Analyzing the Surprising Variability in Word Embedding Stability Across Languages

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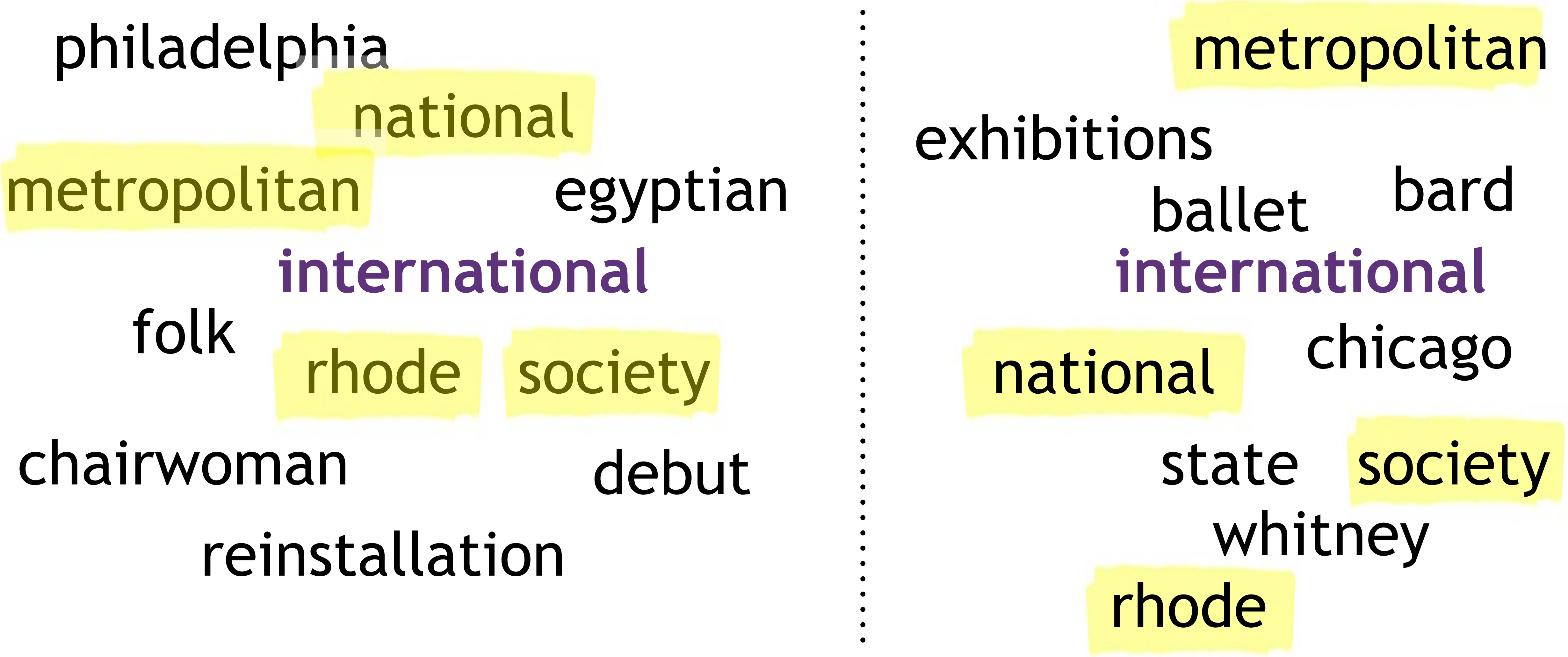
This material is based in part upon work supported by the National Science Foundation (grant #1815291) and by the John Templeton Foundation (grant #61156).

What is Stability?

Stability = *percent overlap between ten nearest neighbors in an embedding space*



philadelphia

national

metropolitan

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folk

rhode

society

chairwoman

debut

reinstallation

metropolitan

exhibitions

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ballet

international

chicago

national

state

society

whitney

rhode

Stability = 40%

This Work

Does stability vary for different languages?

Is stability associated with linguistic properties?

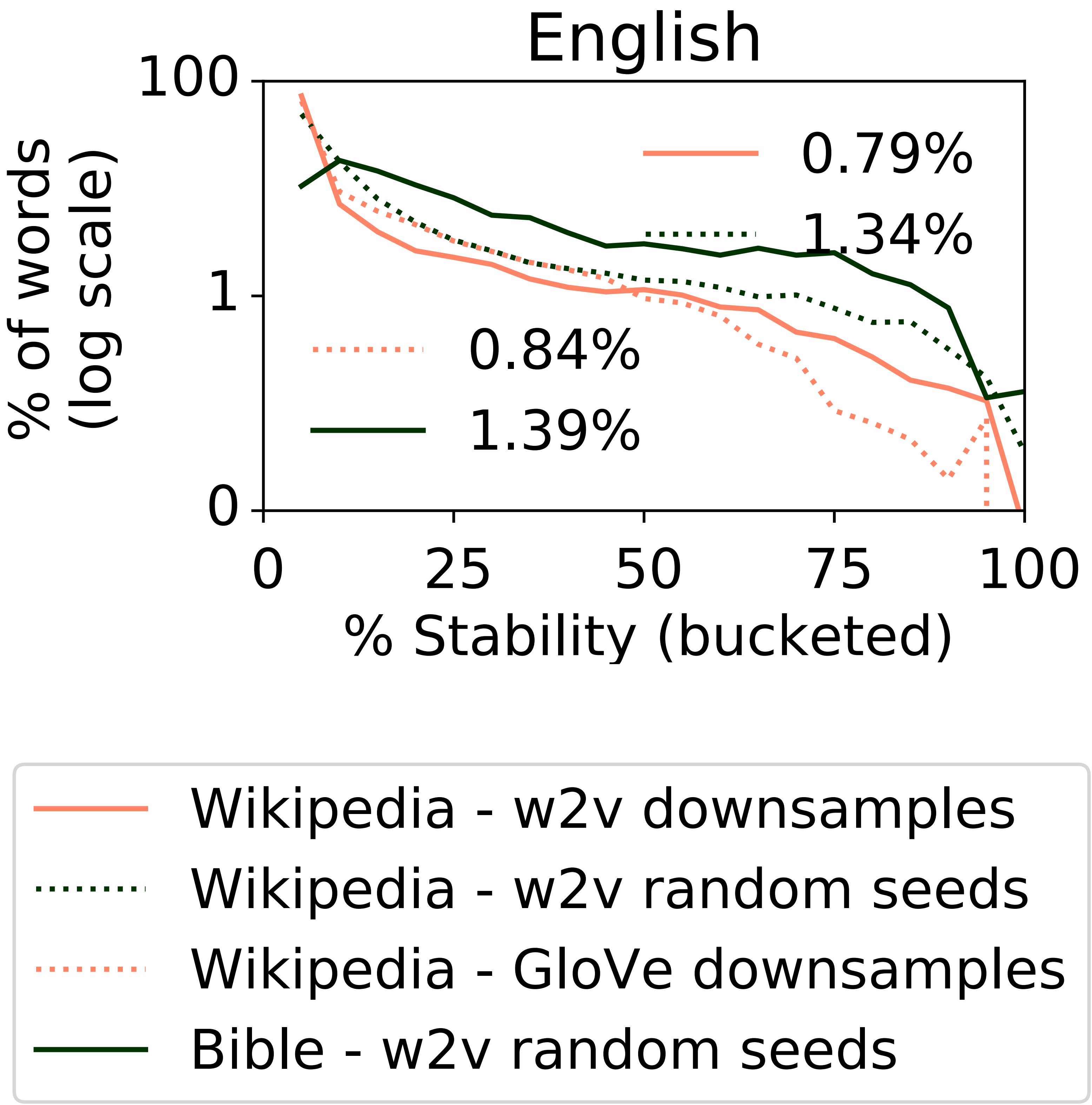
- **Data**
  - **Wikipedia** (40 languages)
  - **Bible** (97 languages)
  - **World Atlas of Language Structures (WALS)**, phonological, lexical, and grammatical properties (>2,000 languages)

Stability for Wikipedia and the Bible

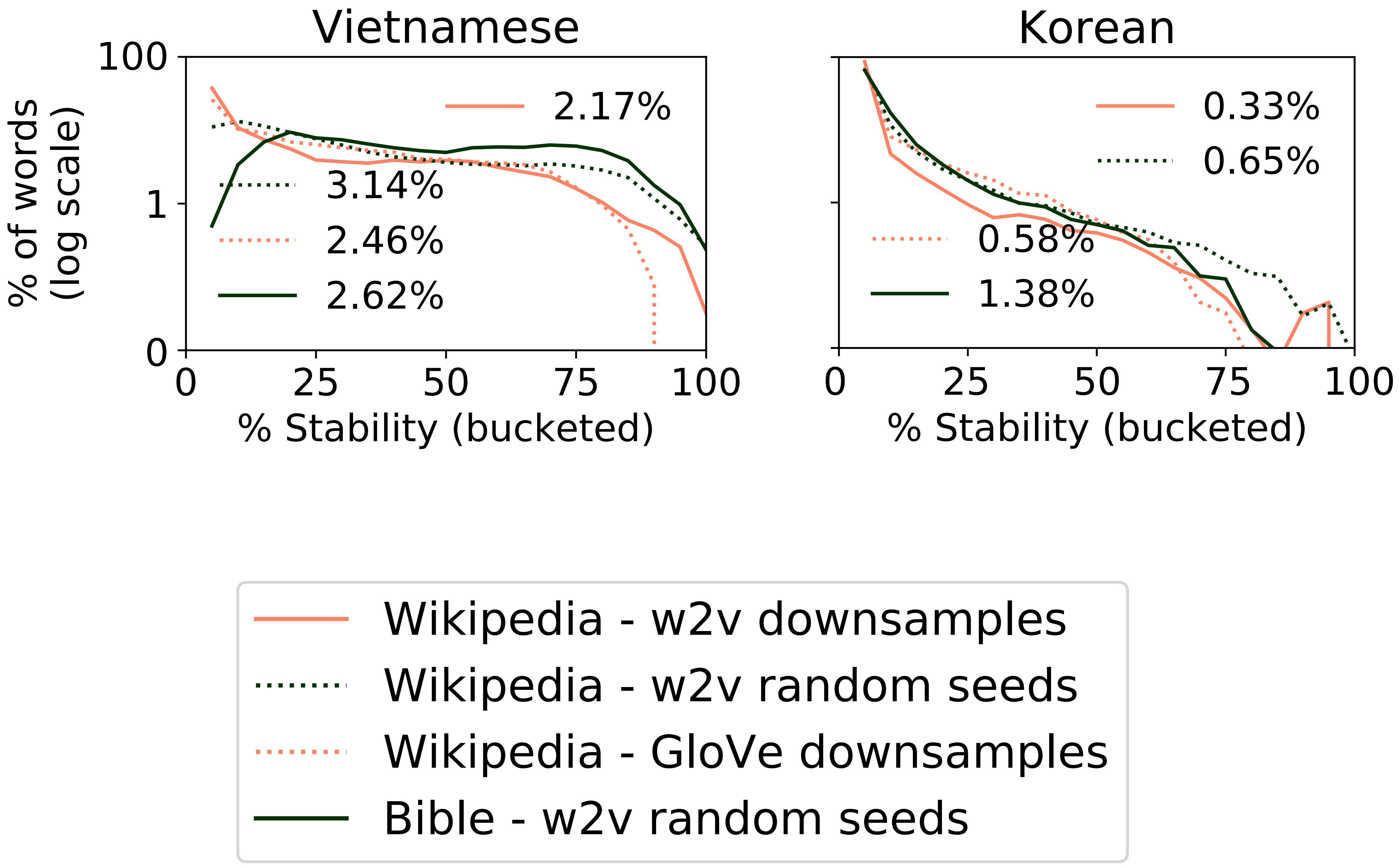
We compare the stability of embeddings for 26 languages.

- **Wikipedia (3 settings):** Stability of…
  - GloVe embeddings across 5 downsampled corpora
  - word2vec (w2v) embeddings across 5 downsampled corpora
  - w2v using 5 random seeds on 1 downsampled corpus
- **One setting for the Bible:** Stability of w2v embeddings using 5 random seeds on 1 downsampled corpus
- Each downsampled corpora 100,000 sentences

Stability for Wikipedia and the Bible



Stability for Wikipedia and the Bible



Regression Modeling

We use a regression model to predict stability in a language using linguistic properties.

- Ridge regression

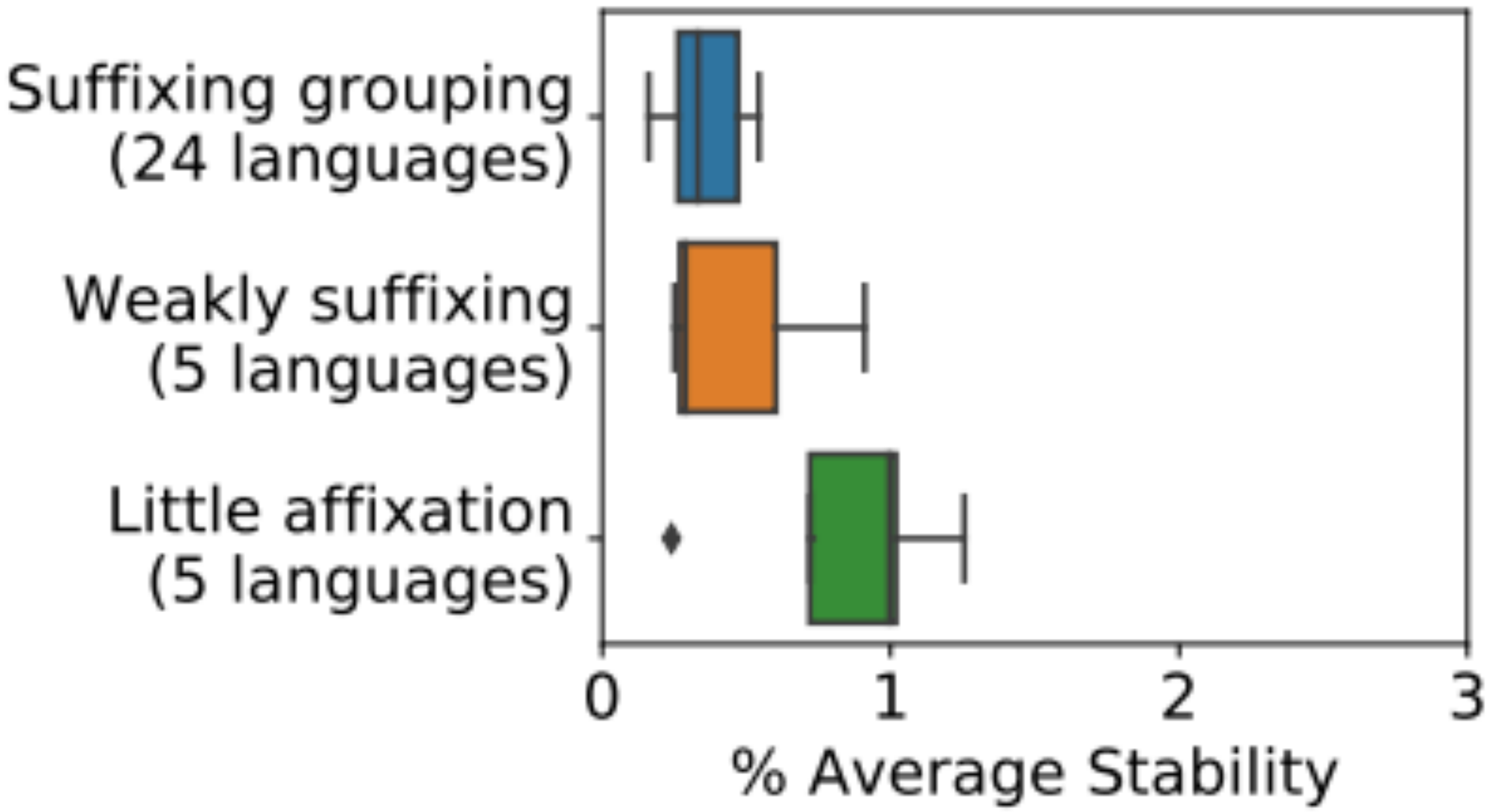
- 37 languages

- Input: 97 WALS properties
- Output: Average stability of all the words in a language

- High R^2 score of 0.96 ± 0.00

Regression Modeling

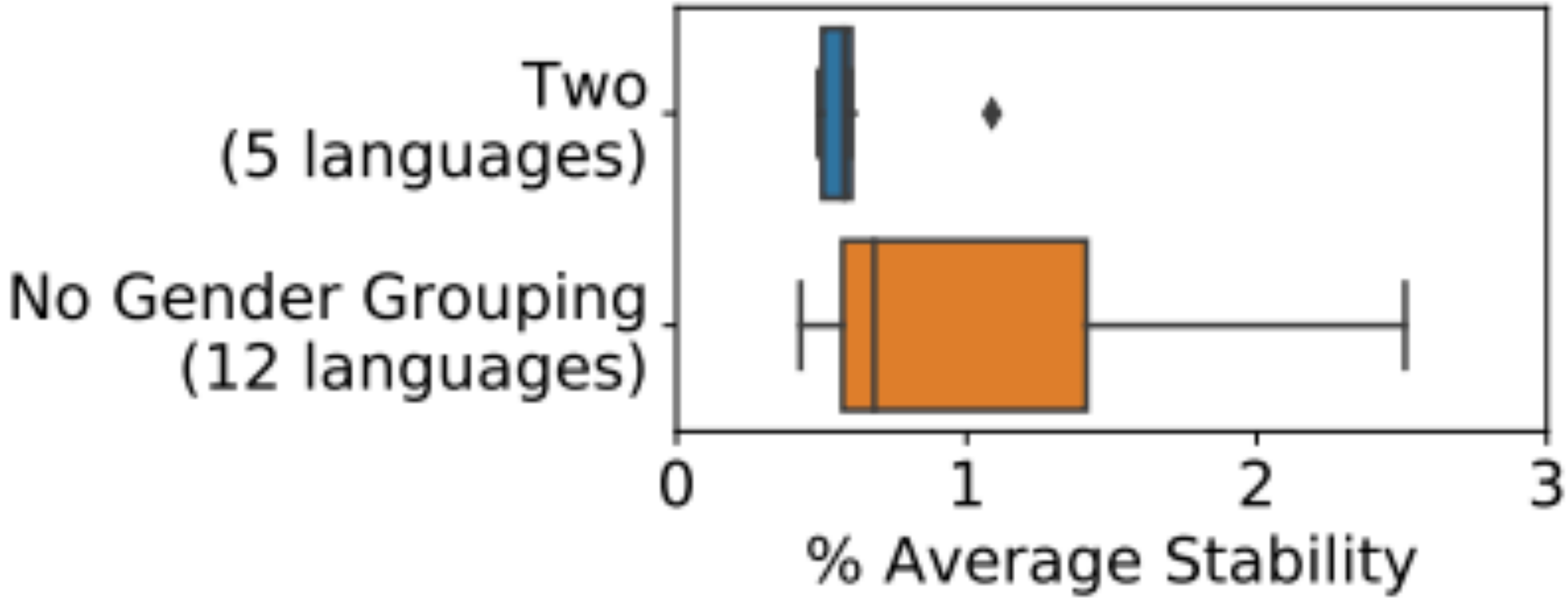
- More affixing (suffixing and prefixing) associated with lower stability
  - Affixes cause increased word variation



Prefixing v. Suffixing in Inflectional Languages

Regression Modeling

- Languages with no gender system associated with higher stability
  - Languages with gender systems have more word forms



Number of Genders

Final Thoughts

- *Languages with more affixing tend to have less stable embeddings*
- *Languages with no gender systems tend to have more stable embeddings*
- *Future embedding design needs to take into account gendered words and morphologically rich words with affixes*

Download our code:

`http://lit.eecs.umich.edu/downloads.html`