Discrimination learning, suffixing and prefixing in an artificial language learning experiment

Maša Vujović[1], Michael Ramscar[2], & Elizabeth Wonnacott [1]

[1] University College London, [2] University of Tübingen

Background

- Recent work in discrimination learning (Ramscar, 2013) suggested that suffixes and prefixes involve different kinds of learning mechanisms:
  - ➢ Suffixes: facilitate learning to abstract common dimensions from a set of preceding elements in a sequence
  - ➢ Prefixes: facilitate learning of probabilities of subsequent elements in a sequence

Research question Can discrimination learning inform our understanding of: (1) learning to generalize abstract patterns to new words, and (2) learning the meanings of individual words?

General method

Participants trained and then tested on an artificial language with two noun classes marked by phonological (vowel) and semantic (shape) cues and each accompanied by one of two affixes.

Condition	Class A	Class B
Suffix	feep ge / ge feep	kood ma / ma kood
Prefix		

Prediction:

Suffix condition	better generalization to new exemplars
Prefix condition	better vocabulary learning

Computational model

- **Rescorla-Wagner Model** (1972): learning only occurs when events violate predictions (*error-driven learning*).
- Goal: learn how strongly each **feature** of a stimulus (cue) predicts a **label** (outcome).
- Rescorla-Wagner equations:

(1) $\Delta V_{ij}^{n} = \alpha_i \beta_j (\lambda_j - V_{total})$ → learning

(2) $V_{ij}^{n+1} = \Delta V_{ij}^{n} + V_{ij}^{n}$ → update

V – strength of association between set of cues i and outcome j; α and β – learning rates; λ – maximum amount of associative value an outcome j can support; V_{total} – predicted response (sum of all weights on a given trial)

- ➢ Suffix simulation cues: nouns & pictures; outcomes: suffixes
- ➢ Prefix simulation cues: prefixes; outcomes: nouns & pictures

Artificial language learning experiment

Participants: N=44 monolingual English-speaking (20 female), M_{age}= 34.4 (age range: 20-62), recruited through Prolific Academic.

Procedure: two consecutive sessions of [Training + Testing]

(1) Training 4 blocks of 24 trials

- ➢ Suffixes: hear noun and see picture, then hear suffix
- ➢ Prefixes: hear prefix, then hear noun and see picture

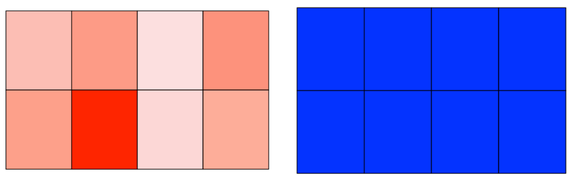
(2) Testing: vocabulary (old items) & generalization (new items)

References [1] Ramscar, M. (2013). Suffixing, prefixing, and the functional order of regularities in meaningful strings. *Psihologija,* 46(4), 377-396. [2] Rescorla, R.A., & Wagner, A.R. (1972) A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In Black A.H., & W.F. Prokasy (Ed.) Classical conditioning II: Current research and theory. New York: Appleton-Century-Crofts, pp. 64-99. **Acknowledgements** Many thanks to Ben Davidson for generous help with web programming and to Matthew Johnes for advice on running online experiments.

Vocabulary learning: prefix condition better

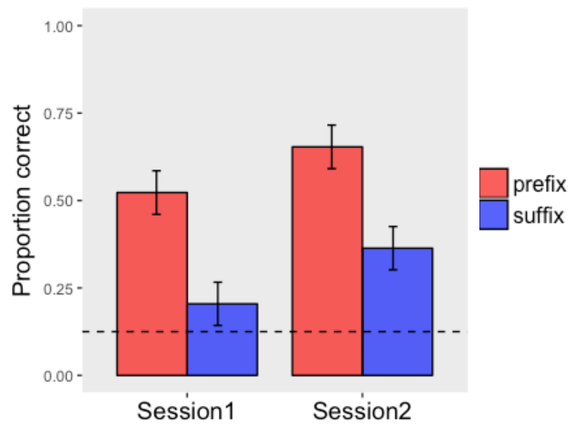
Model

Each cell represents the sum of weights for all features associated with each of the eight individual aliens. Prefix red, suffix blue.



Prefix network distinguishes individual aliens, suffix does not

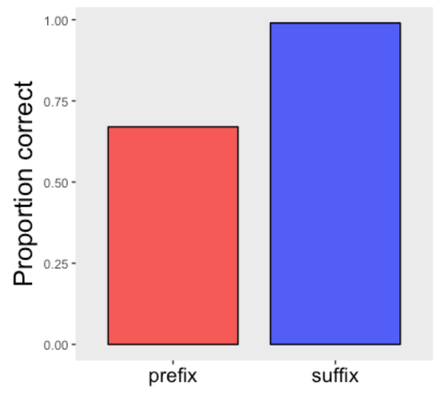
Humans



Prediction met? YES!

Generalization: model better in suffix, humans better in prefix condition

Model



The weights of each novel alien were computed for each class of aliens, and the outcome was turned into probability of choosing the correct class i out of all classes j as follows:

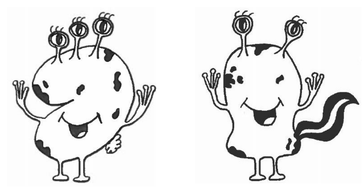
$$P(i) = \frac{w_i}{\Sigma_j w_j}$$

Suffix network classified aliens based on shape and vowel better than prefix.

Humans

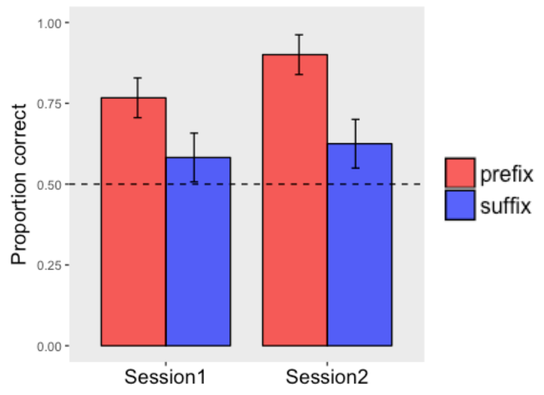
Prediction met? NO!

1. Matching affix with shape



joob ma

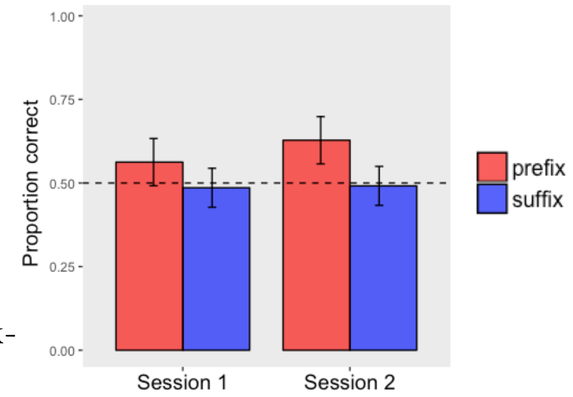
Choose the alien that goes with the sound you heard.



2. Matching affix with vowel

joob ma OR neeb ma

Choose the sound that follows the rules of the alien language.



Note: affix-to-vowel harder than affix-to-shape

Conclusions

- Prefix condition better than suffix condition at vocabulary learning (as predicted) *and* generalization (contrary to prediction).
- Vocabulary learning might have facilitated explicit learning and better generalization.
- Shape is a salient feature, so learning the affix-to-shape mapping might have been more like word learning than generalization of an abstract pattern.
- Future steps: (1) repeat with children (might show less explicit learning and shape might not be as salient; might also favor phonological cues); (2) probabilistic rather than deterministic categories (prediction: should promote discrimination learning).