# Relational vs. attributive interpretation of noun-noun compounds differentially engages angular gyrus



# Introduction

The angular gyrus (AG) has been found to respond to a number of different tasks involving combinatorial processing over and above lexical processing. For instance, meaningful noun compounds like "lake house" have been found to elicit greater activity in the angular gyrus (AG) than when their constituents are reversed ("house lake") and less compositional (Graves et al., 2010). In other studies, AG has been implicated in tracking verb argument structure and thematic relations between concepts (Binder et al., 2009; Schwartz et al., 2011, Thompson et al., 2007). This sort of relation-based combination can be contrasted with feature-/attributebased combination, as in adjective-noun composition, which has been found to elicit activity relative to non-compositional stimuli in other regions, such as the left anterior temporal lobe (left ATL) (Baron et al., 2012; Bemis & Pylkkänen, 2011). In this study, we further investigate the case of noun-noun compounds, and ask whether AG activity is also modulated by the type of combinatorial operation applied to a noun-noun compound.

### "Robin Hawk" Example: Attributive Combination

Concepts are a constellation of features/attributes, which can be recombined







Prediction: Attributive compounds will engage ATL more than relational compounds.

## **Relational Combination**

- Concepts are atomic (not broken down into features) and act relative to some implicit predicate
- Items are arguments in a thematic relation: e.g. preys on (hawk, robin)



compounds.

# Stimuli and Design

Stimuli from Estes, 2003, and Wisniewski & Love, 1998 64 attributive-biased (94.5% bias, 17 subjects) and 64 relational-biased (89.6% bias) compounds matched on frequency, length, imageability

**Task:** Indicate with button press if meaning that appears on screen matches your interpretation 17% of trials had a probe word/phrase ("catch trials") which were not synonymous.





8 runs of ~5 min each

# Christine Boylan<sup>1,2</sup>, John Trueswell<sup>1</sup>, Sharon L. Thompson-Schill<sup>1,2</sup> (1) Department of Psychology, University of Pennsylvania (2) Center for Cognitive Neuroscience, University of Pennsylvania

## Examples of attributivebiased

## compounds

- canary crayon
- shark politician
- molasses traffic

## Examples of relationalbiased

## compounds

- floor television
- battle theory
- employee vote

# speakers of English.

## Voxel Selection

- Task vs. fixation clusters: Family-wise error correction for multiple comparisons was performed using Monte Carlo-based simulations with the AFNI program 3dClustSim,  $p \le 0.01$  FWE, 200voxel cluster size threshold
  - *Task > fixation;* e.g. *cactus carpet >* fixation
  - Fixation > task; evidence that mid/ventral regions of left AG are part of "default network" prompts a look at below-baseline activity (Seghier et al., 2010)
- Anatomical ROI masks: From AFNI's CA ML 18 MNIA atlas. LATL = left temporal pole + left medial temporal pole. LAG = left angular gyrus. RAG = right angular gyrus

## Task > Fixation clusters + ROI outlines







## References

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Methods

Subjects: 11 subjects (5 male) recruited from the University of Pennsylvania, all right-handed native



# Discussion

We compared univariate measures of activity in left anterior temporal lobe and bilateral angular gyrus in response to two different kinds of noun-noun composition: attributive, where properties/features of the modifier noun are applied to the head noun, and *relational*, where a *thematic relation* is imposed between the modifier and head nouns. We find evidence that both right and left angular gyrus differentially engage in attributive and relational interpretation of noun compounds. These findings add to a growing literature implicating bilateral AG in conceptual combination. It also suggests that future study of the neural bases of combinatorial language would benefit from a distinction between attributive and relational operations.

chboylan@sas.upenn.edu



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- fMRI acquisition:
- TR = 2 sec
- 2x2x2 mm voxel size
- B0 unwarping
- multiband (3-band) EPI sequence

## Bilateral AG responds differentially to attributive and relational compounds

• Task-related changes in BOLD signal at the individual level were estimated at each voxel using a finite impulse response (FIR) model and a general linear model (GLM)

Center of LAG task > fixation cluster: [-45 -54 38] Talairach (cf. "dorsal AG/IPS" center: [-41 -55 45], Noonan et al., 2013) Center of LAG fixation > task cluster: [-39 -67 35] Talairach (cf. "midAG" center: [-39 -65 30], Noonan et al., 2013)

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