual networks

This option:
- Requires constructing data files for (one) combined network
- Does not seem to offer advantages over other approaches
SIENA “multi-group”

“different groups are considered to be unrelated except that they have the same model specification, the same variable names, and the same parameter values”

(Manual for RSiena, p. 108)

- Assumes (most) parameters are identical across groups
- Advantage: May produce smaller standard errors
- Ability to relax assumption of identical parameters
  - But: Requires long estimation times
Meta-analysis

A “study of studies”

‣ Traditionally:
  ‣ Summarizes results from a series of related studies

‣ Our application:
  ‣ Estimate models on individual networks
  ‣ Treat results from each network as their own “study”
Why use meta-analysis with SIENA SAOM estimates?

- Produce aggregate network estimates
- Flexibility in model specification
- Flexibility incorporating study features
- Estimate complex models on large networks separately
- Post-hoc analysis of network differences
Introduction to variance-known applications

Application of multi-level and mixed-effects models

‣ Outcomes: Assumed to be unbiased and normally distributed estimates of their population values

‣ Sampling variances: Assumed to be known
Conventional multi-level regression models

Level 1: \( Y_{ij} = \beta_{0j} + r_{ij} \)
Level 2: \( \beta_{0j} = \gamma_{00} + u_{0j} \)

Combined model: \( Y_{ij} = \gamma_{00} + u_{0j} + r_{ij} \)

\( Y_{ij} \) is outcome for level-one unit \( i \) in unit \( j \)
\( \beta_{0j} \) is the mean outcome for unit \( j \)
\( \gamma_{00} \) is the grand-mean outcome in the population
Conventional multi-level regression models

Level 1: \( Y_{ij} = \beta_{0j} + r_{ij} \)
Level 2: \( \beta_{0j} = \gamma_{00} + u_{0j} \)

Combined model: \( Y_{ij} = \gamma_{00} + u_{0j} + r_{ij} \)

\( u_{0j} \) is the random effect associated with unit \( j \sim N(0, \tau_{00}) \)
\( r_{ij} \) is the error for level-one unit \( i \) in unit \( j \sim N(0, \sigma^2) \)
Variance-known models for meta-analysis

Level 1: \( d_j = \delta_j + e_j \)
Level 2: \( \delta_j = \gamma_0 + u_j \)

Combined model: \( d_j = \gamma_0 + u_j + e_j \)

\( d_j \) is a parameter estimate from an SAOM model for network \( j \)
\( \delta_j \) is the unknown true parameter effect corresponding to \( d_j \)
\( \gamma_0 \) is the grand-mean outcome in the population
Variance-known models for meta-analysis

Level 1: \(d_j = \delta_j + e_j\)
Level 2: \(\delta_j = \gamma_0 + u_j\)

Combined model: \(d_j = \gamma_0 + u_j + e_j\)

\(u_{0j}\) is the random effect associated with study \(j \sim N(0, \tau)\)
\(e_j\) is the sampling error associated with \(d_j \sim N(0, V_j)\)
\(V_j\) is the SAOM sampling variance of \(d_j\) as an estimate of \(\delta_j\)
Variance-known model intercept

Represents the estimated mean of the parameter estimates

- Essentially weighted inversely to the standard errors

- Additionally:
  - Variance associated with these effect size estimates
  - Residual variance of the estimates
Extensions to a two-level unconditional model

Examples:

- Additional random errors
  - Account for additional clustering within study design
- Include covariates at level two (or above)
  - “Study” characteristics that predict the outcome
  - Our case: Network characteristics
- Remember: Include actor characteristics in the SAOM
Software packages for meta-analysis

Some examples:

• SIENA \textit{siena08} function
• HLM software (Scientific Software International, Inc)
• Stata: Multilevel mixed-effects models (e.g., \textit{meglm})
• R: \textit{metafor} package
Meta-analysis in R: Three examples

Exercise 1: Meta-analysis vs. Raw mean
Exercise 2: Meta-analysis vs. Raw mean, with outliers
Exercise 3: Introducing network covariates