Changes in semantic structure and free recall due to cognitive impairment and normal cognitive aging

Holly Westfall[1]; Jason R. Bock[2]; Tushar Mangrola[2]; Michael D. Lee[1]

[1]Department of Cognitive Sciences, University of California at Irvine, Irvine, CA, USA
[2]Medical Care Corporation, Newport Beach, CA, USA

Background

In free recall tasks, participants often group their responses by semantic similarity. This response strategy presupposes the existence of an intact similarity-based semantic representation network. However, normal cognitive aging, or various forms of cognitive impairment, could disrupt access to semantic representations. Free recall tasks provide an instrument to test a semantic network's integrity. We investigate the semantic structure of free recall via semantic similarity judgments and free recall output.

Method

We analyzed two different datasets. One dataset included 724,933 observations from cognitively healthy participants ranging in age from 15 to 110 years. Another dataset included 34,593 observations from clinical patients between 16 and 115 years (**Figure 1**), diagnosed with FAST stages ranging from 1 to 7. Participants completed triadic comparisons of animal names and an unexpected delayed free recall task of those animal names. Analyses included a multi-dimensional scaling (MDS) analysis of semantic representation based on similarity judgments inferred from the triadic comparison data. We calculated a spatial statistic dependent on nearest-neighbor distances to quantify the degree of clustering in each semantic representation [Lee, Abramyan, & Shankle (2016). Behavior Research Methods, 48, 1492-1507]. We also calculated conditional response probabilities (CRP) from the free recall data. We visualized changes in nearest-neighbor distances, CRP, and the relationship between semantic similarity judgments and CRP as a function of FAST score in the clinical data set and of normal aging in the cognitively healthy participants.

Result

For clinical patients, as FAST stage increases, semantic representations become less clustered (**Figure 2**) and CRPs are less related to semantic structure (**Figure 3**). We also found a curvilinear relationship between semantic similarity and CRP in early FAST stages, but this relationship is less evident as FAST stage increases (**Figure 4**).

In cognitively healthy participants, a similar pattern emerges for ages greater than 70 years: semantic representations become less clustered, CRPs become more random, and the curvilinear relationship between semantic similarity and CRP diminishes (**Figure 5**).
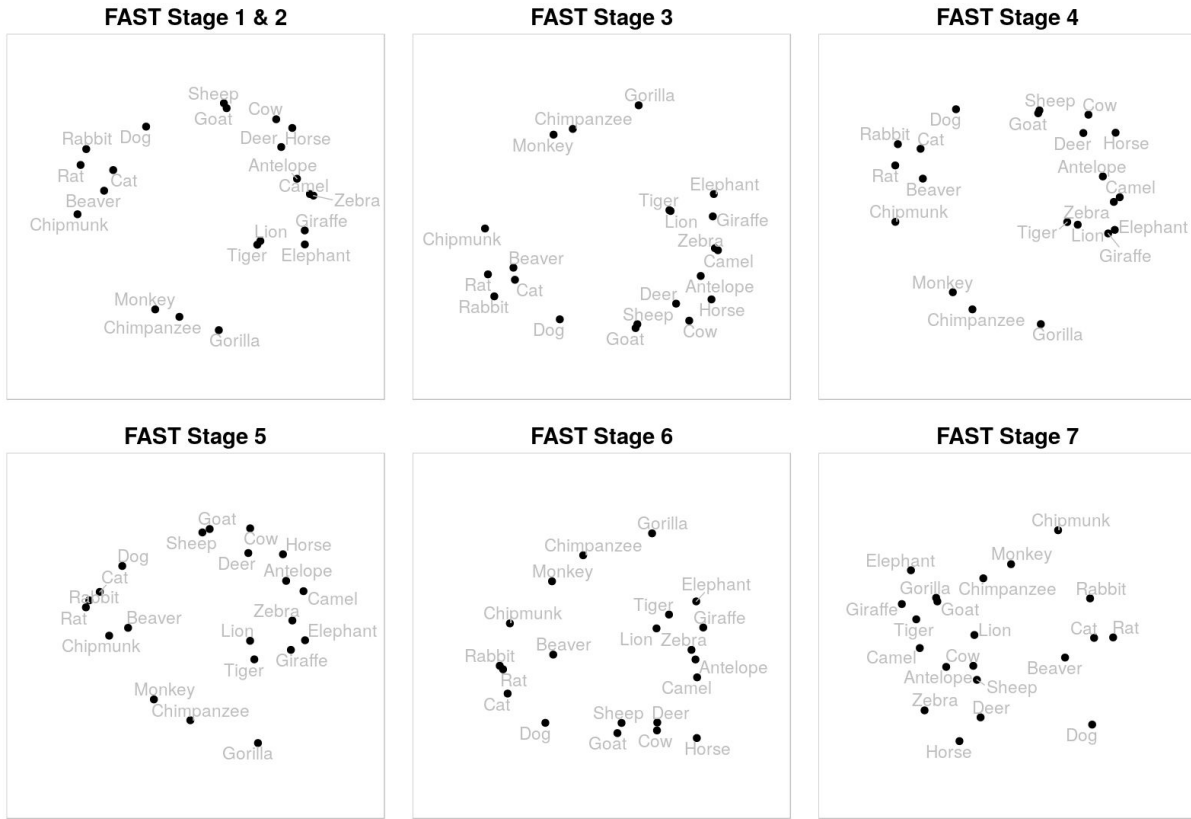
Conclusion

In a clinical population, semantic structure appears to break down as FAST stage increases. We see a similar change in semantic structure in a cognitively healthy population as age exceeds 70 years.
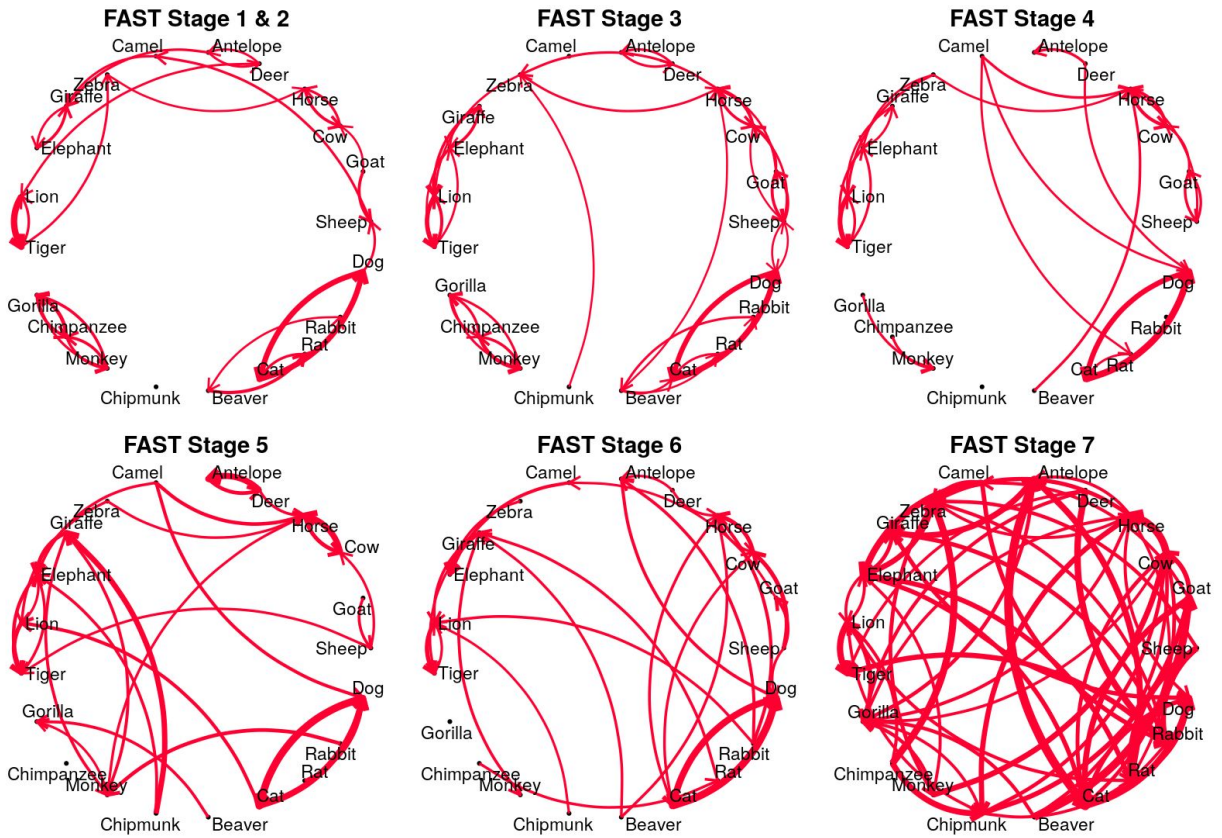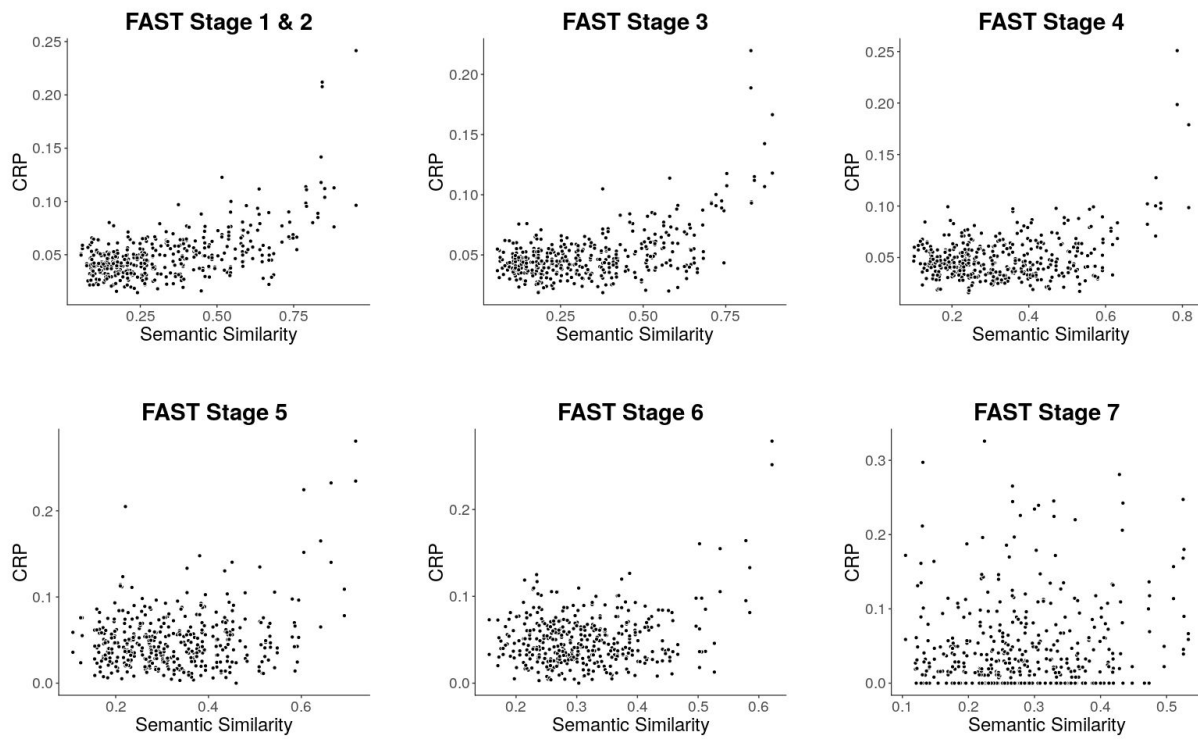
Figure 1

Clinical Participants — Cognitively Healthy Participants
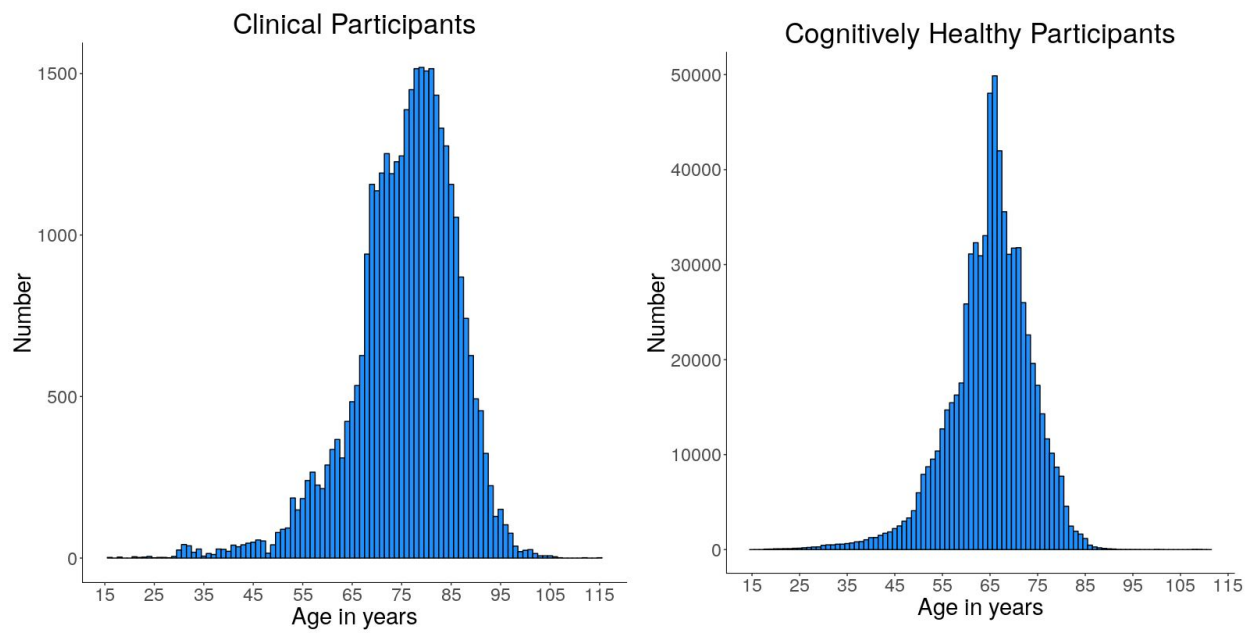
Figure 2

Figure 3

Figure 4

Figure 5