

Memory Searching Pathway Underlying Verb Fluency

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Introduction

- Verbal fluency is one of the most widely used measures of cognitive functioning, in which subjects produce as many different words as possible from a given criterion (e.g., animal category) within 1 minute.
- Compared to noun category fluency, there are fewer studies on verb fluency, even though verbs are thought to play a more prominent role in organizing mental lexicon and in describing events.
- Thus, studying verb fluency may give us additional insights into mental lexicon organization and provide potentially different diagnostic information.
- The current study compares **memory search pathway** underlying verb fluency to noun (animal category) fluency using a **cognitive modeling** approach as in Johns et al. (2017).

Method

Participants

- 50 participants were enrolled through Amazon Mechanical Turk—an online experiment / crowdsourcing platform
- Mean age : 36 (20 ~ 71)
- Mean education level (in years) : 14.9

Procedure

- Each participant completed three verbal fluency tasks: letter F (as the practice trial), animal, and verb
- Their oral responses were collected and transcribed by Google Speech-to-Text API* and checked by the first author.

*The purpose of using online platform and Google Speech Recognition API is to test the feasibility of developing a fully automated system that can profile one's verbal fluency performance. The overall accuracy of Google API in this study is 87%.

Computational Modeling

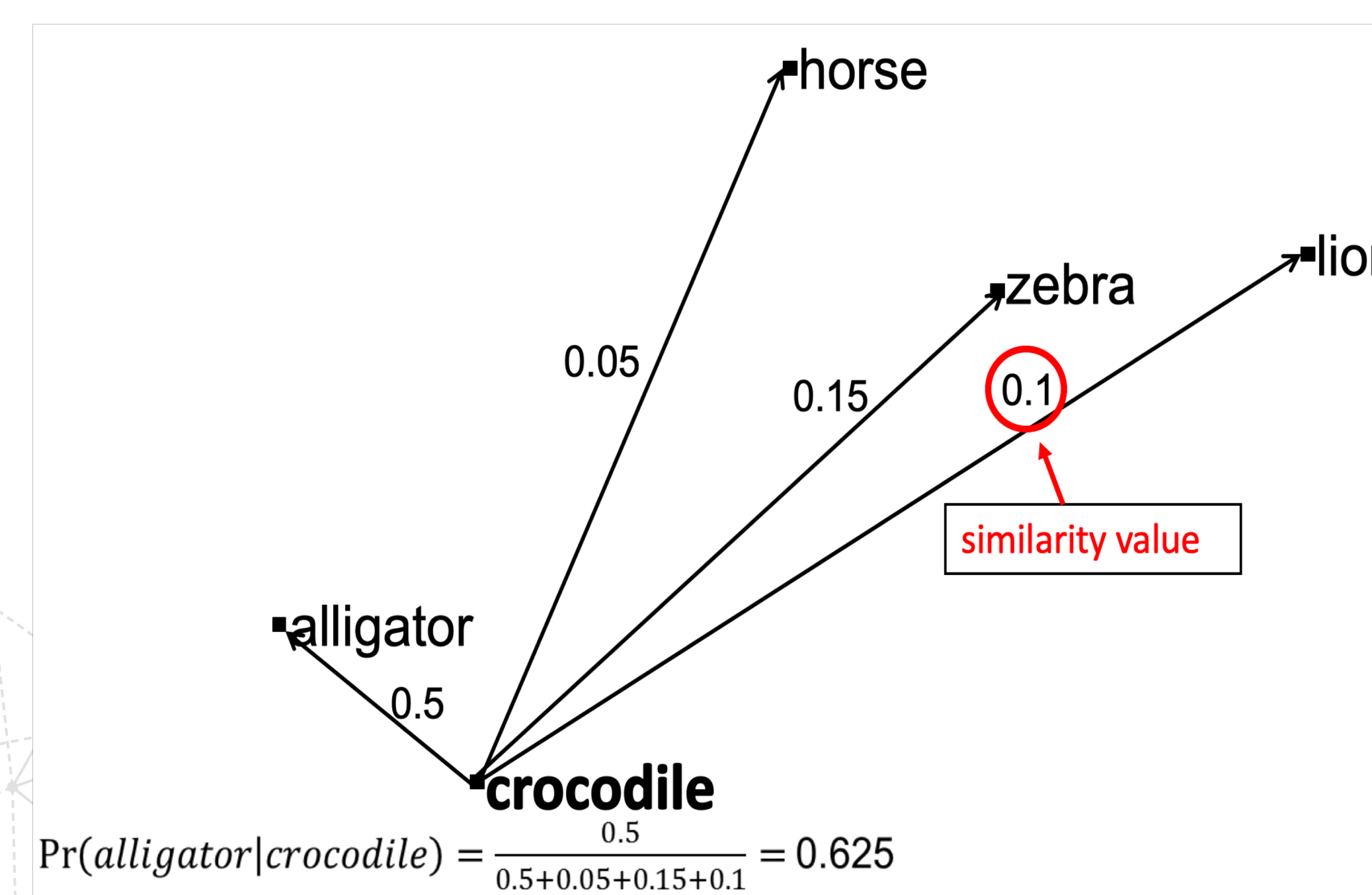
Lexical Information

- Context (semantic) and order (syntactic) similarity information derived from BEAGLE – a semantic space model
- Semantic space models construct lexical representations from large pieces of language (e.g., Wikipedia, ebooks).
- “You shall know a word by the company it keeps” (Firth, 1957).

Similarity Values from BEAGLE (Jones & Mewhort, 2007)	
Context / Semantic co-occurrence information	Order / Syntactic the position of a word relative to other words
BEER	EAT
wine .56	buy .91
liquor .54	get .90
whiskey .53	sell .89
drinks .47	move .89
alcohol .42	save .89

Memory Searching Mechanism

- Luce choice axiom – probabilistically select an item from possible alternatives
- In verbal fluency – the probability of producing *alligator* from the set of {*alligator*, *lion*, ..., *zebra*} after *crocodile*
- The probability of the first word being produced – normalized frequency



Parameter Fitting

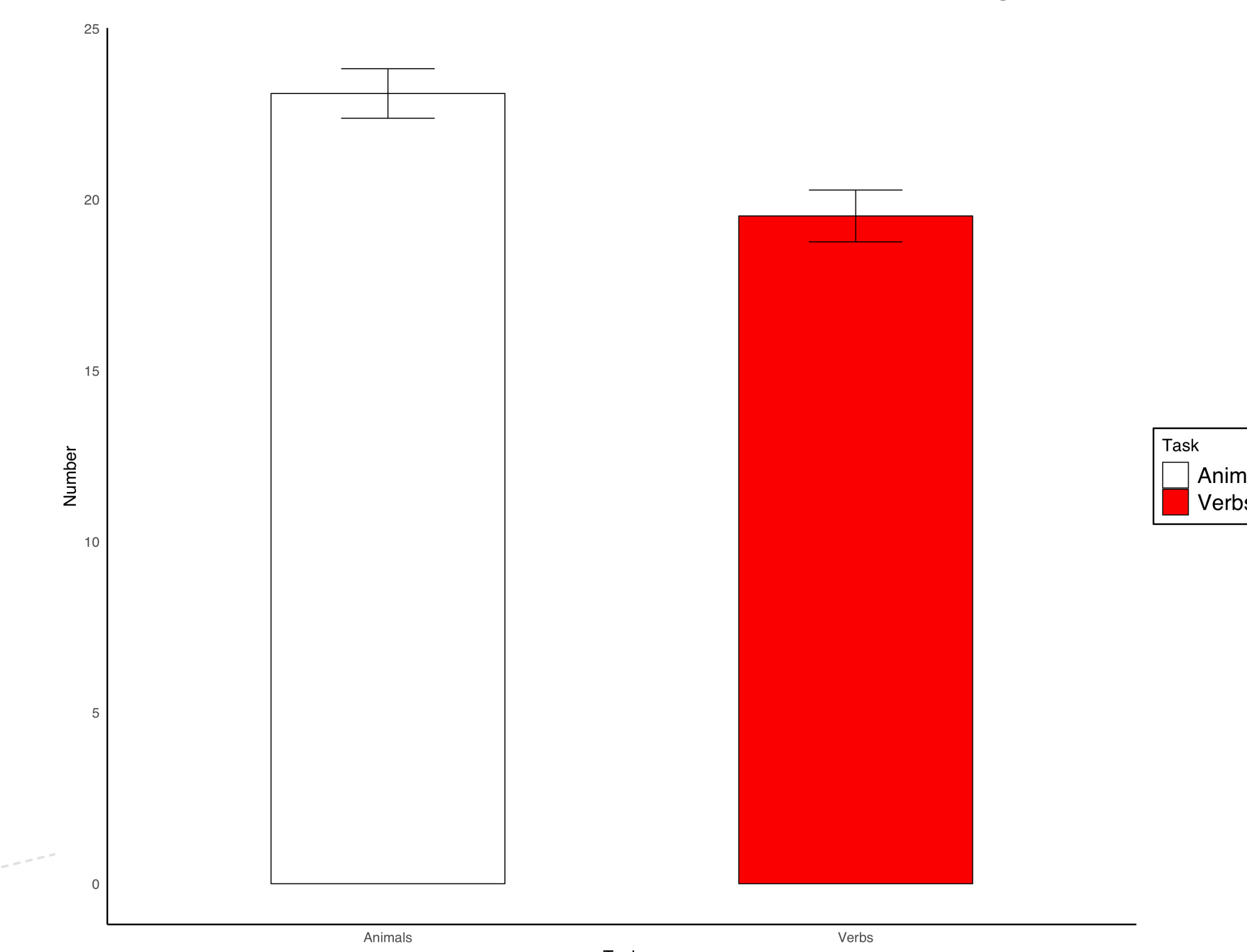
$$P(w_i | w_{i-1}) = \frac{\beta_i^{\lambda_0} \prod_{j=1}^2 S_j(w_{i-1}, w_i)^{\lambda_j}}{\sum_k \beta_k^{\lambda_0} \prod_{j=1}^2 S_j(w_{i-1}, w_k)^{\lambda_j}}$$

- β_i is the normalized log-frequency of the current word.
- S_1 and S_2 are semantic and syntactic similarity between the previous and current word.
- λ parameters control the contribution of each lexical information.
- The goal is to find the most likely set of λ parameters that would have generated each participant's sequence of words using maximum likelihood estimation.

Results

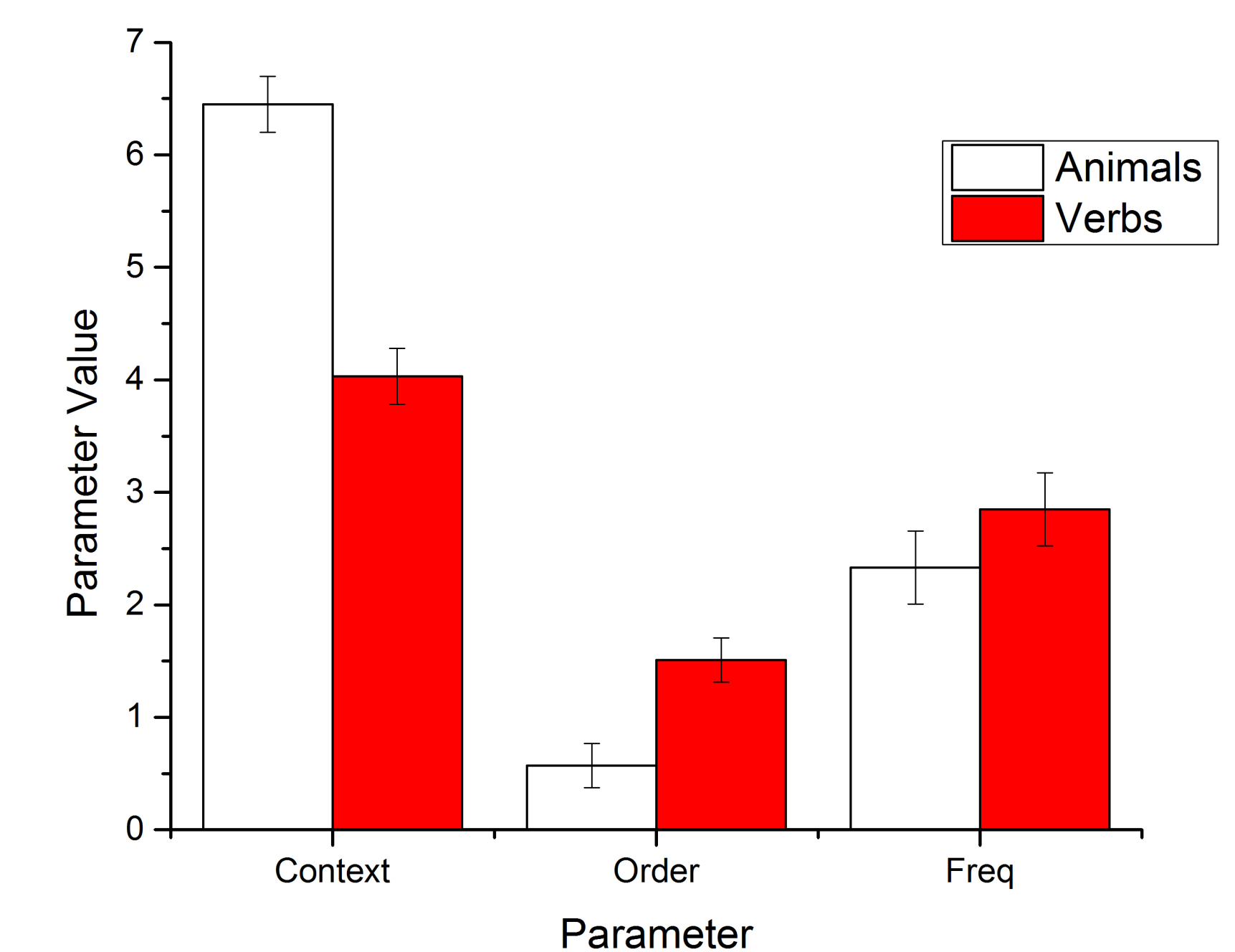
Behavioral Results

- Participants produced statistically more words ($t = 3.42$, $p < .001$) in animal fluency ($M = 23.10$, $SD = 5.12$) than in verb fluency ($M = 19.52$, $SD = 5.36$), which indicates that verb fluency is a harder task than animal fluency.



Modeling Results

- Animal fluency and verb fluency have distinct memory search pathways.
- Animal fluency – semantic information
- Verb fluency – semantic & syntactic info



Discussion

- People dynamically use semantic and syntactic information to organize memory retrieval in verb fluency, which is in line with the claim that verbs encode both information in mental lexicon.
- Verb fluency may be useful in diagnosing different clinical populations (e.g., agrammatic vs. anomic aphasia) as they may exhibit different search patterns (that is, different parameter values).

References

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- Jones, M. N., & Mewhort, D. J. K. (2007). Representing word meaning and order information in a composite holographic lexicon. *Psychological Review*.