

Structural Comparisons of Noun and Verb Networks

Mengyang Qiu[†] Nichol Castro[†] Brendan T. Johns[‡]

[†] Department of Communicative Disorders and Sciences, University at Buffalo

[‡] Department of Psychology, McGill University

{mengyang, nicholca}@buffalo.edu brendan.johns@mcgill.ca



The State University of New York

Introduction

- Many studies over the past two decades have conceptualized semantic memory (i.e., the mental lexicon) as semantic networks, where words/concepts are represented as nodes and links/edges between nodes represent certain semantic relatedness.
- Analyzing and contrasting semantic network measures have provided important insights into the organizational differences and changes of the mental lexicon in various populations (e.g., aging, bilingualism, and people with neurodegenerative disorders).
- Semantic verbal fluency is particularly efficient in estimating networks of specific semantic categories.
- However, most of the network studies of semantic verbal fluency have focused primarily on the animal category. Another semantic category, namely verbs, has received far too little attention compared to the animal category or noun-based categories in general.
- **The primary goal of the present study is to further investigate the underlying organizational differences of nouns and verbs in the mental lexicon from a network science point of view.**
- **Another goal is to explore how category cue specificity influences the overall network structure within the same lexical category.**

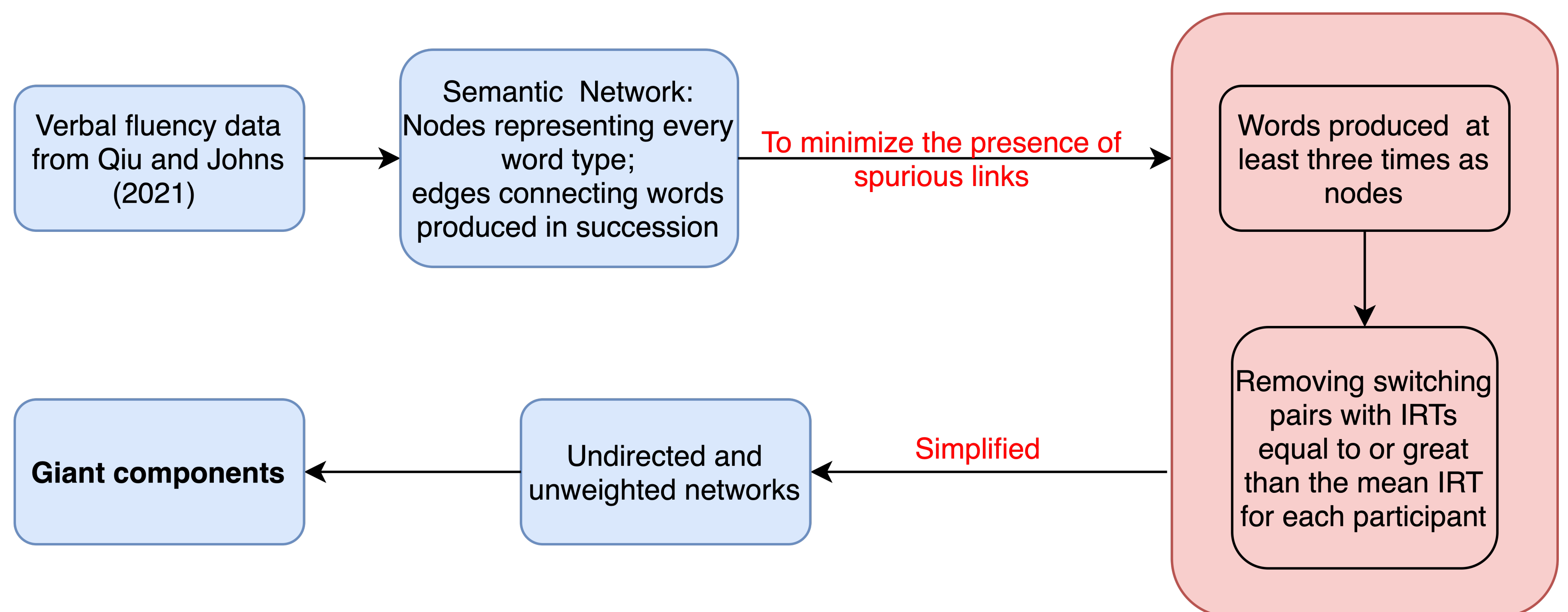
Semantic Fluency

- In a semantic verbal fluency task, participants are asked to produce as many exemplars of a given category (e.g., *animals* or *vegetables and fruits*) as possible within a given time limit.
- The general pattern of words produced in semantic fluency is called **clustering**—words that are semantically related to each other tend to be produced in succession or close proximity.
- Participants typically **switch** to a new semantic cluster when no semantically proximal word is available in the current cluster.
- Given this cluster-and-switch pattern, one efficient and psychologically plausible way to construct semantic networks from semantic fluency data is to form an edge connecting each pair of successive words.

Selected References

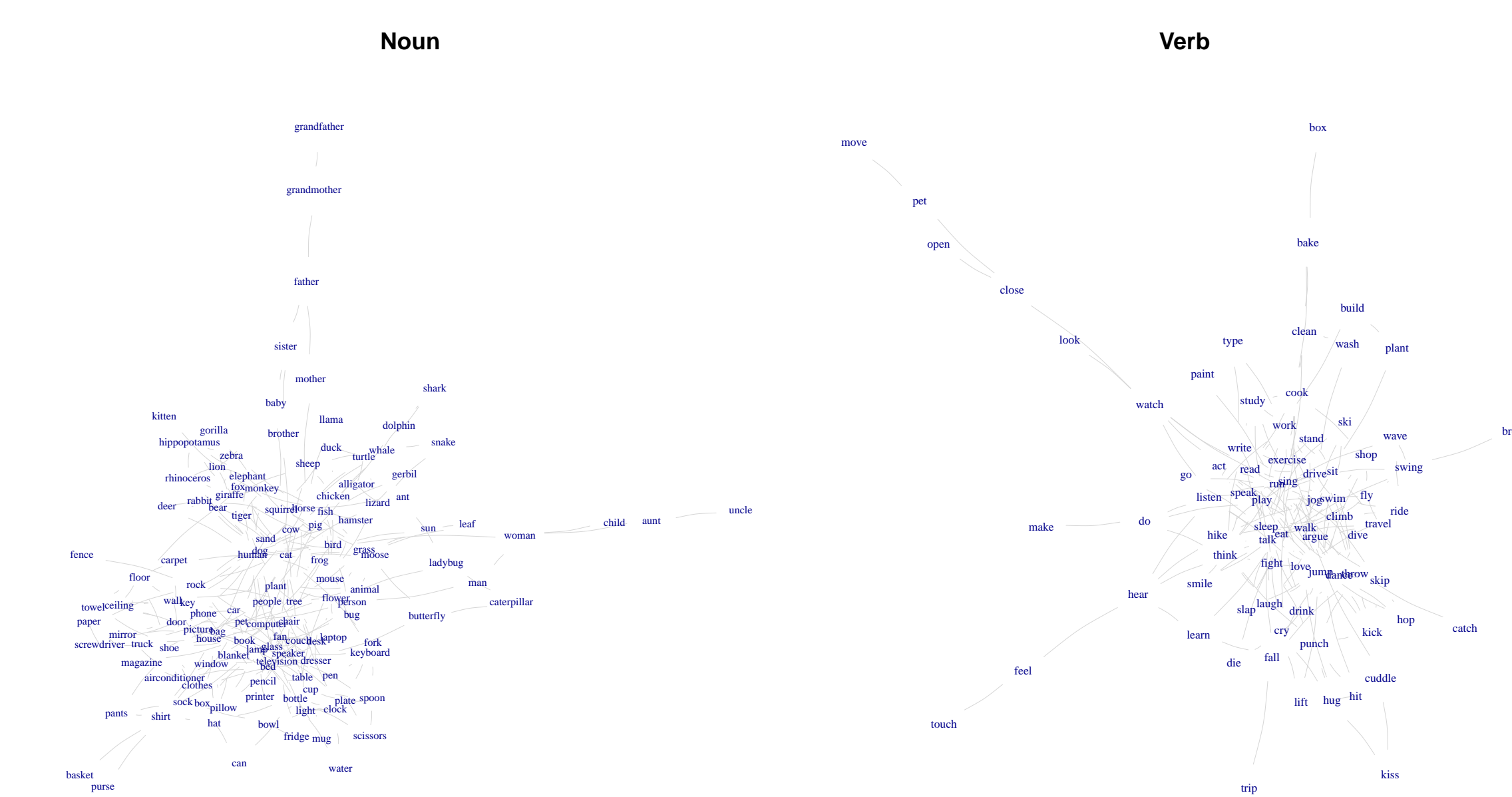
- Borodkin, K., Kenett, Y. N., Faust, M., & Mashal, N. (2016). When pumpkin is closer to onion than to squash: The structure of the second language lexicon. *Cognition*, 156, 60–70
- Hills, T. T., Jones, M. N., & Todd, P. M. (2012). Optimal foraging in semantic memory. *Psychological Review*, 119(2), 431–440
- Qiu, M., & Johns, B. T. (2021). A distributional and sensorimotor analysis of noun and verb fluency. *PsyArXiv*
- Zemla, J. C., & Austerweil, J. L. (2018). Estimating semantic networks of groups and individuals from fluency data. *Computational Brain & Behavior*, 1(1), 36–58

Network Construction and Measures



- Common network parameters and the small-worldness structure (an important global feature of semantic networks that may contribute to efficient memory search and retrieval) were evaluated.
- Two types of comparisons: noun-based and verb-based networks were contrasted to each other while controlling for the category cue specificity; networks within the same lexical category were contrasted to each other in order to examine the effects of category cue on network parameters.
- Since direct comparisons of networks with different numbers of nodes may introduce confounds, we used a sub-network bootstrap procedure and simulated 1,000 partial networks with a fixed number of randomly selected nodes for each semantic network (the assumption is that any structural differences between the original networks will also emerge in their corresponding sub-networks).

Results



Parameters of the four semantic networks

	Animal	Noun	Body Movement	Verb
Nodes	97	130	79	78
Edges	337	359	260	241
Average degree	6.95	5.52	6.58	6.18
CC	0.21	0.15	0.20	0.24
ASPL	2.61	3.17	2.61	2.85
Small-worldness (S)	1.44	1.86	1.24	1.27
Modularity (Q)	0.35	0.47	0.31	0.33
CC _{random} ****	0.07	0.04	0.08	0.08
ASPL _{random} ****	2.55	3.01	2.50	2.56

Parameters of bootstrapped partial networks

	Animal	Noun	Body Movement	Verb
Nodes	48	48	48	48
CC	0.20 ± 0.05	0.14 ± 0.06	0.20 ± 0.05	0.23 ± 0.05
ASPL	3.06 ± 0.31	3.67 ± 0.58	2.78 ± 0.22	2.82 ± 0.25
Modularity (Q)	0.45 ± 0.06	0.59 ± 0.07	0.39 ± 0.05	0.38 ± 0.05

Networks constructed from the general noun and verb fluency tasks

- All the four networks showed small-world properties.
- Compared to nouns, verb organization is more condensed and less modular (larger CC and smaller ASPL and modularity).
- Within the noun category, the general noun network was more distributed and had more communities than the animal network. However, this pattern was not clear in the verb category.

Discussion and Conclusion

- Results of the network analysis revealed systematic differences in the global network structure of the two lexical categories.
- Comparisons of the specific and general networks within the noun category showed patterns consistent with its hierarchical structure. No such pattern was found within the verb category, which is consistent with the more flat organization of verbs.
- The present study directly utilized this information in network construction. Future work could compare this filtering method with other advanced group-level semantic network estimation methods.
- Although the organizational differences of nouns and verbs have been well documented in theoretical linguistics, and have been discussed extensively in the psycholinguistic and neurolinguistic literature, we showed here that by examining the network measures, these qualitative differences can be quantitatively compared and contrasted.