Investigating Non-adjacent Dependency Learning in 12-month-old Infants

Helen Shiyang Lu[a] and Toben H. Mintz[a,b]

Department of Psychology, University of Southern California[a]; Department of Linguistics, University of Southern California[b]

Scan to view online

For additional information
lushiyan@usc.edu

Introduction

- Items that are structurally related sometimes occur in linearly non-adjacent relationships

  "the cat is (desperately) trying to catch the laser dot"

- Learning non-adjacent dependencies (NADs) may benefit the acquisition of word categories[1-3], and it is linked to later vocabulary development[4]

- Starting at 15 months, infants successfully learned NADs in an artificial language[5] (but see 6 for behavioral and 7-9 for neurophysiological findings in younger infants)

- Yet, 12-month-old English-hearing infants were sensitive to distributional-grammatical patterns in English, some of which involved non-adjacent relationships[10-11]

- **This study aims to investigate 12-month-old infants' ability to learn NADs from an artificial language**

- Bilingual infants may be better able to track non-adjacent dependencies compared to their monolingual peers[12 & pilot]

  Language exposure is examined to see whether it is associated with NAD learning outcomes

Online Experiment Setup

- We used an infant-controlled habituation procedure[13], adapted for online testing environments

- Parents were asked to sit the child on their lap or place the child in a high chair, with a laptop in front of them

- A sound volume check and an internet speed test were administered during the study

PyHab   Zoom

Photos are presented with parents' consent.
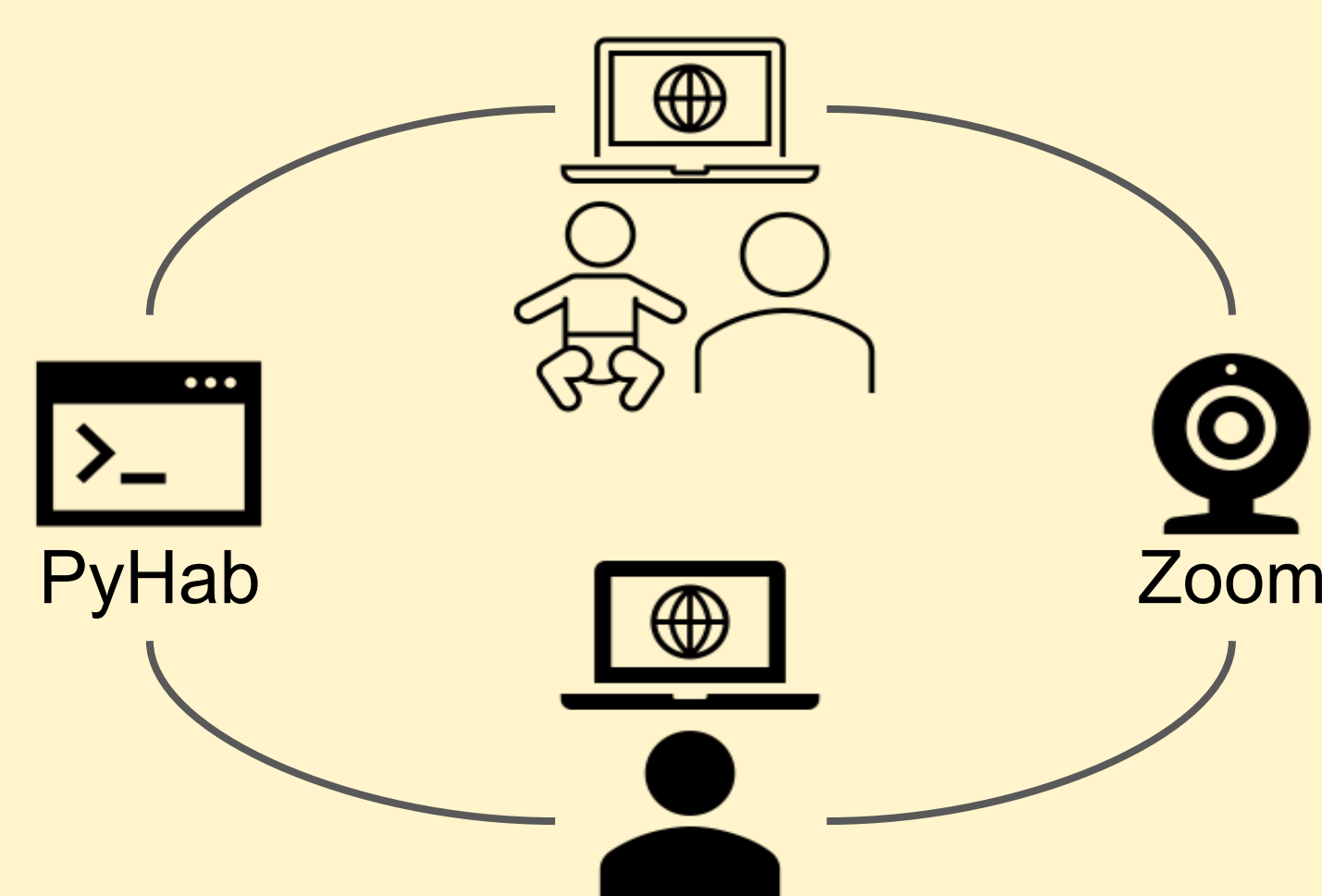
Methods

Stimuli

- 15 monosyllabic nonce words were recorded by a female speaker

  e.g., *"bep", "bok", "des", "dob", "feep", "foom", "ghan"...*

- Each word was then modified to last 250 ms and had a 83-ms silence added to its end to increase intelligibility

  A 250-ms silence was then added in between trigrams

Habituation Phase

- Nonce words were combined pseudo-randomly to create 3 sets of 3 trigrams

- Each set depicted a unique NAD

  a $\{X_1, X_2, X_3\}$ b
  c $\{X_4, X_5, X_6\}$ d
  e $\{X_7, X_8, X_9\}$ f

- A cartoon drawing of a baby stayed on screen, accompanying the audio stimuli, to sustain infants' attention

Test Phase

- 3 **grammatical (G)** trigrams

  e.g., a X_4 b   c X_7 d   e X_1 f

- 3 **ungrammatical (U)** trigrams

  e.g., a X_4 f   c X_7 b   e X_1 d

- Infants had not heard the exact combinations of words before

- Grammatical and ungrammatical trigrams **only** differed in their adherence to NAD relations
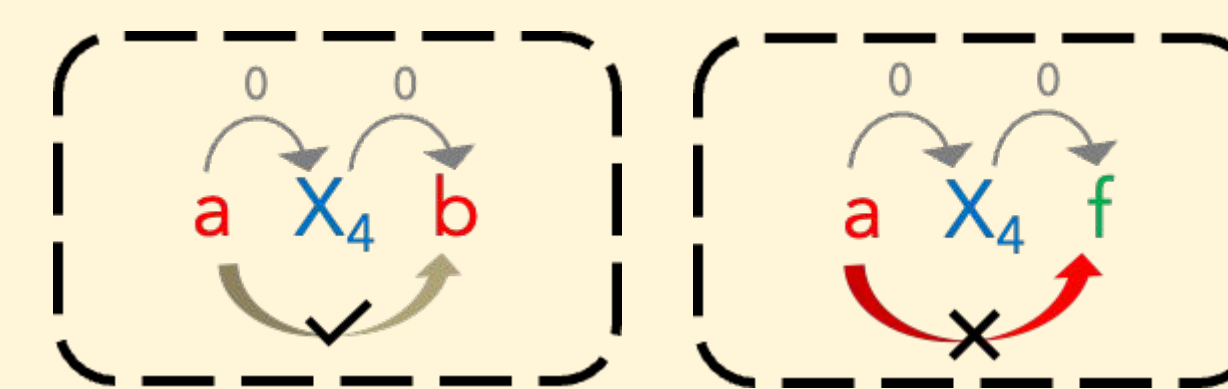

Note: Each letter above represents one of the 15 nonce words.

Participants

- 97 twelve-month-old infants were included in the current analysis

- Their language exposure was estimated using the LEAT[14]

  66 monolinguals (>= 90% in L1)

  36 females, 30 males; Age: M = 366.7 days, SD = 12.3, 347–397 days
  On-lap: 47 infants; In-chair: 19 infants

  31 multilinguals (>10% in non-L1)

  14 females, 17 males; Age: M = 363.8 days, SD = 9.5, 352–387 days
  On-lap: 20 infants; In-chair: 11 infants

- Additional 59 infants participated in the study but were excluded due to the following reasons

  fussiness (29), technical issues (9), distraction (8), falling asleep (1), sickness (1), premature birth (8), and insufficient valid test trials (3)
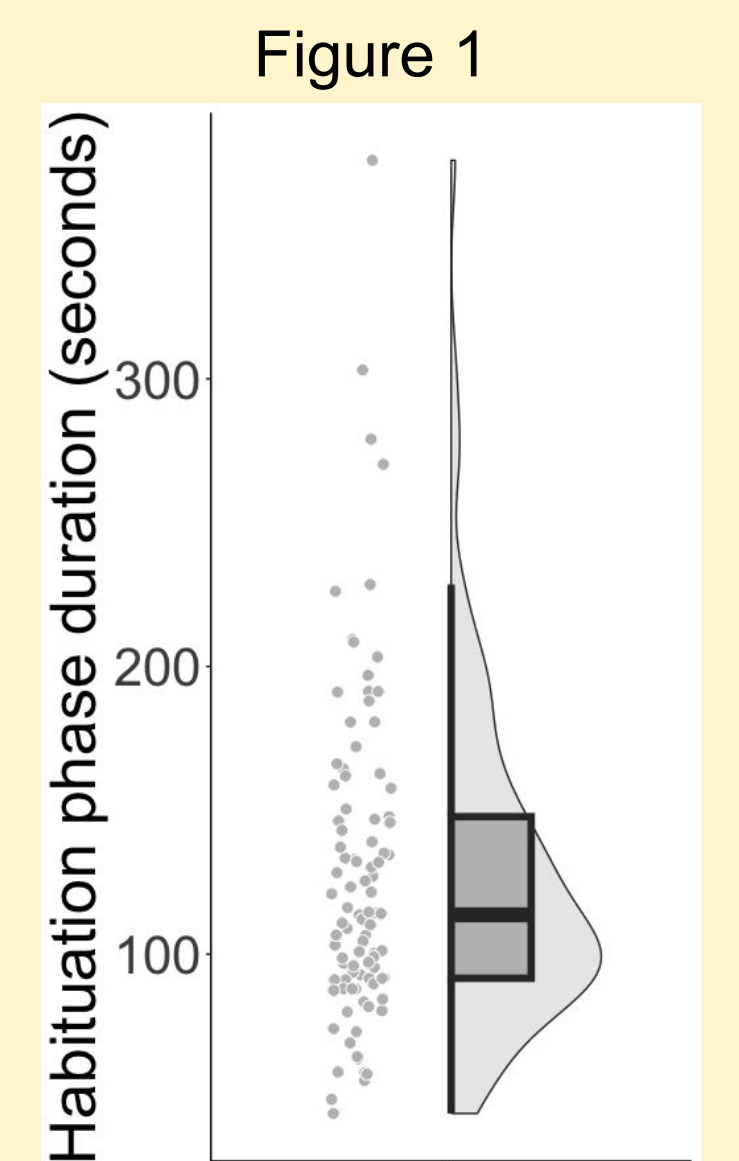
Results

Habituation Phase

- These infants spent, on average, 127.7 seconds (*SD* = 56.2) in the habituation phase (Fig 1)

  Comparable w/ in-person habituation durations (M = 124.3, SD = 49.5)

Test Phase

time ~ grammaticality + multiling + (1|child)

- Infants looked significantly longer to **U** than **G** trigrams (Fig 2; $\beta = 0.04$, $SE = 0.02$, $p = .039$)

  U: M = 7.26 s, SD = 3.02 s; **G**: M = 6.90 s, SD = 3.04 s

- Multilingual infants spent less time on test trigrams than monolingual infants, regardless of the grammaticality of test trigrams (Fig 3; $\beta = -0.11$, $SE = 0.04$, $p = .011$)

Figure 1

Figure 2

Figure 3
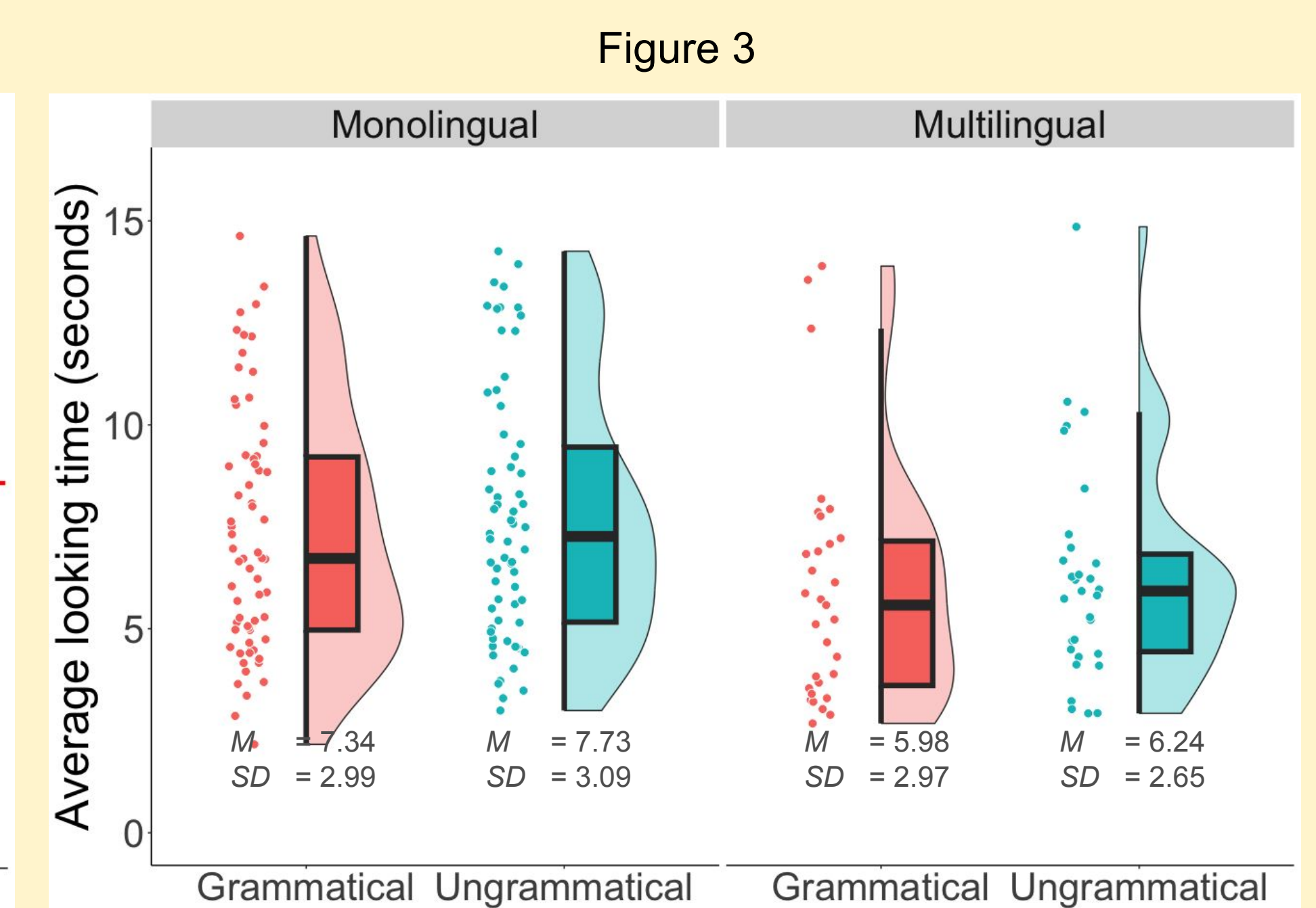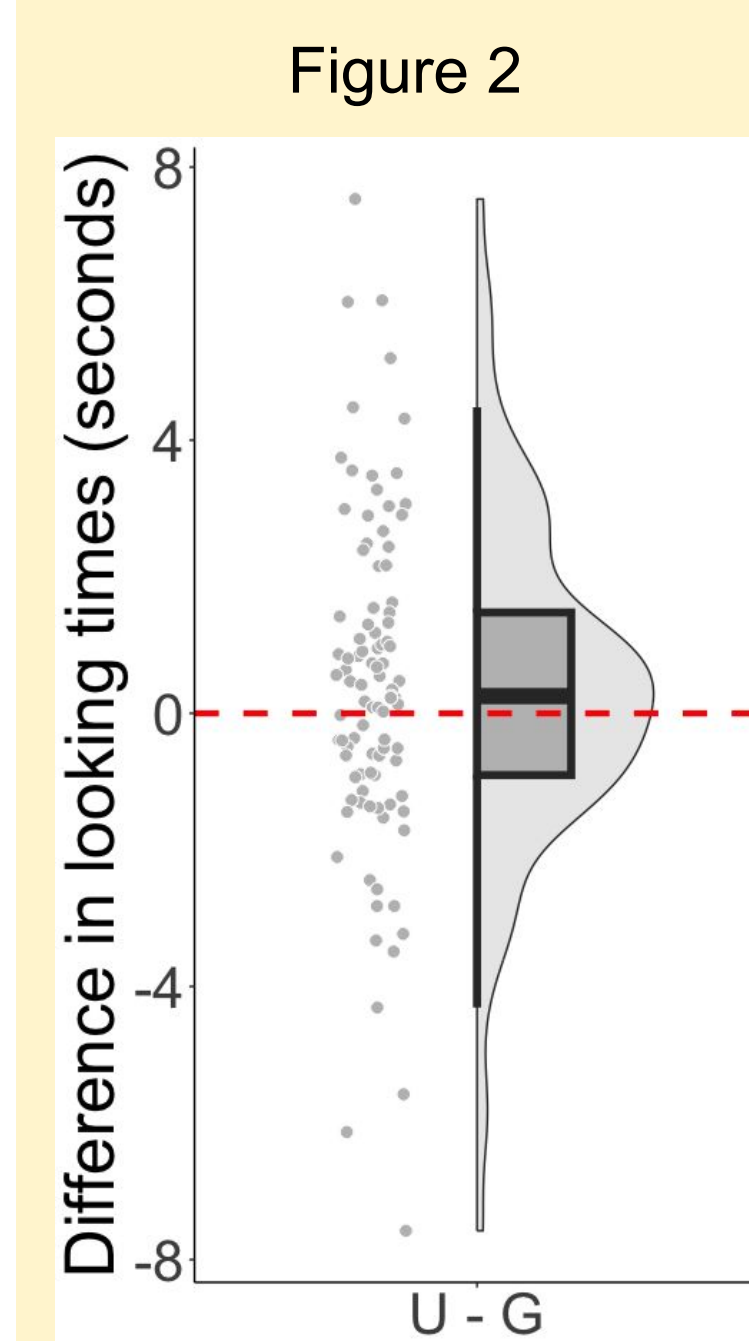
Take-homes

Infants are able to learn non-adjacent dependencies from an artificial language at 12 months of age. However, there is no evidence suggesting that language exposure (mono- vs. multi-lingual) affects their NAD learning.

References: 1) Mintz, T. H. 2006. Frequent frames: Simple co-occurrence constructions and their links to linguistic structure. 2) Mintz, T. H. 2003. Frequent frames as a cue for grammatical categories in child directed speech. 3) Chemla, E., Mintz, T. H., Bernal, S., & Christophe, A. 2009. Categorizing words using 'frequent frames': what cross-linguistic analyses reveal about distributional acquisition strategies. 4) Frost, R. L., Jessop, A., Durrant, S., Peter, M. S., Bidgood, A., Pine, J. M., ... & Monaghan, P. 2020. Non-adjacent dependency learning in infancy, and its link to language development. 5) Gómez, R., & Maye, J. 2005. The developmental trajectory of nonadjacent dependency learning. 6) Marchetto, E., & Bonatti, L. L. 2015. Finding words and word structure in artificial speech: The development of infants' sensitivity to morphosyntactic regularities. 7) Mueller, J. L., Friederici, A. D., & Männel, C. 2012. Auditory perception at the root of language learning. 8) Kabdebon, C., Peña, M., Buiatti, M., & Dehaene-Lambertz, G. 2015. Electrophysiological evidence of statistical learning of long-distance dependencies in 8-month-old preterm and full-term infants. 9) Martinez-Alvarez, A., Gervain, J., Koulaguina, E., Pons, F., & de Diego-Balaguer, R. 2023. Prosodic cues enhance infants' sensitivity to nonadjacent regularities. 10) Geffen, S., & Mintz, T. H. 2015. Can you believe it? 12-month-olds use word order to distinguish between declaratives and polar interrogatives. 11) Mintz, T. H. 2006. Finding the verbs: distributional cues to categories available to young learners. 12) De Bree, E., Verhagen, J., Kerkhoff, A., Doedens, W., & Unsworth, S. 2016. Language learning from inconsistent input: Bilingual and monolingual toddlers compared. 13) Kominsky, J. F. 2019. PyHab: Open-source real time infant gaze coding and stimulus presentation software. 14) DeAnda, S., Bosch, L., Poulin-Dubois, D., Zesiger, P., & Friend, M. 2016. The language exposure assessment tool: Quantifying language exposure in infants and children.