Artificial Language Learning of an Optional Grammatical Marker

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Introduction

Goal of the Study: Investigate the learning (and use) of optional grammatical markers from variable input using an artificial language learning paradigm

Filler-Gap Dependencies

(1) **The book** that the author wrote the article about ___ …
filler gap

Cues to Gap Positions

- Fillers are cues to the presence of a gap with no details about gap position
- *Wh*-agreement = morphological marker on verb that unambiguously indicates the gap position (e.g., direct object gaps in Chamorro [1])

Online Processing

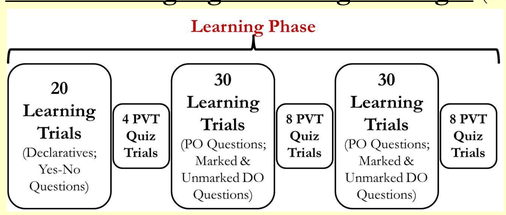
- Active completion of filler-gap dependencies → gap predicted in first possible syntactic position (i.e., the direct object position) without bottom-up evidence (e.g., [2,3])
  - No active completion of the direct object gap in Chamorro when the *wh*-agreement marker is absent [1]

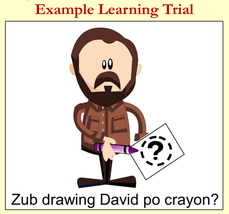
Main Questions: Can participants learn a new cue that is informative about the gap position? What do they learn about this cue, and can they use it in their real time processing?

Artificial Language Learning Paradigm

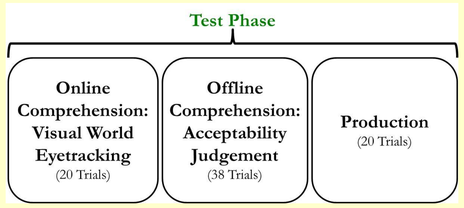
Participants 80 native English speakers from JHU community

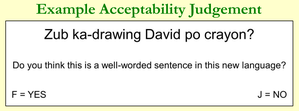
Artificial Language Learning Paradigm (following [4,5])

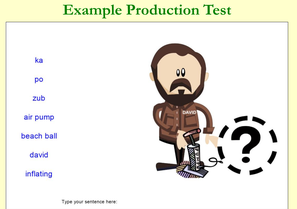




- Participants heard, read, & repeated on each trial







Artificial Chamorro (AC)

- VSOX word order (same as Chamorro)
- English verbs & nouns

3 novel function words / morphemes:

- **zub** → question marker (equivalent to *what*)
- **po** → preposition
- **ka-** → optional direct object gap marker

Example AC Sentences

(2) Declaratives: eating David cake po fork.
'David is eating the cake with the fork.'

(3) Yes-No Questions: eating David cake po fork?
'Is David eating the cake with the fork?'

(4) Prepositional Object (PO) Questions: zub eating David cake po __?
'What is David eating the cake with?'

(5) Direct Object (DO) Questions: zub (**ka-**)eating David __ po fork?
'What is David eating with the fork?'

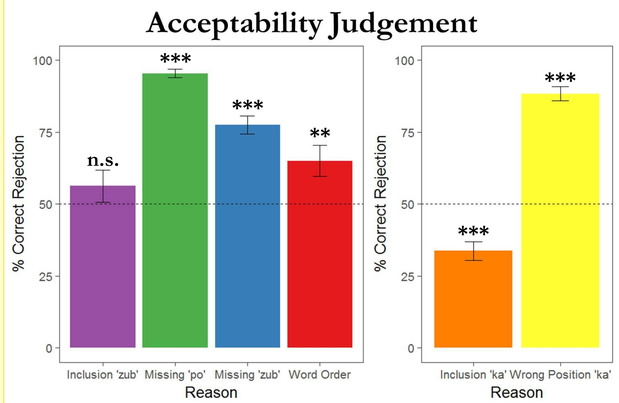
Results: Offline Comprehension

Grammatical sentences = 85.3% accurate

- Presence **ka** does not affect accuracy ($p > 0.1$)

Participants learned the word order as well as the meaning of **zub** & **po**

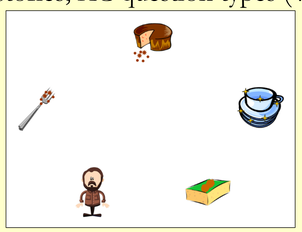
- Learned the position of **ka**, but poor at rejecting it



Results: Online Comprehension

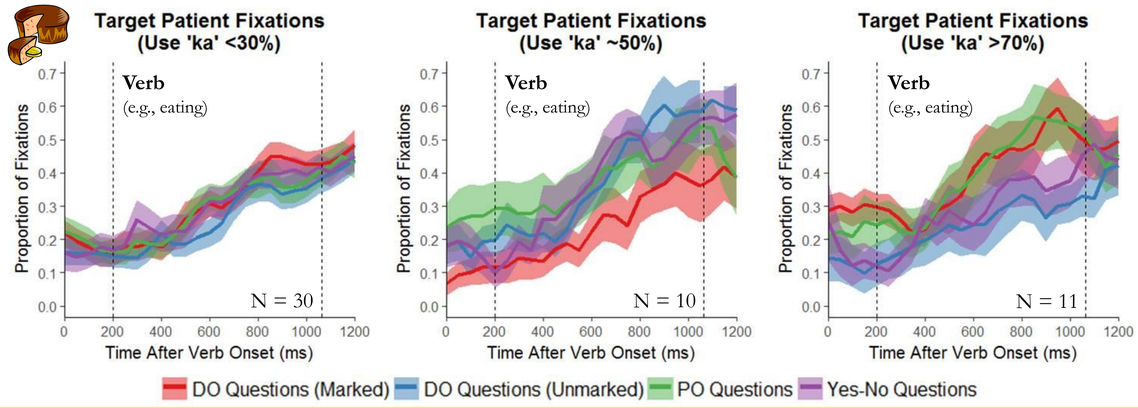
Design Question-after-story design [3]

- 20 stories; AC question types (4 each)



Participants Subset of 51

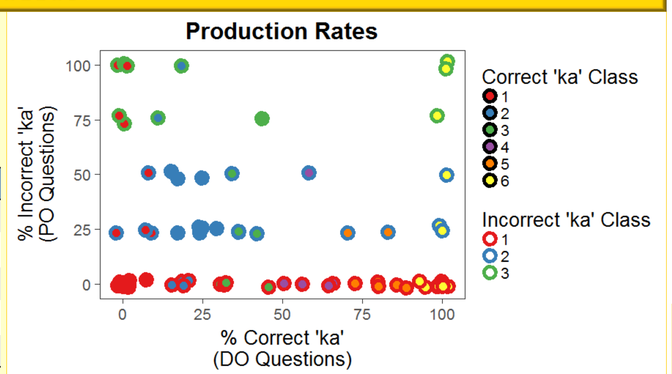
Eye Tracking EyeLink 1000 Remote eye tracker (SR Research, Toronto, ON)



Results: Production

More successful at ***producing DO*** vs. PO questions (78.3% vs. 51.6%, $p < 0.001$)

ka-Knowers ka Use	#
Never (class 1)	17
~20% (class 2)	5
~50% (classes 3 & 4)	8
>70% (classes 5 & 6)	14
Total	***44***



Discussion & Conclusion

Main Findings Participants learned the meaning of an optional marker with limited exposure to variable input, but this knowledge is somewhat unstable as they are poor at rejecting incorrect usages of the marker & demonstrate variable production rates.

Significance

Optional grammatical markers ***are learnable*** from variable input

Production of variability may require more input

- Generalization of **ka**-usage (always vs. never use) despite 50:50 input
  - Not just pattern matching (cf. [4,6])
  - Commonly found with more skewed input (e.g., [4-5,7])

Some evidence of online comprehension effects

- Eye tracking results differ based on production rates
- 50% **ka**-users look at the patient image less in marked DO questions
- 70% **ka**-users did not actively complete the dependency at the verb in unmarked DO questions (& PO questions?)

[1] Wagers, M., Borja, M.F., & Chung, S. (2015). The real-time comprehension of WH-dependencies in a WH-agreement language. *Language*, *91*(1), 109-144. [2] Stowe, L. E. (1986). Parsing WH-constructions: Evidence for on-line gap location. *Language and Cognitive Processes*, *1*(3), 227-245. [3] Atkinson, E., Wagers, M.W., Lidz, J., Phillips, C., & Omaki, A. (under review). Developing incrementality in filler-gap dependency processing. [4] Clothier, K., Satoshi, N., Ono, H, & Omaki, A. (2017). *Cross-situational learning of novel anaphors*. Paper presented at CogSci 2017. London, UK. [5] Culbertson, J., Smolensky, P., & Legendre, G. (2012). Learning biases predict a word order universal. *Cognition*, *122*, 306-329. [6] Estes, W.K. (1964). Probability learning. In A.W. Melton (Ed.), *Categories of human learning* (pp. 89-128). New York: Academic Press. [7] Hudson Kam, C.L. & Newport, E.L. (2009). Getting it right by getting it wrong: When learners change languages. *Cognitive Psychology*, *59*(1), 30-66.