Peer Community In
Network Science

Multiplex vs. Uniplex: Deciphering the Differential Health Impacts of Complex Social Interactions in Rhesus Macaques

Cédric Sueur *based on peer reviews by* ***Tamao Maeda*** *and 2 anonymous reviewers*

Jessica Vandeleest, Lauren J. Wooddell, Amy C. Nathman, Brianne A. Beisner, Brenda McCowan (2022) Differential effects of multiplex and uniplex affiliative relationships on biomarkers of inflammation. bioRxiv, ver. 4, peer-reviewed and recommended by Peer Community in Network Science. https://doi.org/10.1101/2022.11.01.514247

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Social relationships are recognized as an important age-related mediator of health in humans and fitness-related traits in animals (Sueur et al., 2021). Vandeleest et al. (2024) is a pioneering exploration into the complex interplay between social relationships and health in rhesus macaques. It breaks new ground by differentiating between two types of affiliative relationships – multiplex (engaging in multiple types of affiliative behaviors like grooming and contact sitting) and uniplex (involving only one type of behavior, such as grooming) (Beisner et al., 2020). The study's crux lies in its novel approach to understanding how these differing social interactions correlate with biomarkers of inflammation, namely pro-inflammatory cytokines like IL-6 and TNF-alpha.

The research is innovative in its use of social network analysis (Sosa et al., 2021), allowing for a nuanced view of the rhesus macaques' social dynamics. It reveals that multiplex grooming networks, characterized by more modular structures and kin bias, are associated with lower inflammation levels. This is in contrast to uniplex grooming networks, where a stronger link to social status correlates with higher inflammation. These findings suggest that multiplex relationships could serve as supportive, health-promoting bonds, while uniplex relationships might be more transactional, with possible physiological costs.

Moreover, the study's results highlight the importance of the diversity of affiliative interactions within a dyad. It posits that relationships involving multiple types of affiliative behaviors may have different implications for health and well-being compared to those based on a single behavior type, even if interaction rates are similar. This insight opens up new avenues for understanding the health implications of social behaviors in non-human primates and potentially in humans (Sueur et al., 2021).

Furthermore, the paper provides a comprehensive analysis of the network structures, examining kin bias, clustering, modularity, and associations with dominance rank. It also evaluates the correlations between individual network positions and health markers, offering a multifaceted understanding of how social networks influence physical well-being.

In essence, this research makes a significant contribution to our understanding of the link between sociality and health. It underscores the complexity of social relationships (Moscovice et al., 2020) and their varied impacts on health, suggesting that the nature of social bonds (multiplex vs. uniplex) plays a critical role in determining their health consequences. This study not only enhances our comprehension of primate social behavior but also has broader implications for the fields of social neuroscience, behavioral ecology, and health psychology.

References:

Beisner, B., Braun, N., Pósfai, M., Vandeleest, J., D'Souza, R., & McCowan, B. (2020). A multiplex centrality metric for complex social networks: Sex, social status, and family structure predict multiplex centrality in rhesus macaques. PeerJ, 8, e8712. https://doi.org/10.7717/peerj.8712

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Vandeleest, J. J., Wooddell, L. J., Nathman, A. C., Beisner, B. A., & McCowan, B. (2024). Differential effects of multiplex and uniplex affiliative relationships on biomarkers of inflammation. bioRxiv, ver. 4 peer-reviewed and recommended by Peer Community in Network Science. https://doi.org/10.1101/2022.11.01.514247

Reviews

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.1101/2022.11.01.514247
Version of the preprint: 2

Authors' reply, 08 January 2024

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Decision by Cédric Sueur, posted 09 December 2022, validated 12 December 2022

Preprint meriting a revision

Dear authors,

Thank you very much for having submitted your preprint. The three reviewers found it very interested but have some concerns. Please revise your manuscript according to their comments and submit a new version. We hope to see your nice work very soon. Best,

Reviewed by anonymous reviewer 1, 24 November 2022

This manuscript presents a study linking social structure to measures of individual health in captive primates. The authors show that individuals who were more connected when considering "multiplex" networks were healthier, while the opposite effect was found in "uniplex" networks. I found the results potentially interesting, but I have serious reservations regarding the network definitions and the analysis.

The most major issue is that multiplex networks are a type of multilayer networks, where there are several types of interactions between the same set of nodes/individuals. Here, both multiplex and uniplex interactions were analyzed as single-layer networks, with both types of networks using only one interaction type (lines 204-206). Basically, instead of analyzing one grooming network where some dyads also huddled, the authors split the same grooming interaction into two different networks. The authors did not offer any biological reasoning for defining the two networks, and I have never seen such analysis. This type of analysis makes the interpretation of the results very difficult. The networks were divided based on one interaction that was not included in the analysis (huddling). I suggest the authors rethink the analytical approach. The differences between the two networks can come from individual traits, such as sex, kinship, or rank. In that case these factors should be included in the analysis.

Other comments:

Line 73 and on: At some point I asked myself if this discussion relates only to non-human animals. It is worthy to clarify that, because the beginning of the introduction referenced both humans and other animals.

Line 100: Multiplex networks should be defined.

Line 129: Were there dyads that only huddled? How were these cases treated?

Line 133: Modularity and clustering are not the same. A network may be highly modular but not clustered, if in each module, or sub-group, clustering is low.

Lines 164-176: This paragraph should be part of the introduction. It provide general information on the species and why it was chosen.

Line 188: How were individuals identified?

Figure 1: Is there any text in each node? It's impossible to read so either enlarge it or delete it.

Statistics: Was there any treatment of the fact that network measures are not independent? Usually, some sort of null model based on permutations of the data is being used to compare to the observed patterns.

Dominance: Perhaps I have missed it, but was there a correlation between dominance and measures of centrality in the multiplex network? I am wondering if the main result could be, at least to some extent, be explained by dominance. Readers would benefit from data addressing this question, for example by adding rank to the selected models and testing its effect.

Line 261: Multidimensional vs unidimensional network metrics?

Line 271: Why undirected?

Figure S1: What is the number of dyads without interactions?

Line 265 Table S2 or table S3?

Reviewed by anonymous reviewer 2, 06 December 2022

I really like the idea of the paper and also the aim to explore social relationships in more complex way. The paper is very well written, the text is clear and comprehensive. The authors cite relevant literature sources. The specific aim of the study is clearly presented. The sample size in terms of groups and individual females is

impressive. The paper is overall very informative in terms of discrepancies in previous studies and methods used.

My major concern stems if the presented results of the comparison of uni vs multiplex networks is really representative of the two types of networks or if it is more related to the way how data were filtered for each network. In the methods section Affiliative network analysis the authors stated that "...and a network containing edges for dyads that groomed but were never seen huddling (uniplex affiliative relationships)." However if one would do an independent study using grooming for uniplex network one will not filter out edges based on the huddling behavior thus the resulting uniplex network based on grooming will be different of that presented by the authors. So it might not be completely fair to say that the uniplex network is "grooming only" because is grooming only and never huddling", thus grooming ties between individuals who also huddled were not included in this grooming network. This approach in my opinion leads to bigger differences in the two networks which is not necessarily connected to multiplex vs uniplex networks but to the way how the edges were filtered.

In other words if the uniplex network would be based on all grooming edges (without filtering out the dyads that huddle as well) would there be same differences between the two networks? I understand that using the approach the authors made the two networks rather independent in terms the data used but then I think you are comparing rather two different types of relationships one based on grooming and huddling and one based on grooming only and never huddling but not necessarily uniplex and multiplex networks.

This also has consequences when comparing results of previous studies which in many cases would use "full" grooming uniplex networks which is not completely comparable with the uniplex grooming network in this study.

Additional comments:

Although authors stated in conclusion that is not clear if using different behaviors like proximity would provide similar results, still I would like to know why huddling was selected for this study? Why not the more traditional proximity or body contact? It makes me think that the authors in fact did expect different results with huddling behavior.

Is it possible from this study to say if huddling might be also beneficial just as a thermoregulatory behavior? In other words, it is not beneficial for one's health because of the social relationship it represents but because one is not cold?

Just a nitpicky question which is not specific to this paper but Is the word "multiplex" warranted if there are two types of interactions only?

Reviewed by Tamao Maeda, 06 December 2022

The paper proposed very interesting approach in order to assess how the quality of affiliative relationships affects the health status of Rhesus macaques. Overall, I found the study well-designed and nicely presented. Although the results seem robust and convincing, you will find several questions and comments below requesting additional input from the authors to justify and clarify some analytical approaches and expressions in the manuscript.

Comments and questions:

Would you please explain why you did not examine the opposite version of the network, i.e. creating huddling network and using grooming to filter it? The authors used huddling degree in the model to exclude the possibility that huddling behavior itself has an effect on the inflammation, but to be more precise, I thought it is better that you also compare only huddling and, huddling and grooming network.

Line 80: I suggest you to change "assess the quality of affiliative social relationships" to something like "assess the overall amount/frequency of multiple behaviors". To my understanding, DSI is just a method of

averaging all the correlated dyadic interactions, thus it is indicating the overall frequency of affiliative behavior and not actually measuring the quality (and I guess it is the point of your discussion).

Line 109: It is better to specify what is "huddling" behavior here, as it is not a very common term (especially for non-primatologist).

Line 113-115: "Therefore to understand the impact of social relationships on individual health and fitness, we must examine the cumulative impact of an individual's diversity and breadth of social relationships to really understand their potential influence on health."
I felt this part is duplicating the meaning. Please revise.

Line 187: Did you also observe other types of direct affiliative behavior? As you mentioned "Affiliation in primates takes many forms, including grooming, huddling, proximity, embracing, and less commonly coalitionary support" in Introduction, I presume that huddling and grooming are the main forms of direct affiliations, but I wondered if there is a possibility that other affiliative behavior potentially affects the inflammation.

Line 213: To my understanding, information centrality is based on concept of efficient propagation of information in a group. I rarely see it is used in the context similar to this study. Please justify the reason of using it here. In addition, the authors explain that information centrality indicates the social cohesion, but you should put the citation or more detailed explanations.

Table 2: As I mentioned above, I thought it is better to put citation for each interpretation of the network metrics.

Figure 1. I cannot read the labels of each node. Also, the image resolution seems not good enough. Please make it clearer.