GESIS Leibniz Institute for the Social Sciences

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# GESIS Fall Seminar in Computational Social Science 2025
# "Advanced Methods for Social Network Analysis"


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| Lecturers: | Lorien Jasny | Laura Roldan Gomez |
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Date: September 15-19, 2025
Time: 09:00-16:00

## About the Lecturers

**Lorien Jasny** is an Associate Professor of Computational Social Science at the University of Exeter. Her work focuses on the role of social networks in questions of public engagement, environmental management, and community health. In her research she explores two related themes – how the structure and dynamics of inter-organizational networks affect policy change, and how the structure and dynamics of social and belief networks affect behavioral change. Substantively, she studies how people try to bring about societal change in response to political and environmental concerns. Methodologically, the need to grapple with these often-complex phenomena requires the use and development of techniques for handling large, dynamic, and relational datasets. Lorien has taught workshops in social network methods for over 10 years, including for the International Consortium for Social and Political Research (ICPSR) and the International Network for Social Network Analysis (INSNA).

**Laura Roldan-Gomez** is a PhD Candidate in Advanced Quantitative Methods at the University of Exeter, specializing in advanced network statistical methods for analyzing social networks in complex contexts. Her dissertation applies Relational Event Models to study the dynamics of armed conflicts, alongside a difference-in-differences analysis exploring the relationship between deforestation and conflict. She has extensive experience with Exponential Random Graph Models (ERGMs) through her work on a project examining socio-ecological systems in local fisheries across Jamaica, Kenya, and Papua New Guinea. Beyond research, Laura has a strong background in teaching and training. She has taught undergraduate modules in network analysis, statistics, linear and logistic regression, and co-led R programming workshops at various levels.

## Course Description

Social network analysis focuses on relationships between or among social entities. In studying social networks, we often use many different descriptive analyses, like which actors are the most central or how clustered the network is. This course moves beyond these descriptive measures and presents an introduction to advanced concepts, methods, and applications of social network analysis used in the social and behavioral sciences focusing on statistical methods for social networks. Often, traditional statistical methods cannot be used for the analysis of networks because their relational nature violates the independence assumptions of standard approaches. In this course, we will discuss where and when standard approaches can be used and why they often can't. We'll then cover some of the standard statistical models for networks including Network Regression, the Quadratic Assignment Procedure, the Network Autocorrelation Model, Exponential Random Graph Models (ERGM), and the Stochastic Actor Oriented Model (SAOM). We will also focus on approaches for multilevel, multimode, and temporal data.

## Organizational Structure of the Course

Each day will consist of lectures in the morning which often will include demonstrations of code to run the models discussed in the lecture. The afternoon will then include lab or group discussion time. During this period, participants will be given exercises to work through on their own or in small groups to apply the methods described in the morning. Both lecturers will be available to assist as needed. Exemplar datasets will be provided, but participants are encouraged to bring data they are interested in exploring to the course. Participants can also work on their own projects during this time as well as present their projects to the lecturers and/or other participants for feedback and discussion. We will often conclude with a short group discussion of the main themes of the day.

## Keywords

Social network analysis; network statistics; exponential random graph models ; temporal networks; multimodal networks; stochastic actor oriented models

## Target Group

You will find the course useful if:

- You have already had an introduction to social network analysis and want to move beyond descriptive measures to start to develop and test hypotheses about network data. Or, you have the idea that one (or more) of the models we'll focus on might be useful in your research but you'd need some guidance in getting started and understanding the practicalities of applying these models. Or, you understand the basics of the models you want to use in your research, but your data are more complex (missing data, limitations from the data collection process, multilevel or multiplex ties, or longitudinal) than standard approaches accommodate.

## Course and Learning Objectives

By the end of the course, you will:

- Understand why the relational nature of network data violates assumptions of standard statistical models
- Be comfortable with the major R packages for social network analysis (Statnet and igraph)
- Be able to generate different hypotheses for social network data
- Know how to apply a variety of statistical models for networks
- Understand how the Exponential Random Graph (ERGM) and Stochastic Actor Oriented (SAOM) models work and what the differences between them are
- Know how to apply these models to advanced data structures like multilevel, multimodal, and temporal network data

## Course Prerequisites

- Be comfortable with basic R programming and data management, i.e. know how to load your data into R, understand how to work with data frames and matrices to generate basic descriptions or plots of the data contained within, and understand the differences between bracket and dollar sign notation.
- Familiarity with descriptive measures from social network analysis like centrality, centralization reciprocity, transitivity, homophily, structural equivalence
- Understand basic statistical metrics like correlation, t-tests, linear regression, logistic regression and how to perform these tests in R

## Software and Hardware Requirements

Participants should bring their own laptops for use in the course.

The R statistical programming package is required to follow along with the course material and is available as a free download (http://cran.r-project.org/). We also suggest downloading the free software program R Studio (http://www.rstudio.com), which offers a user-friendly interface to R. In addition to the base packages that are installed with R, we will also use the following additional packages: statnet, igraph, ndtv, numderiv, coda, nlme, and trust. If possible, please install them prior to the start of the course.

## Course Contents

- Network Regression
- Baseline Models
- Exponential Random Graph Models
- Bipartite (two-mode) Networks
- Temporal Networks

## Recommended Literature to Look at in Advance

There are plenty of social networks textbooks or handbooks that cover similar material. For those with little knowledge of social network analysis, the key topics we will build upon are: centrality, reciprocity, transitivity, block models, structural equivalence, and Erdos-Renyi random graphs. Some texts that cover these topics are:

- Light, R., and Moody, J., eds (2020). *The Oxford handbook of social networks*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190251765.001.0001
- McLevey, J., Carrington, P. J., and Scott, J. (2023). *The Sage handbook of social network analysis*: 1-100. https://doi.org/10.4135/9781529614695
- Yang, S., Keller, F. B., and Zheng, L. (2016). *Social network analysis: Methods and examples*. Sage Publications. https://doi.org/10.4135/9781071802847
- Wasserman, S. (1994). *Social network analysis: Methods and applications.* The Press Syndicate of the University of Cambridge. http://dx.doi.org/10.1017/CBO9780511815478
- Victor, J. N., Montgomery, A. H., and Lubell, M., eds. (2017). *The Oxford handbook of political networks*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190228217.001.0001

## Day-to-day Schedule and Literature

**Day 1:** Inferential Methods for Social Networks

- Baseline models, network regression, QAP, and the Network Autocorrelation model

*Optional Reading:*

- Farine, D. R. (2017). "A guide to null models for animal social network analysis." *Methods in Ecology and Evolution, 8*(10), 1309-1320. https://doi.org/10.1111/2041-210X.12772
- Leenders, R. T. A. (2002). "Modeling social influence through network autocorrelation: constructing the weight matrix." *Social networks, 24*(1), 21-47. https://doi.org/10.1016/S0378-8733(01)00049-1
- Jasny, L. (2012). "Baseline models for two-mode social network data." *Policy Studies Journal, 40*(3), 458-491. https://doi.org/10.1111/j.1541-0072.2012.00461.x
- Mayhew, B. H. (1984). "Baseline models of sociological phenomena." *Journal of Mathematical Sociology, 9*(4), 259-281. https://doi.org/10.1080/0022250X.1984.9989948

**Day 2:** Exponential Random Graph Models

- Everything you wanted to know about ERGMs but were afraid to ask

*Optional Reading:*

- Lusher, D., Koskinen, J., and Robins, G., eds. (2013). *Exponential random graph models for social networks: Theory, methods, and applications.* Cambridge University Press. Chapters 2-5. https://doi.org/10.1017/CBO9780511894701

**Day 3:** ERGM Extensions

- Bipartite, multilevel and multilayer terms
- How to write your own ERG terms

*Optional Reading:*

- Wang, P., Pattison, P., and Robins, G. (2013). "Exponential random graph model specifications for bipartite networks—A dependence hierarchy." *Social networks, 35*(2), 211-222. https://doi.org/10.1016/j.socnet.2011.12.004

- Jasny, L. (2023). "Multimodal social network analysis." *The Sage handbook of social network analysis*, 392-403. https://dx.doi.org/10.4135/9781529614695.n28

**Day 4:** Temporal Methods

- We will discuss how to use the models we've covered with temporal data

*Optional Reading:*

- Krivitsky, P. N., and Handcock, M. S. (2014). "A separable model for dynamic networks." *Journal of the Royal Statistical Society Series B: Statistical Methodology, 76*(1), 29-46. https://doi.org/10.1111/rssb.12014
- Leifeld, P., Cranmer, S. J., and Desmarais, B. A. (2018). "Temporal exponential random graph models with btergm: Estimation and bootstrap confidence intervals." *Journal of Statistical Software, 83*, 1-36. https://doi.org/10.18637/jss.v083.i06

**Day 5:** Stochastic Actor Oriented Models

- We will introduce the model and focus on the differences between SAOMs and ERGMs in perspective, modelling, and estimation

*Optional Reading:*

- Snijders, T. A. B., Van de Bunt, G. G., and Steglich, C. E. G. (2010). "Introduction to stochastic actor-based models for network dynamics." *Social networks 32*(1), 44-60. https://doi.org/10.1016/j.socnet.2009.02.004
- Block, P., Stadtfeld, C., and Snijders, T. A. B. (2019). "Forms of dependence: Comparing SAOMs and ERGMs from basic principles." *Sociological Methods & Research 48*(1), 202-239. https://doi.org/10.1177/0049124116672680

## Additional Recommended Literature

- Cranmer, S. J., Desmarais, B. A., and Morgan, J. W. (2020). *Inferential network analysis*. Cambridge University Press. https://doi.org/10.1017/9781316662915