# Does Language Cause Thought?
## Beyond Correlation with Transcranial Magnetic Stimulation

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### Abstract:

*Philosophers and neuroscientists have long explored the link between natural language and other cognitive processes. Monti et al. (2011, 2012) have shown, via fMRI, that in solving hierarchical problems (ie. those dependent on embedded structures) in the domains of logic and math, the brain uses neural resources independent of major language areas. The present study seeks to bolster these correlational imaging findings with a causal paradigm that applies transcranial magnetic stimulation (TMS) to Broca's area in order to temporarily inhibit processing. This region of interest (ROI) in the left inferior frontal gyrus is key to syntax processing and has also been thought to act as a supra-modal hierarchical parser (SMHP) for all structure-dependent thought. Subjects' accuracy and response times will be measured during sessions with and without TMS focused on the ROI, while completing behavioral tasks in five domains: 1) language syntax processing, 2) algebraic reasoning, 3) theory of mind comprehension, 4) harmonic violation judgment, and 5) action sequence planning. The TMS is expected to significantly impair performance in 1, to a lesser extent in 4 and 5 (both theorized to involve syntax processing), and not in 2 or 3. This pattern would show that the ROI does not support all hierarchical tasks and disprove the SMHP hypothesis. Overall, this experiment will shed more light on the relationships, or lack thereof, between language processing and other domains of cognition.*

**Main Question:** How might inhibiting the function of the left inferior frontal gyrus (in blue) with electromagnetism affect subjects' ability to complete tasks like the following?
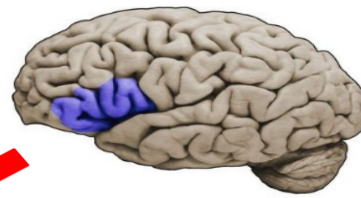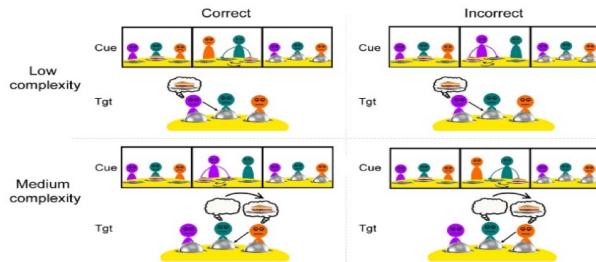
## Algebraic Reasoning

| Correct | Incorrect |
|---|---|
| Cue: 1 + 3 | 2 + 3 |
| Low Complexity Target: (2 + 3) - 1 | |
| Cue: 2 x 3 | 3 / 1 |
| Higher Complexity Target: ((2x2) + 3) - 1 | |

## Theory of Mind Comprehension

Correct — Incorrect
Cue / Low complexity / Tgt
Cue / Medium complexity / Tgt

## Linguistic Syntax Processing

Correct — Incorrect

Low complexity
Cue
Tgt — The cat chases the dog and the mouse.

High complexity
Cue
Tgt — The cat chases the mouse that is chasing the dog.
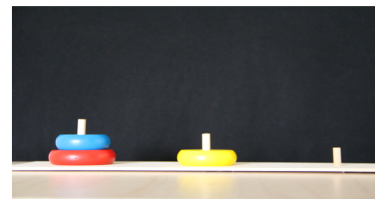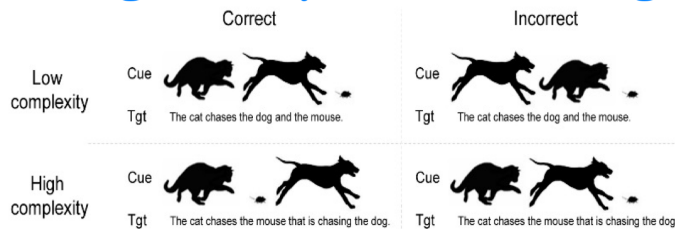
## Action Planning

## Musical Judgment

Regular
Irregular

Sammler et al. 2010

TARGET CHORD EXPECTED — TARGET CHORD UNEXPECTED
Sequence A — Sequence A'
I V IV I V I V — I V VI IV V V I IV

Bigand and Pineau 1997

**Key terms (Ask me!):** *Hierarchy; Broca's area; Transcranial magnetic stimulation; Supramodal hierarchical parser; Syntax (harmonic and linguistic)*