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# Challenges, Solutions, and Directions in Comparative Animal Social Network Analysis

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## Extended Abstract

Social relationships are a key determinant of health and well-being. The effect of social isolation on human survival is known to be similar in magnitude to that of well-known risk factors such as smoking, heavy drinking and obesity [1]. Similarly, social relationships have been linked to clear fitness benefits in a wide range of animal species [2]. Yet, the mechanisms linking sociality to their benefits remain unclear [3]. Understanding the adaptive function of social behaviour has long been a key goal of behavioural ecology, and long-term efforts to collect social data from human and other animal populations have resulted in vast datasets quantifying social interactions in a wide range of environments. These comparative datasets are critical, as studying the many types of social relationships individuals can form to help them deal with their social-ecological environment is central to understanding the evolution of sociality. Yet, fundamental challenges remain in our ability to reliable compare across these rich datasets, key to drawing insights on the selective pressures acting on social behaviour [4].

In this talk, I will present two projects that address challenges in comparative social network analysis. Social network analysis is a widely adopted method to quantify social structure, defined as the patterning of social relationships, themselves the sum of social interactions between individuals. While social network analysis is an invaluable tool to study the function of social relationships at an individual and global level, there are several critical issues that prevent the reliable comparison of social networks [5, 6]. A first challenge is that the interactions on which networks are based can be recorded using distinct methods [7]. Two main sampling methods are commonly used to record interactions: (1) continuous sampling, where all occurrences of a behaviour are recorded (as either the count of onsets of behavioural events, or the duration of time spent engaged in a behaviour) and (2) time sampling, where at regular time intervals it is recorded whether the behaviour of interest is occurring or not (binary data). Data can be recorded focusing on one individual at a time (i.e. focal sampling) or on a group of individuals (i.e. group sampling). How choice of sampling method impacts how well the recorded network captures the true underlying social structure is still unclear. Taking a simulation approach, we compared the performance of group time sampling to focal continuous sampling. While focal continuous sampling is the most used sampling method for the construction of social networks [8], we found that group time sampling generates more precise and accurate estimates of the true underlying probability of engaging in a behaviour. This suggests that, although behaviours are more likely to be missed using time sampling, this effect is offset by the vast amounts of additional data that group time sampling generate compared to focal continuous sampling.

Crucially, differences in sampling method and network size (which often drives choice of sampling method) also have consequences for comparing across networks. Recording behaviour using different sampling methods results in different estimates of the occurrence of that behaviour, with distinct underlying properties. When recording behaviour over enough time and correcting for observation effort, count, duration, and binary data can be used to estimate the rate, proportion of time, and probability (respectively) of engagement in a behaviour. While proportions and probabilities can be readily compared, comparing

probabilities (or proportions) to rates is not as simple. Rates and probabilities capture fundamentally different processes, so there is no natural way to interpret them on the same scale. Although it is often assumed that greater proportions of time spent engaging in a behaviour correlate with greater rates of events, there is no reason why this is necessarily the case (Fig 2). In fact, it is less likely to be the case for behaviours with appreciable durations, which include most affiliative behaviours used to estimate social relationships. Yet, data on social structure have been collected using rates, proportions, or indices combining both, hampering direct comparisons between those networks.

Another major challenge for comparative social network analysis is to compare networks of different sizes. Global network metrics, in particular, are sensitive to the number of nodes and edges in a network, which might mask actual structural differences between networks of different sizes. Alternatively, what might appear as differences between networks might in fact just be statistical artifacts driven by their different sizes. Complicating matters further, network size can also be influenced by network structure. For example, groups that become too large to remain cohesive might split. Network size could therefore be considered as an integral property of network structure, and therefore a crucial component of how network structure relates to socio-ecological context. Controlling for network size is therefore not only a methodological challenge, but whether to control for network size at all becomes a conceptual question, contingent on the aims of the research being undertaken.

Using mathematical justifications and simulations, we show the impact that differences in sampling method and network size have on comparative analyses and propose guidelines for when and how robust comparative social network analyses can be done. We hope that the findings from both projects will help to make meaningful advances towards a more complete suite of tools to enable the comparative analysis of social networks.

# References

1. Holt-Lunstad, J., T.B. Smith, and J.B. Layton, *Social relationships and mortality risk: A meta-analytic review.* PLoS Med, 2010. **7**(7): p. e1000316.
2. Snyder-Mackler, N., et al., *Social determinants of health and survival in humans and other animals.* Science, 2020. **368**(6493): p. eaax9553.
3. Ostner, J. and O. Schülke, *Linking sociality to fitness in primates: A call for mechanisms*, in *Advances in the Study of Behavior*, M. Naguib, et al., Editors. 2018, Academic Press: London, UK. p. 127-175.
4. Croft, D.P., R. James, and J. Krause, *Exploring animal social networks*. 2008: Princeton University Press.
5. Castles, M., et al., *Social networks created with different techniques are not comparable.* Animal Behaviour, 2014. **96**: p. 59-67.
6. Davis, G.H., M.C. Crofoot, and D.R. Farine, *Estimating the robustness and uncertainty of animal social networks using different observational methods.* Animal Behaviour, 2018. **141**: p. 29-44.
7. Bateson, M. and P. Martin, *Measuring behaviour: An introductory guide*. 2021: Cambridge University Press.
8. Webber, Q.M.R. and E. Vander Wal, *Trends and perspectives on the use of animal social network analysis in behavioural ecology: A bibliometric approach*. Animal Behaviour, 2019. **149**: p. 77-87.

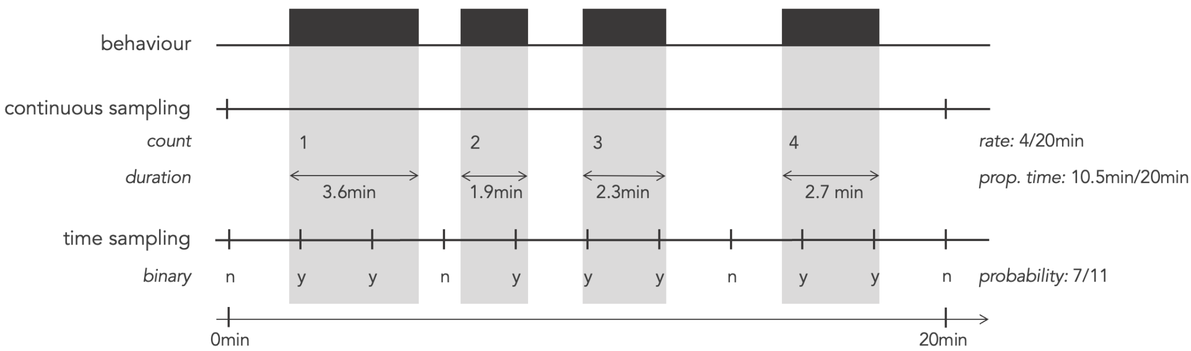


Figure 1. Overview of different sampling methods to record behaviour

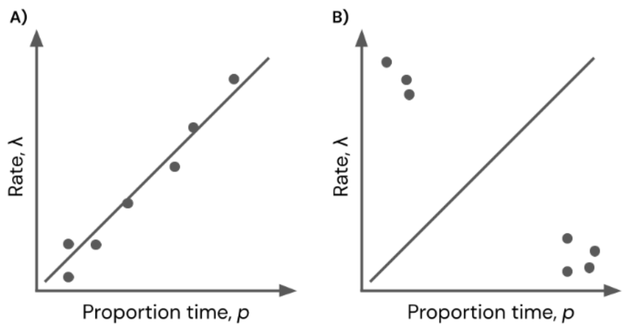


Figure 2. Rates of onset of a behaviour and proportion of time spent in a behaviour represent distinct components behaviour