# Linguistic Rule Representation in the Bilingual Brain

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## Background

The majority of research on the neural basis of bilingualism has focused on how multiple semantic systems are represented and controlled; however, bilingualism increased demands in at least two ways:

1. **Lexical Selection:** Two linguistic codes are available for one reference.
2. **Linguistic Rule Selection:** Two sets of rules exist for each grammatical function.

And very little is known about multiple rule representation.

## Methods

**Participants:** Proficient Bilinguals (n = 24, 21 females)

- Highly fluent in both Spanish & English before the age of 10
- Right-handed

**Part 1:** Completed Psychometric and Language History Measurements

- Spanish & English grammar proficiency tests
- Language Experience and Proiciency Questionnaire, Bilingual Switching Questionnaire

**Part 2:** Received training for Linguistic-Rapid Instructed Task Learning (L-RITL) paradigm

- Learned the codes in L-RITL with a memory task
  - #: English ; #: Spanish
  - 1: Pronoun ; 2: Plural
- A: Past ; B: Future
- Practiced the L-RITL paradigm

**Part 3:** Completed L-RITL paradigm in fMRI scanner

**Hypothesis:** Target Language (e.g., English vs. Spanish) is represented hierarchically with specific grammatical rules (e.g., to pluralize) stored separately under each language.

**Hypothesis:** Target language is represented as a feature of each grammatical rule.

## Results

**Encoding Target Language (TL)** distributed patterns of activation in bilateral prefrontal cortex and in superior temporal and parietal regions, including classic Broca’s and Wernicke’s areas (A). Regions that are more active for encoding target language > linguistic rules include bilateral anterior superior and medial frontal regions and Wernicke’s area (C).

**Encoding Linguistic Rules (LR)** elicits a more left lateralized pattern of activation including Broca’s area and parietal regions (B), but not semantic regions. The one region that was more active for encoding linguistic rules > target language was the inferior frontal gyrus (approximately Broca’s area) (D).

**Encoding Dominant Language vs. Non-Dominant Language**

- Conducting region of interest analyses in prefrontal and striatal regions.
- Using Dynamic Causal Modeling to examine the flow of information through key regions of interest during encoding and execution of rules.

## Discussion

- The results suggest that preparing to execute a rule in a target language recruits a distributed network including semantic regions and grammatical regions.
- To our knowledge this is the first attempt to investigate the representation of linguistic rules in bilinguals in the absence of semantic influence.
- The results may not capture natural linguistic representation, as some shared regions are recruited in the non-linguistic rule based behavior (i.e., parietal lobe in encoding rules).
- Follow up analysis shows that dominant and non-dominant languages have separate and overlapping areas of rule representation (similar to semantic networks).