# Cognition

PSYC 2040

L10: Language

Part 1

# participate in a lab study!

https://tinyurl.com/2710PSYC2024

# lunch with Psychology faculty!

## Lunch with Psychology Faculty

The Psychology Department is hosting lunches with faculty and students this semester.

All lunches will be in **Thorne Dining**! Please meet us at the check-in station at the times mentioned for the specific dates.

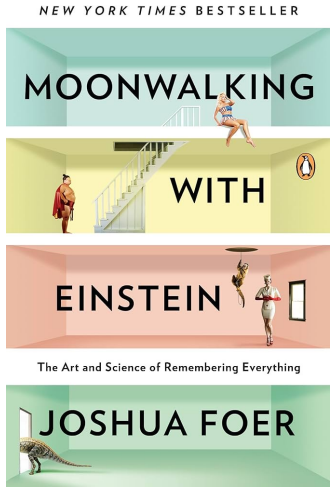
The lunches are on the following dates/times:

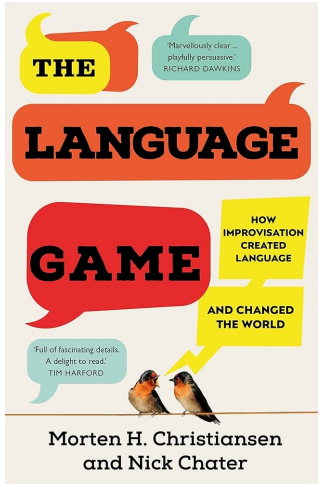
- Wednesday, February 21 2024 (**12 pm**): Prof. Erika Nyhus and Prof. Hannah Reese
- Tuesday, March 5 2024 (**12 pm**): Prof. Kacie Armstrong, Prof. Suzanne Lovett, and Prof. Thomas Small
- Friday, April 12 2024 (**1.10 pm**): Prof. Abhilasha Kumar and Prof. Samuel Putnam

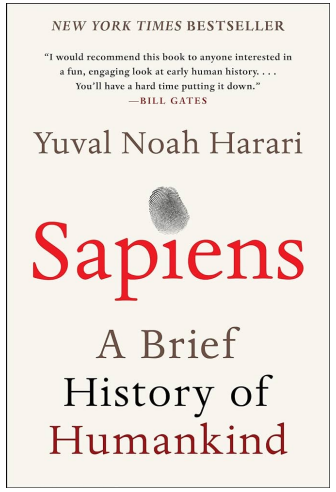
We look forward to seeing you!

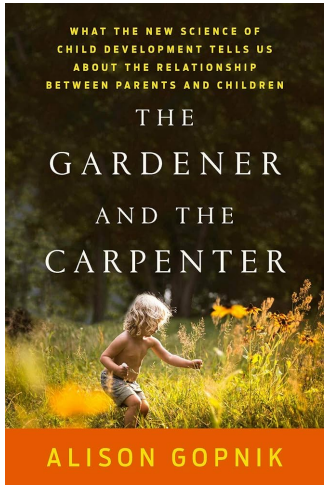
https://forms.gle/BGDXsRWFB6xNuoyE7

# some book recommendations

# logistics

- monthly quiz #2
  - due April 16 (available Friday onwards)
  - use weekly quizzes + practice multiple-choice to review
- office hours
  - Nick, Sunday 7-9 pm
  - Prof. Kumar:
    - Monday, 11 - 1 pm
    - Wednesday,  2 - 5 pm
    - Thursday, 2 - 4 pm (VIRTUAL)

| | | |
|---|---|---|
| 12 | Monday: April 8, 2024 | **Research Summary [SPARK] due** |
| 12 | Wednesday, April 10, 2024 | L10: Language |
| 12 | Friday, April 12, 2024 | L10 continued… |
| 13 | Tuesday: April 16, 2024 | **Monthly Quiz 2** |
| 13 | Wednesday, April 17, 2024 | L11: Judgment and Decision Making |
| 13 | Friday, April 19, 2024 | L11 continued… |
| 14 | M: April 22, 2024 | **Research Summary [QALMRI] due** |
| 14 | Wednesday, April 24, 2024 | L12: Social Cognition |
| 14 | Friday, April 26, 2024 | L12 continued… |
| 15 | Monday: April 30, 2024 | **Monthly Quiz 3** |
| 15 | Wednesday, May 1, 2024 | L0-L12 review! |
| 15 | Friday, May 3, 2024 | **Final** |
| 16 | Wednesday, May 8, 2024 | Wrapping up! |
| 16 | M: May 13, 2024 | **Research Reflection due** |

# what is language?

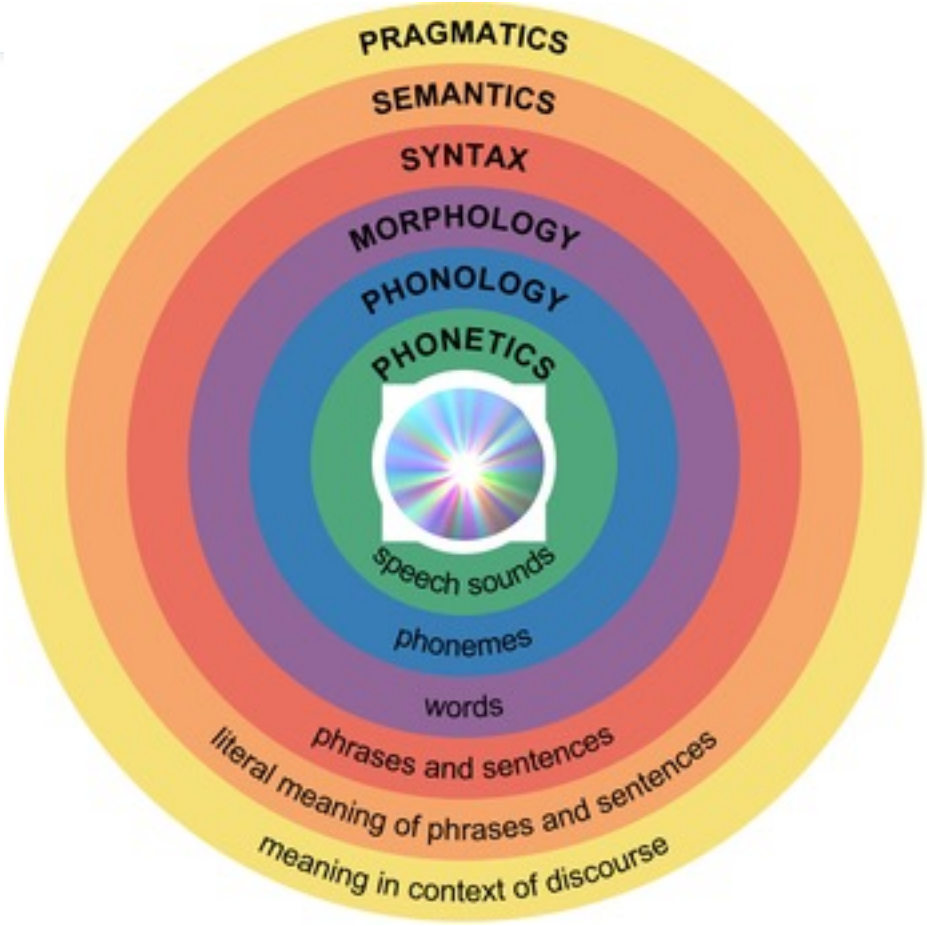
# (some) properties of human language

| | |
|---|---|
| discreteness | • individual units combine to form larger units |
| grammar | • a set of rules that govern how units are combined |
| displacement | • being able to use language to talk about events in the past and future |
| reflexivity | • talk about language itself |
| arbitrariness | • no strong relationship between form and meaning (BUT) |
| productivity | • we invent new words, can create infinite new ideas/concepts |
| cultural transmission | • we learn the language of the culture we are embedded in |

https://www.youtube.com/watch?v=_1FY5kL_zXU

# components of human language

- phonetics: speech sounds
- phonology: relationship between letters and sounds (phonemes)
- morphology: smallest meaningful units in speech and writing (words)
- syntax: set of rules that govern a given language (grammar)
- semantics: the way language conveys meaning
- pragmatics: relationships between context and language use



# learning

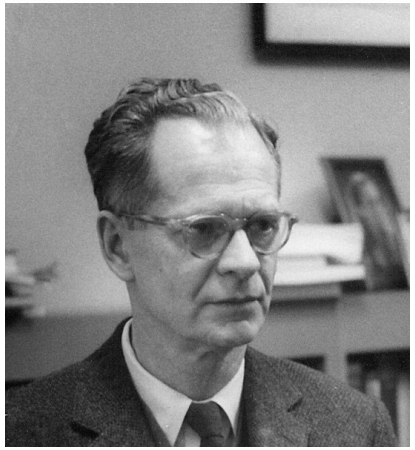
- how do you think you learned language?

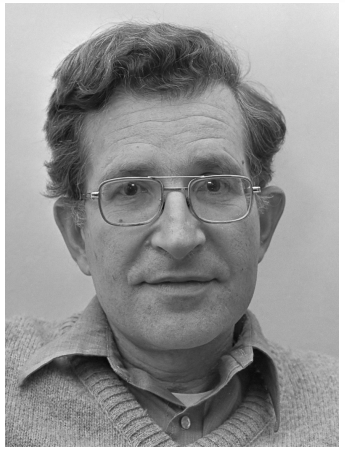
# key debates about language

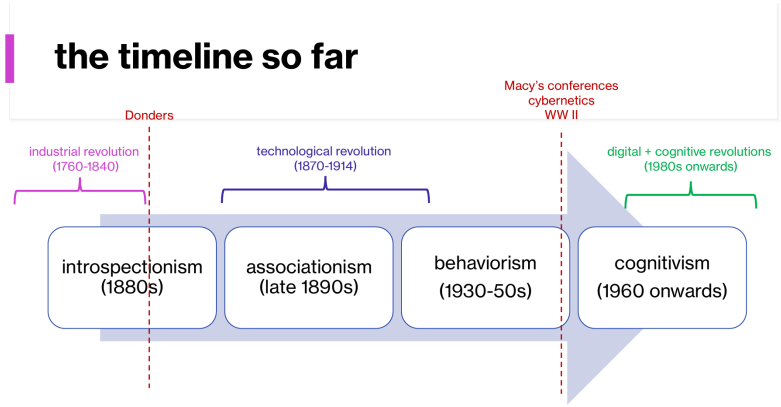
- is language innate or learned from scratch?
- is learning error-free or error-driven?
- how are concepts mentally represented?
- how are concepts searched for and retrieved?

# Skinner vs. Chomsky

- Skinner: language was a learned behavior (1957)
- Noam Chomsky: language is a result of innate capacities (1959)

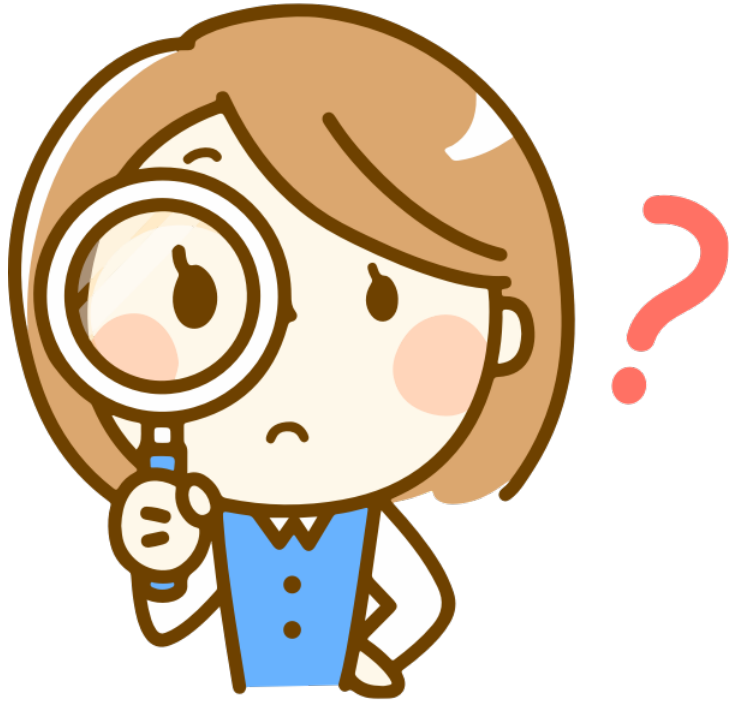






# testing the claims

- how can we test the merit of these claims?
- some possible methods (not exhaustive):
  - find natural exceptions
  - teach language to an animal
  - find neurological exceptions/examples
  - examine language learning in infants
  - create an artificial language model



# some early evidence

- Genie the feral child
- language “universals”
- neurological evidence
  - critical period
  - brain areas (Broca/Wernicke)
  - language & thought
- Nim Chimpsky

Language and thought are not the same thing: evidence from neuroimaging and neurological patients

Evelina Fedorenko[1,2,3] and Rosemary Varley[4]

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The publisher's final edited version of this article is available at Ann N Y Acad Sci

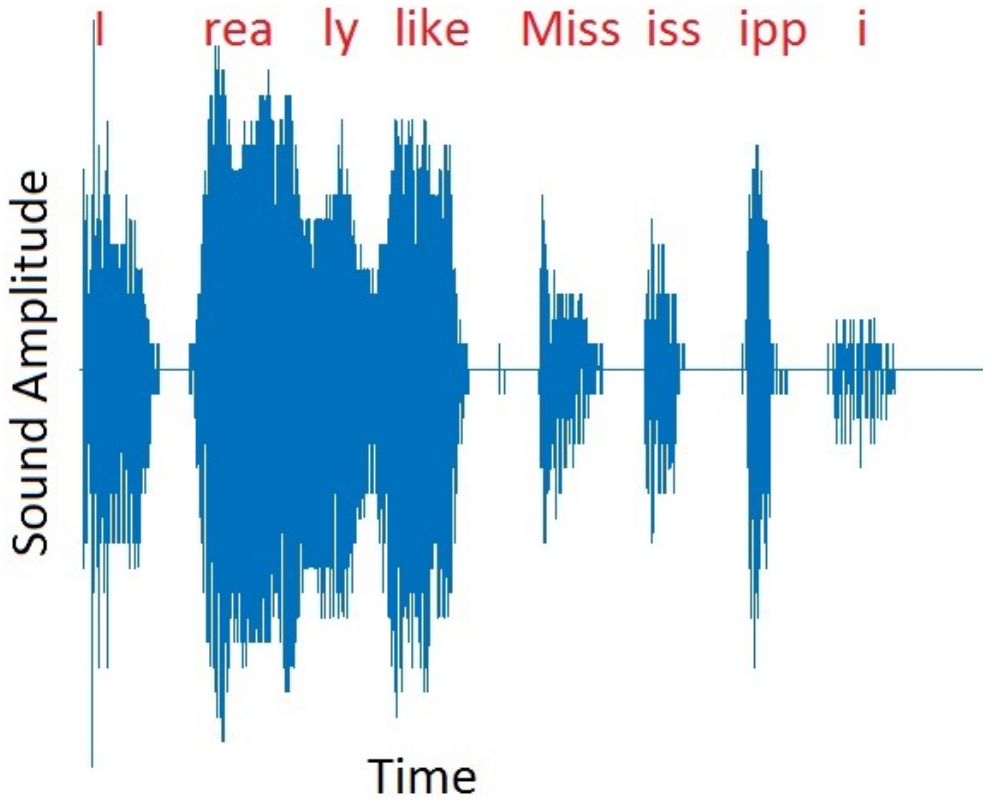
Abstract Go to:

Is thought possible without language? Individuals with global aphasia, who have almost no ability to understand or produce language, provide a powerful opportunity to find out. Astonishingly, despite their near-total loss of language, these individuals are nonetheless able to add and subtract, solve logic problems, think about another person’s thoughts, appreciate music, and successfully navigate their environments. Further, neuroimaging studies show that healthy adults strongly engage the brain’s language areas when they understand a sentence, but not when they perform other nonlinguistic tasks like arithmetic, storing information in working memory, inhibiting prepotent responses, or listening to music. Taken together, these two complementary lines of evidence provide a clear answer to the classic question: many aspects of thought engage distinct brain regions from, and do not depend on, language.

# Nim

# acquiring language

- human speech signals are extremely complex
- we do not pause consistently at word boundaries
- and yet humans, even babies, appear to pick up word boundaries and meanings rather effortlessly
- proposal: humans extract statistical regularities from natural language (and the environment)
- observing which sounds go together gives us information about the sounds that make up specific words



# statistical learning demo

- you will hear a 2-minute sequence of sounds from an artificial language (close your eyes for this part)
- then you will be played “words” or “non words” from this language and you have to judge whether you’ve heard that word before or not
- you will then anonymously report your score

# statistical learning demo

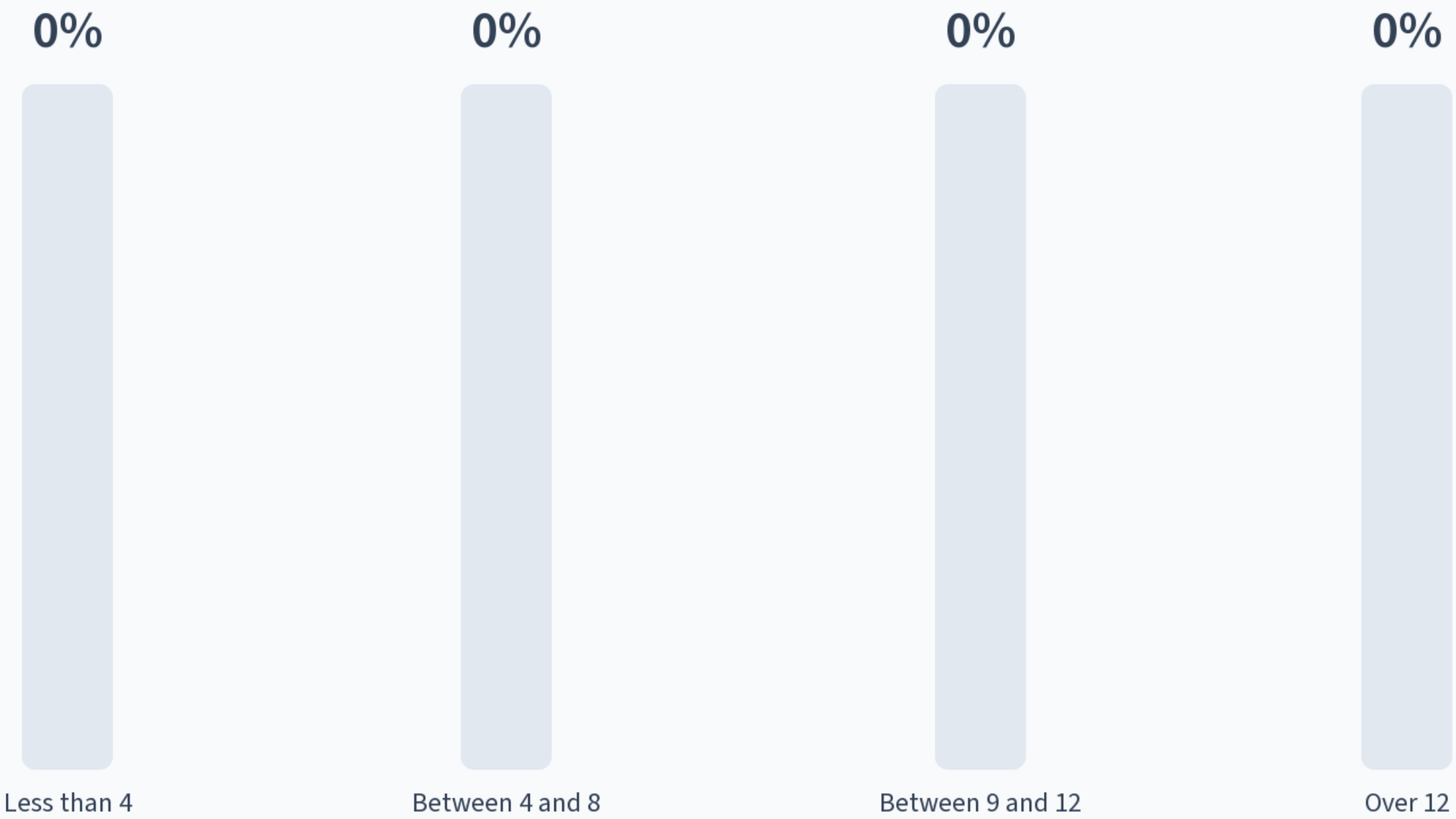
# results:

| Trial #1 | Syllable Combination | Correct Response |
|---|---|---|
| 1 | bulado | Y |
| 2 | ladobi | N |
| 3 | tibata | N |
| 4 | dobigo | N |
| 5 | bigoku | Y |
| 6 | datiba | Y |
| 7 | dupabu | N |
| 8 | tadupa | Y |
| 9 | tibata | N |
| 10 | dobigo | N |
| 11 | dupabu | N |
| 12 | bigoku | Y |
| 13 | bulado | Y |
| 14 | ladobi | N |
| 15 | datiba | Y |
| 16 | tadupa | Y |

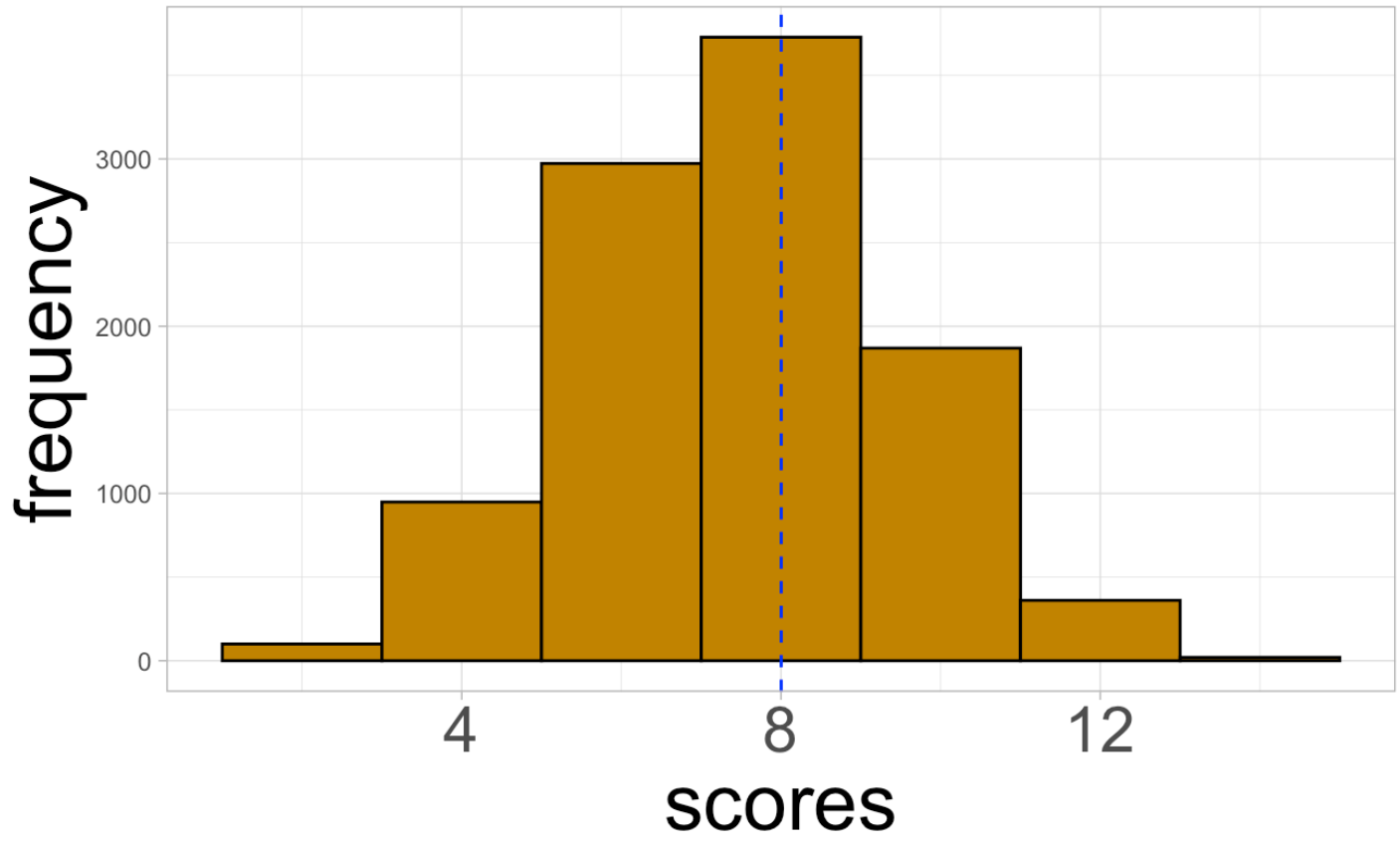
# measuring chance performance

- 16 items were shown to you
- if you were guessing throughout, what would be the mean number of items you would guess correctly?

## What was your score?



# 10000 random scores (chance performace)



# Saffran, Aslin & Newport (1996): E1

- played these sounds to 8-month-old infants (familiarization)
- some sounds had greater transition probability (words) than others (non words)
- replayed some familiar words and unfamiliar words (test) and measured "looking time"

words

tu-pi-ro
go-la-bu

non-words

da-pi-ku
ti-la-do

P ( go-la) >>> P ( ti-la)

# Saffran, Aslin & Newport (1996): E1

- infants listened/looked longer to unfamiliar words

| Experiment | Mean listening times (s) | | Matched-pairs *t* test |
|---|---|---|---|
| | Familiar items | Novel items | |
| 1 | 7.97 (SE = 0.41) | 8.85 (SE = 0.45) | $t(23) = 2.3, P < 0.04$ |

words

tu-pi-ro
go-la-bu

non-words

da-pi-ku
ti-la-do

P ( go-la) >>> P ( ti-la)

# Saffran, Aslin & Newport (1996): E2

- potential confound: were infants truly tracking statistical regularities or simply recognizing what was familiar vs. unfamiliar?
- E2: more difficult test, comparing words (higher transition probabilities) and part-words (lower but non-zero transition probabilities)
- infants still showed the same pattern

words

go-la-tu
da-ro-pi

part-words

tudaro
pigola

**Table 1.** Mean time spent listening to the familiar and novel stimuli for experiment 1 (words versus nonwords) and experiment 2 (words versus part-words) and significance tests comparing the listening times.

| Experiment | Mean listening times (s) | | Matched-pairs *t* test |
|---|---|---|---|
| | Familiar items | Novel items | |
| 1 | 7.97 (SE = 0.41) | 8.85 (SE = 0.45) | $t(23) = 2.3, P < 0.04$ |
| 2 | 6.77 (SE = 0.44) | 7.60 (SE = 0.42) | $t(23) = 2.4, P < 0.03$ |

# from artificial to natural language

- Pelucchi, Hay, & Saffran (2009) tested English-learning 8-month-old infants with Italian speech and found the same pattern

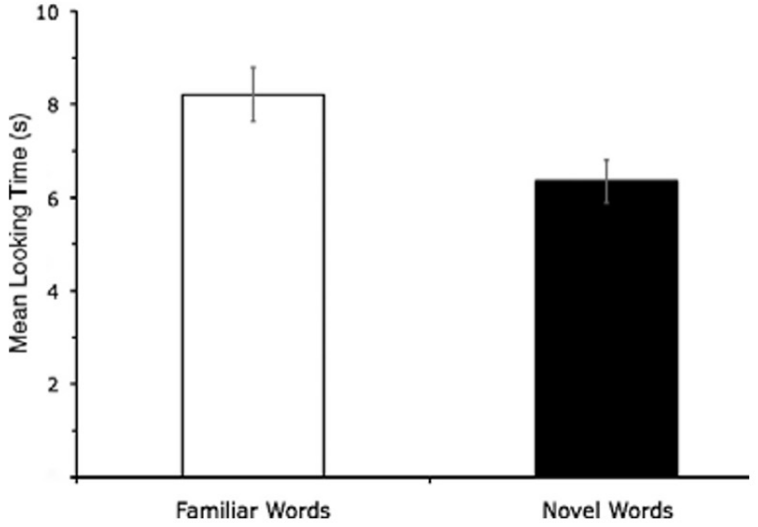
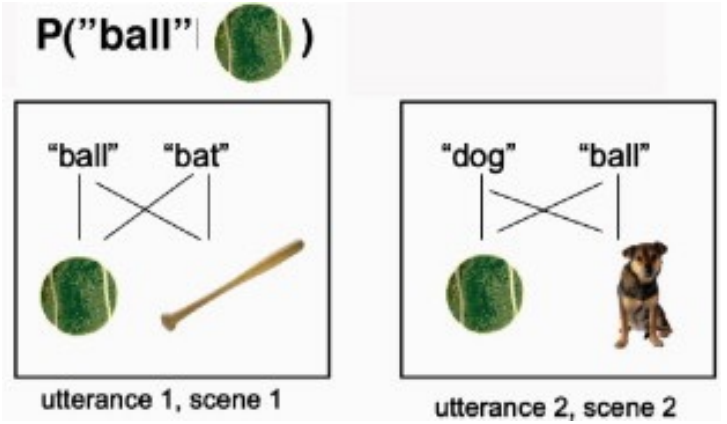



*Figure 1.* Results of Experiment 1: Mean looking times (±1 *SE*) to familiar words and novel words.

# labels to referents: cross-situational statistics

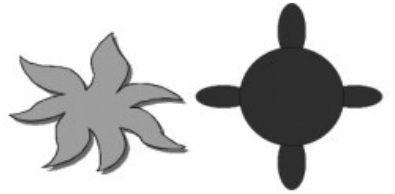
- mapping labels (“ball”) to the object is difficult as multiple objects may be in view when the label is used
- Smith and Yu (2008) showed that 12- and 14-month-old infants resolve this uncertainly by combining statistics across situations



# labels to referents: cross-situational statistics

- infants first "studied" referents and novel word labels
- infants were tested by playing a sound and then displaying the target referent and a distractor 4 times and recording looking times
- key finding: infants looked reliably longer to the target than to the distractor
- inference: infants were able to identify label to referent mappings by tracking cross situational statistics

BOSA
COLAT



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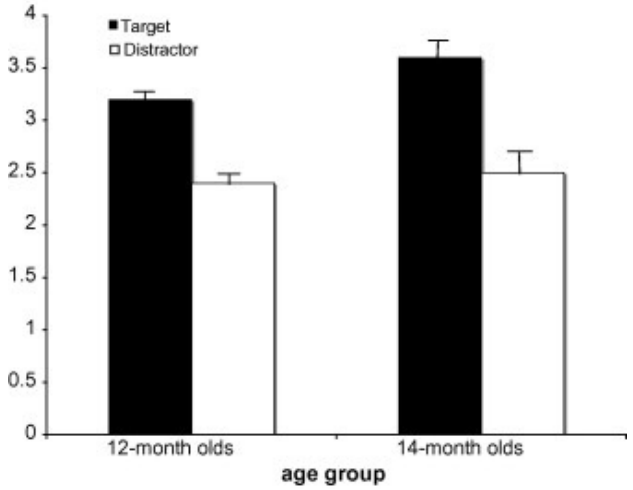


# revisiting innateness vs. learning

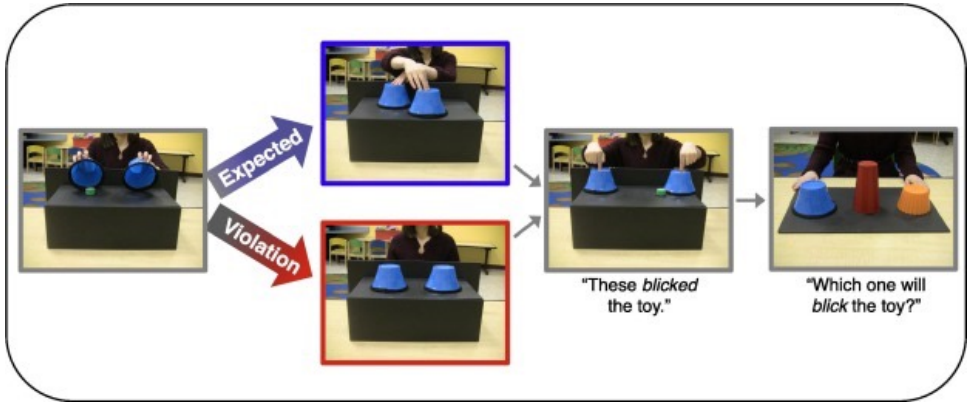
- statistical learning studies show that infants are able to extract regularities from environmental input
- suggestion: some aspect of language learning is *innate*
  - Chomsky's "poverty of the stimulus" argument
- but....you only need *one example* to falsify a theory! (next time)

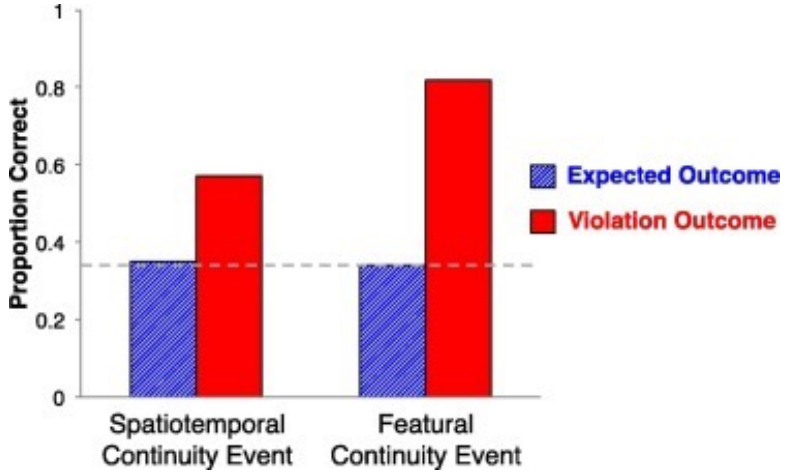
# why track statistics?

- infants are not required to or motivated by reward to track statistics, so why do they do it?
- possible hypotheses:
  - infants want to communicate with their caregivers
  - infants want to generate predictions about the environment

# statistical learning and prediction

- natural language is rich in statistical structure and unfolds over time
- infants appear to generate expectations about which word forms and labels are likely, after being exposed to some regularities in speech or language
- Stahl & Feigenson (2017) tested 3- to 6-year-old children on an experiment where novel labels (blick) were mapped to actions in expected or violation conditions
  - expected : ball was revealed in the expected location
  - violated: ball was revealed in the unexpected location
- learning was maximized when children were surprised by the outcomes



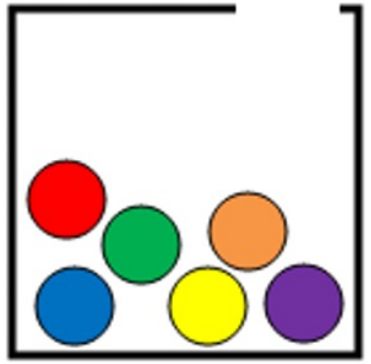



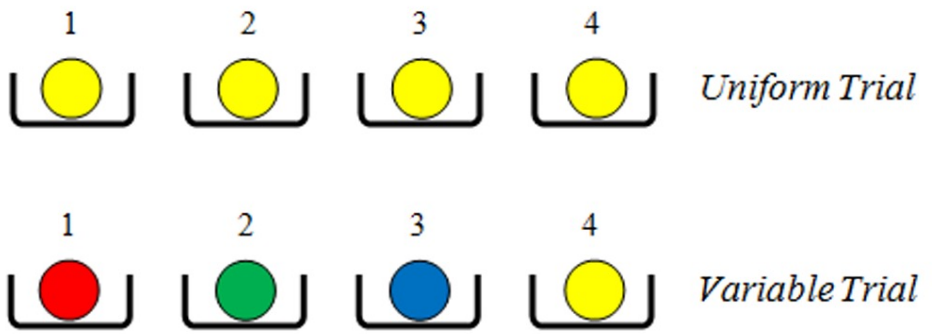
# statistical learning and curiosity

- while there is evidence that statistical learning can inform predictions, it may also inform what to learn about in the first place
- curiosity may be particularly important in creating learning opportunities and minimizing uncertainty in the environment

# statistical learning and curiosity

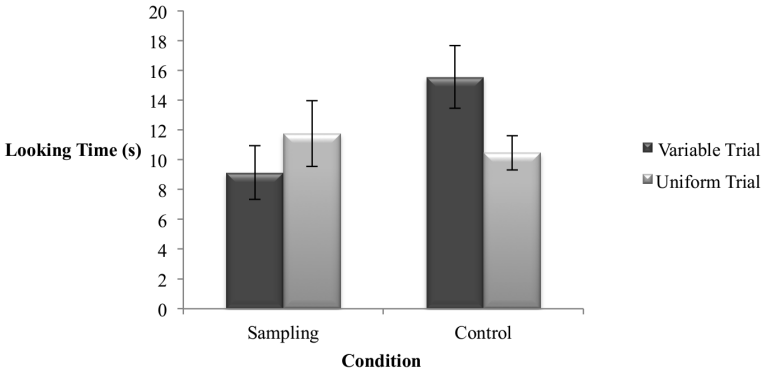
- Sim & Xu (2017) tested 13-month-old infants in a violation of expectation (VOE) and crawling paradigm
  - draw: could be “uniform” or “variable”
  - condition: control condition (experimenter looked into the box before drawing out the balls) or sampling (no looking)
- two experiments: looking time (VOE) vs. touching/reaching time (crawling)

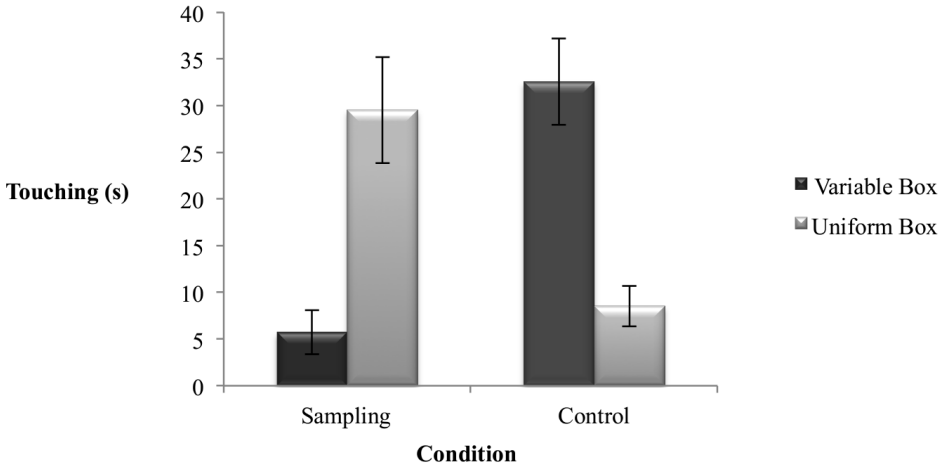


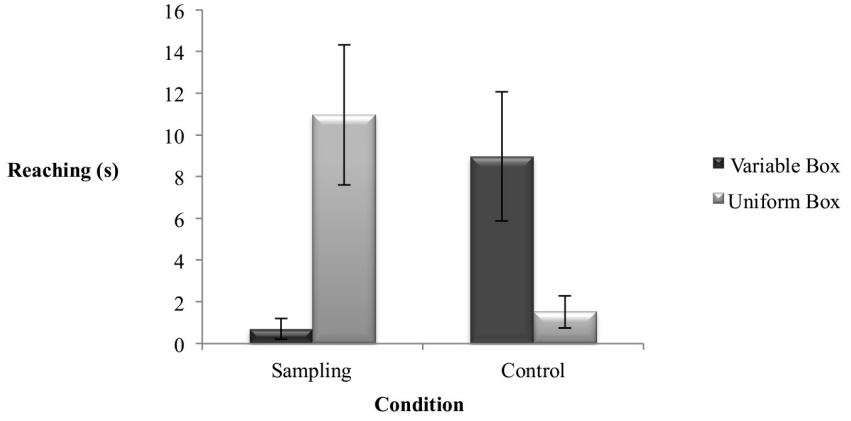


# statistical learning and curiosity

- Sim & Xu (2017) showed that 13-month-old infants preferentially explore sources of unexpected events



# review of findings/inferences

- infants track statistical regularities
- children learn from prediction error
- children are inherently curious and want to reduce uncertainty
- but.....
- how far can you take this idea of statistical learning?

# statistical learning in animals

## Segmentation of the speech stream in a non-human primate: statistical learning in cotton-top tamarins

Marc D Hauser [a], Elissa L Newport [b], Richard N Aslin [b]

Show more



https://doi.org/10.1016/S0010-0277(00)00132-3  

### Abstract

Previous work has shown that human adults, children, and infants can rapidly compute sequential statistics from a stream of speech and then use these statistics to determine which syllable sequences form potential words. In the present paper we ask whether this ability reflects a mechanism unique to humans, or might be used by other species as well, to acquire serially organized patterns. In a series of four experimental conditions, we exposed a New World monkey, the cotton-top tamarin (*Saguinus oedipus*), to the same speech streams used by Saffran, Aslin, and Newport (Science 274 (1996) 1926) with human infants, and then tested their learning using similar methods to those used with infants. Like humans, tamarins showed clear evidence of discriminating between sequences of syllables that differed only in the frequency or probability with which they occurred in the input streams. These results suggest that both humans and non-human primates possess mechanisms capable of computing these particular aspects of serial order. Future work must now show where humans' (adults and infants) and non-human primates' abilities in these tasks diverge.

## Learning at a distance II. Statistical learning of non-adjacent dependencies in a non-human primate

Elissa L. Newport [a], Marc D. Hauser [b], Geertrui Spaepen [b], Richard N. Aslin [a]

Trends in Cognitive Sciences

Review

## Constraints on Statistical Learning Across Species

Chiara Santolin[1,*] and Jenny R. Saffran[2]

Both human and nonhuman organisms are sensitive to statistical regularities in sensory inputs that support functions including communication, visual processing, and sequence learning. One of the issues faced by comparative research in this field is the lack of a comprehensive theory to explain the relevance of statistical learning across distinct ecological niches. In the current review we interpret cross-species research on statistical learning based on the perceptual and cognitive mechanisms that characterize the human and non-human models under investigation. Considering statistical learning as an essential part of the cognitive architecture of an animal will help to uncover the potential ecological functions of this powerful learning process.

# next class


- **before** class:
  - *finish:* L10 readings
  - *complete (by 10 am)* : language experiment
    - link also on canvas!
- **during** class:
  - language models!