Neuroimaging the language network with a parsing algorithm

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Question: which parts of the brain work like a parser during naturalistic comprehension?

materials: 15K words from literary text

four comprehension questions after each section (~ 15 minutes)

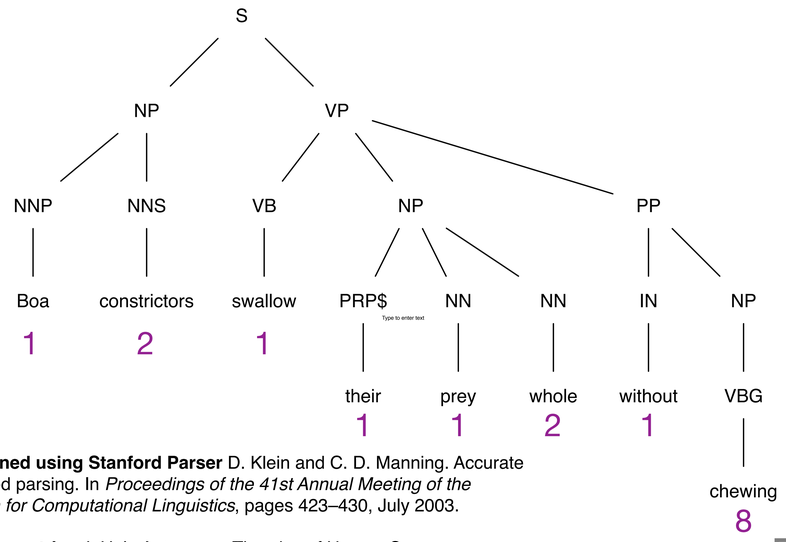
What does the narrator most often discuss with grown-ups?
(a) Boa constrictors, primeval forests, and stars
(b) Tiaras, diamonds, gold, and platinum
(c) Bridge, golf, politics, and neckties
(d) Drawings, paintings, and sculptures

Participants: college-age, right handed native English-speakers

multi-echo fMRI

- Multi-echo T2*-weighted fMRI images were acquired with echo-planar imaging (EPI) at 3 echo times (TEs) – 12.8, 27.5 and 43 ms – opposed to conventional single-echo EPI (Kundu et al 2012)
- Multi-echo fMRI acquisition allows for differentiating signal changes due to Blood Oxygen Level Dependent (BOLD) effects and non-BOLD artifacts such as head motion and cardiac pulsation based on goodness of fit to BOLD biophysical model
- Independent Component Analysis (ICA) was first applied to multi-echo data and derive spatial components subject to sorting based on statistical scores associated with BOLD and non-BOLD signal changes
- Multi-echo fMRI data were de-noised by removing non-BOLD fluctuations from time series data to reliably and robustly improve data quality

Method: parser action count, convolved with HRF enters into regression against observed BOLD signal

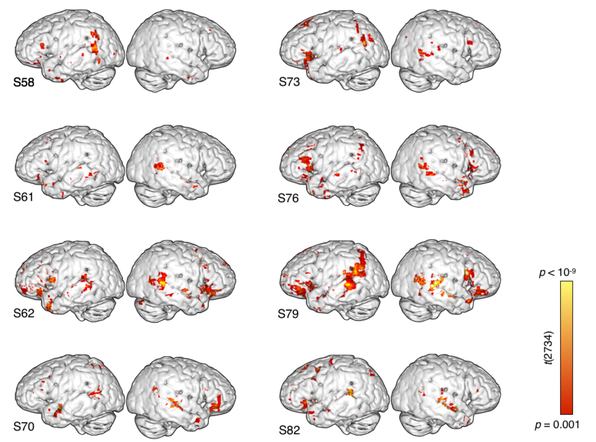


trees obtained using Stanford Parser D. Klein and C. D. Manning. Accurate unlexicalized parsing. In *Proceedings of the 41st Annual Meeting of the Association for Computational Linguistics*, pages 423–430, July 2003.

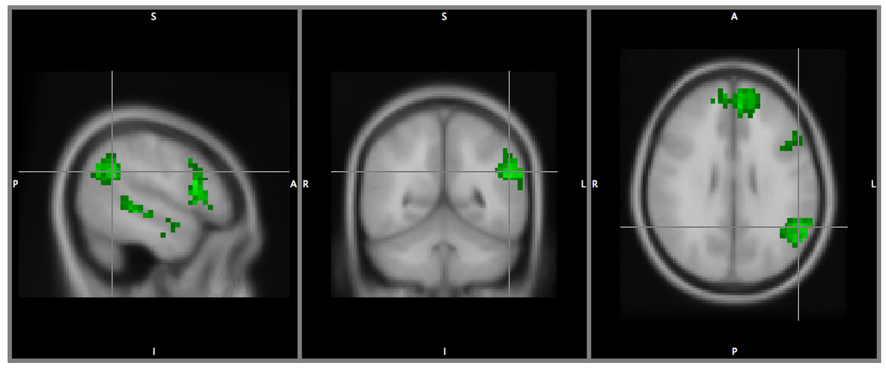
for more on metrics J. Hale Automaton Theories of Human Sentence Comprehenson. CSLI Publications 2014.

word	time offset	bottom-up parser actions	freq per million in movie subtitles
boa	17.584	1	1.29
constrictors	18.321912	2	0.16
swallow	18.811869	1	12.73
their	18.984	1	655.16
prey	19.45755	1	5.51
whole	19.913324	2	385.49
without	20.334	1	354.65
chewing	20.9022	8	5.51

Results: per-subject t-maps



Results: group analysis N=32



Discussion: peaks observed in left angular gyrus and left inferior frontal gyrus, p<0.05 FWE
Activation in superior temporal sulcus visible at slightly lower thresholds

Conclusion: activation in frontal & temporal areas correlates with transient workload of bottom-up parser