Cognition: Methods and Models

PSYC 2040

L10: Language

Part 1

logistics: reminders

- project milestone #5 (first draft) due April 30th
- 3 flex days are available for each student!
  - 24-hour no-questions-asked extensions for project + weekly assignments
  - after the extensions, you get graded on 50% automatically
- Apr/May survey will be posted by end of next week
- no office hours next week!

logistics: grades!

Points

Component	Points	Total	Learning goal
Weekly assignments	6+	up to 65	Understand, Connect, Reflect
Class participation	5	5	Connect, Reflect
Assessment 1	10	10	Understand, Connect
Assessment 2	10	10	Understand, Connect
Final project	10	10	Connect, Reflect
Extra credit	5	5	Reflect
Total		105	

logistics: what's coming up

13	April 18 (Tuesday)	L10: Language
13	April 20 (Thursday)	L10 continued…
14	April 25 (Tuesday)	L11: Social Cognition
14	April 27 (Thursday)	Guest Lecture: Dr. Marta Stojanovic
14	April 30 (Sunday)	**Project Milestone 5: First Draft due**
15	May 2 (Tuesday)	L12: Judgment and Decision Making + L7-L12 Review
15	May 4 (Thursday)	**Assessment 2**
16	May 9 (Tuesday)	Wrapping up + Project presentations
16	May 14 (Sunday)	**Project Milestone 6: Final Project due**

recap: Apr 11/13, 2023

- what we covered:
  - cognitive models (exemplar vs. prototype)
  - memory models (MINERVA, instance theory)
- your to-dos were:
  - *finish*: L9 assignments
  - *read*: L10 reading

today’s agenda

- key debates in language science
- statistical learning & prediction

how do you think you learned language?

Nobody has responded yet.

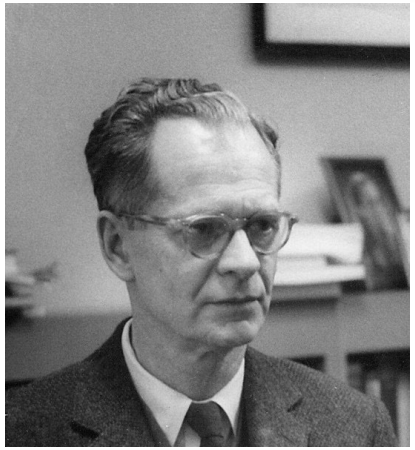
Hang tight! Responses are coming in.

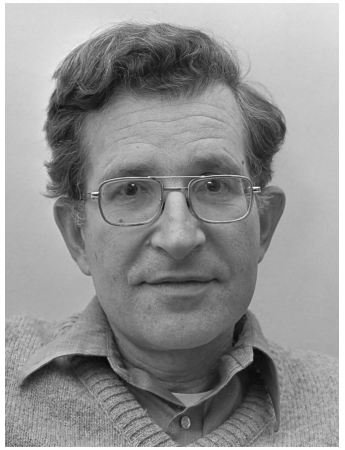
key debates in language science

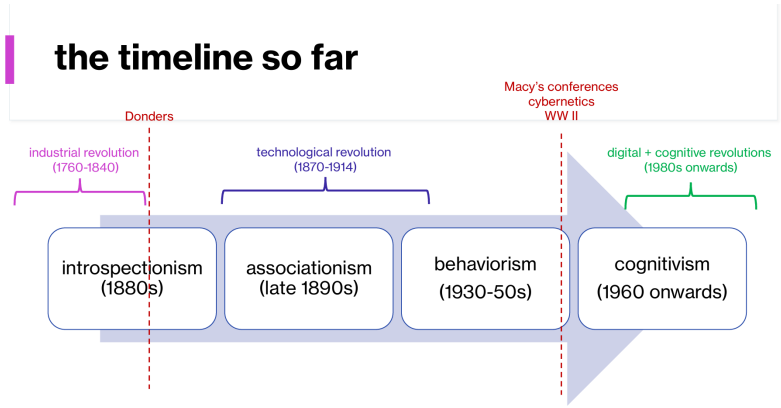
- there are many!
- is language innate or learned from scratch?
- is learning error-free or error-driven?
- how are concepts mentally represented?
- how are concepts searched for and retrieved?

Skinner vs. Chomsky

- Skinner published Verbal Behavior in 1957, arguing that language was a learned behavior and behaviorist principles could be applied to predict and control this behavior
- Noam Chomsky wrote a scathing review of Skinner's book in 1959, arguing instead that language is a result of innate capacities that could not simply be learned; he also argued that language was a tool of thought
- this debate was at the turning point of when the tide was turning from behaviorism to cognitivism

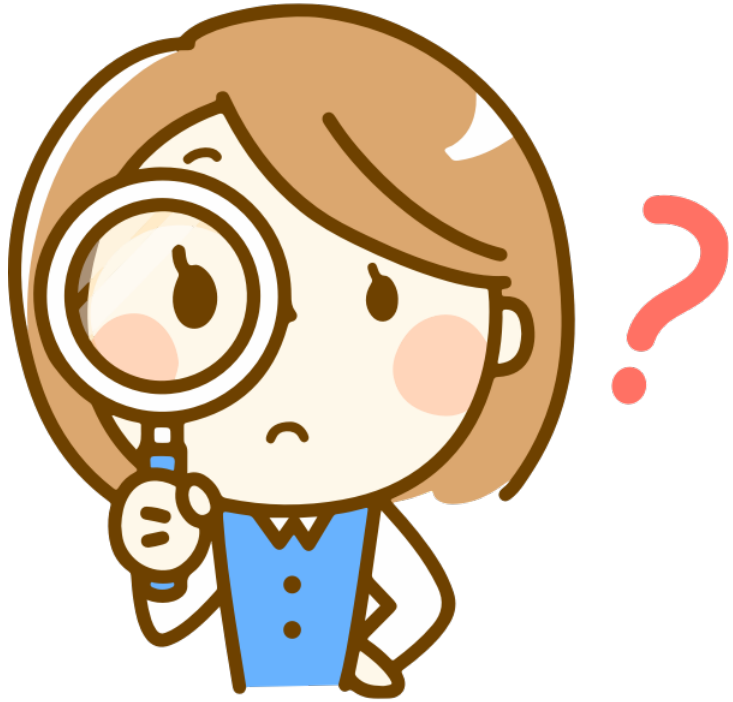






testing the claims

- 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”
- Nim Chimpsky
- neurological evidence
  - critical period
  - brain areas (Broca/Wernicke)
  - language & thought

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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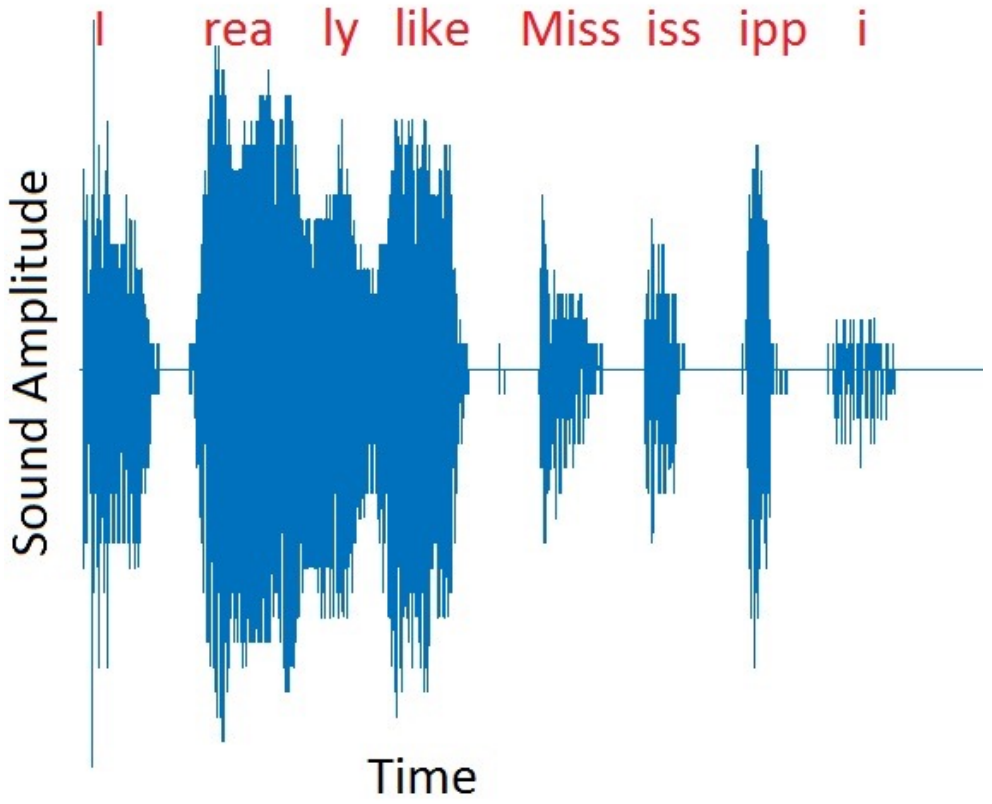
Abstract Go to:

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.

acquiring language

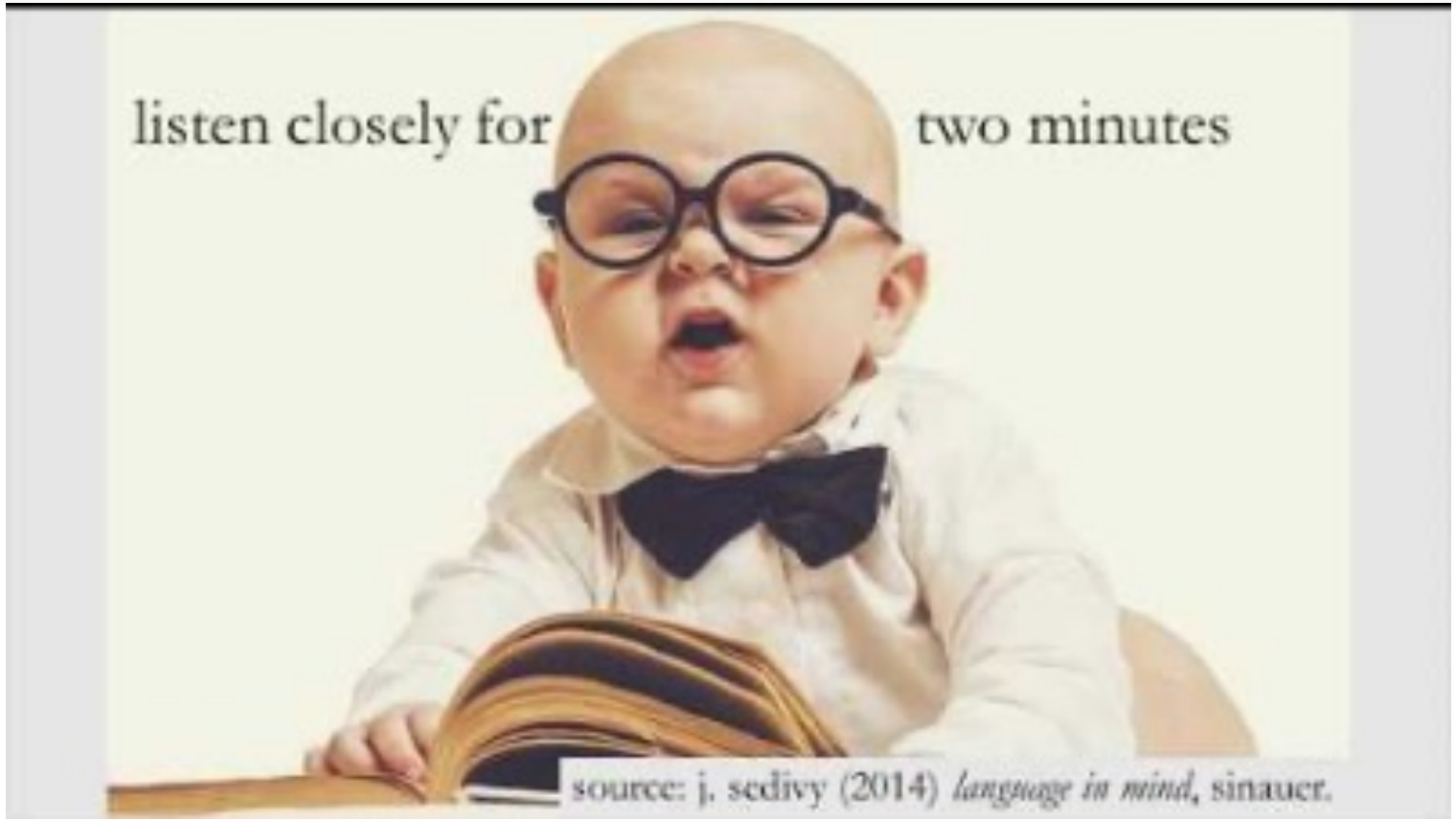
- human speech signals are extremely complex
- we do not pause consistently at word boundaries
- and yet humans, even babies, appear to pick up word boundaries and meanings rather effortlessly
- how do we do this?
- proposal: humans extract statistical regularities from natural language (and the environment)
- 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



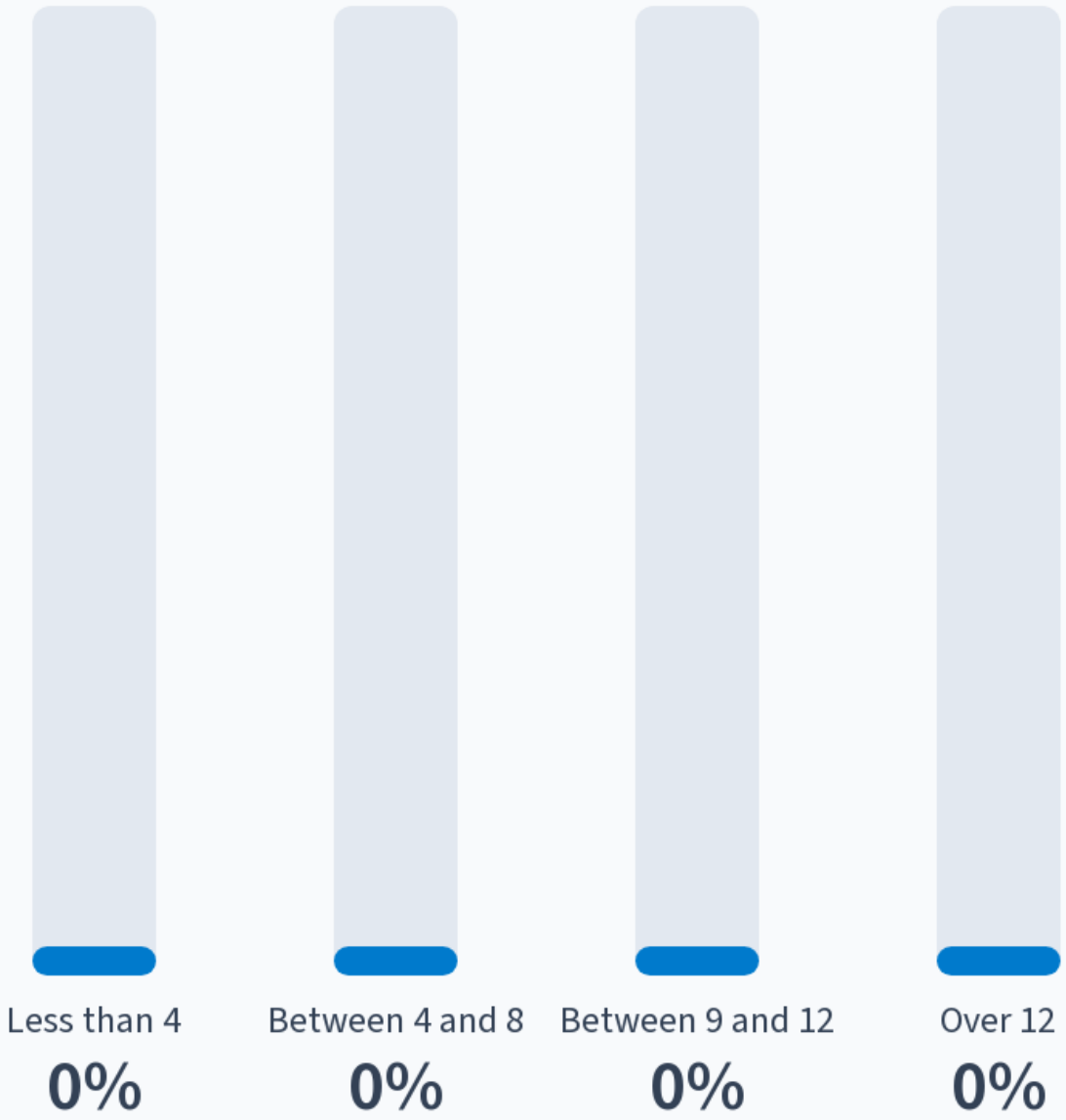
results:

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

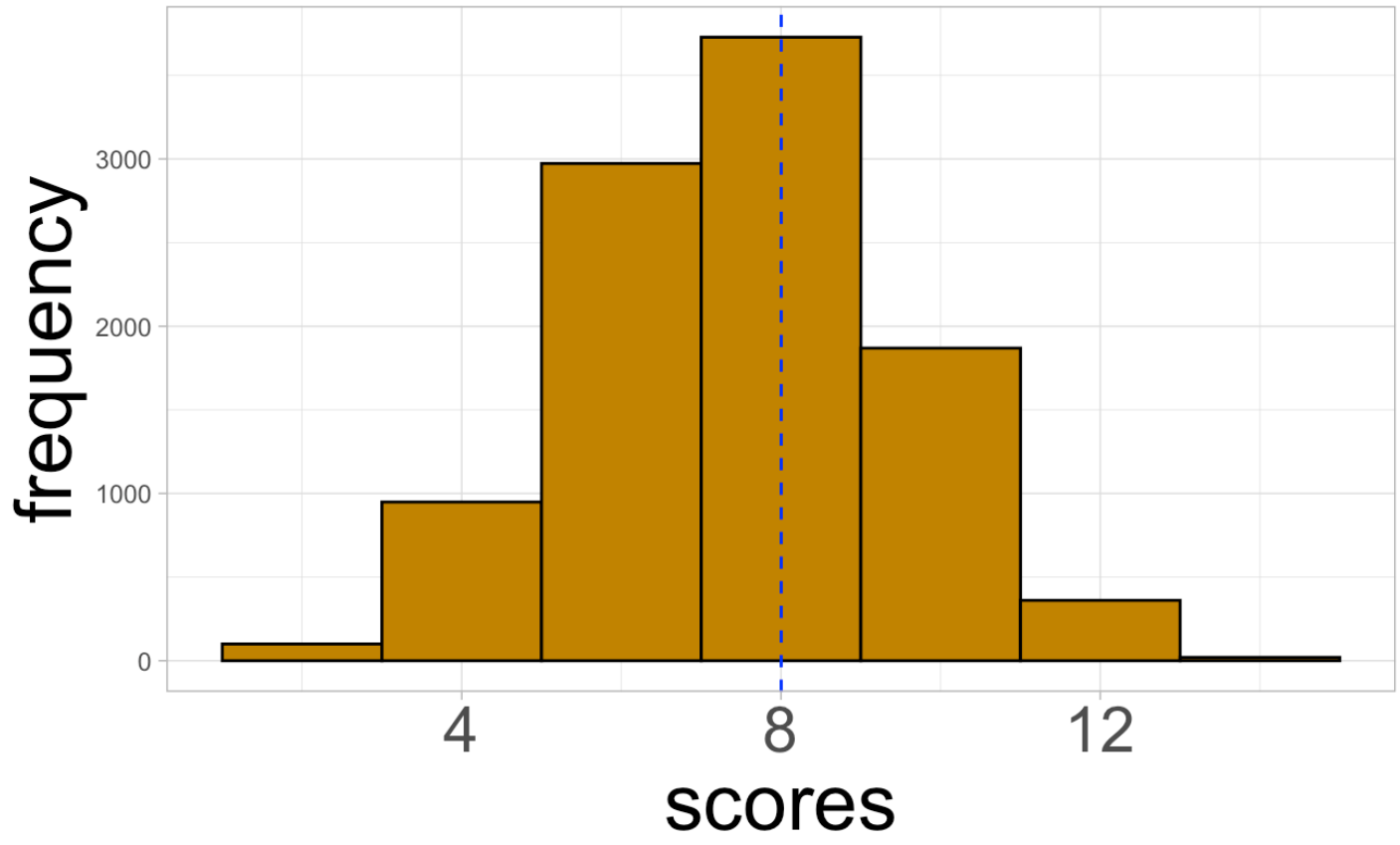
measuring chance performance

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

What was your score?

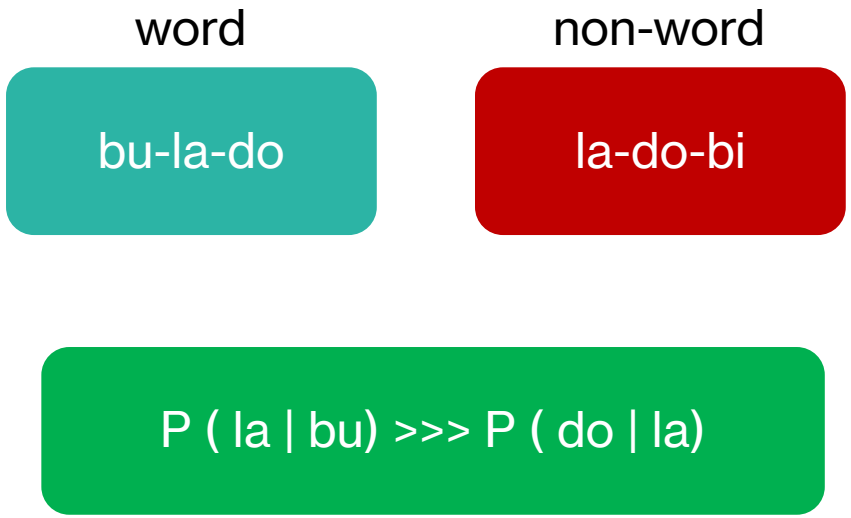


10000 random scores (chance performace)



Saffran, Aslin & Newport (1996)

- played these sounds to 8-month-old infants (familiarization)
- some sounds had greater transition probability (words) than others (non words)
- replayed some words and nonwords (test)
- measured “looking time” to a blinking light when sound was played
  - greater looking/listening time = novelty
- groups of 2: predicted pattern??



Saffran, Aslin & Newport (1996)

- infants listened/looked longer to unfamiliar words
  - infants successfully **extracted/learned** statistical regularities!

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

- the original infant study (and other follow-ups) were using artificial languages so it wasn't clear if the patterns would generalize to natural language
- Pelucchi, Hay, & Saffran (2009) tested English-learning 8-month-old infants with Italian speech and found the same pattern

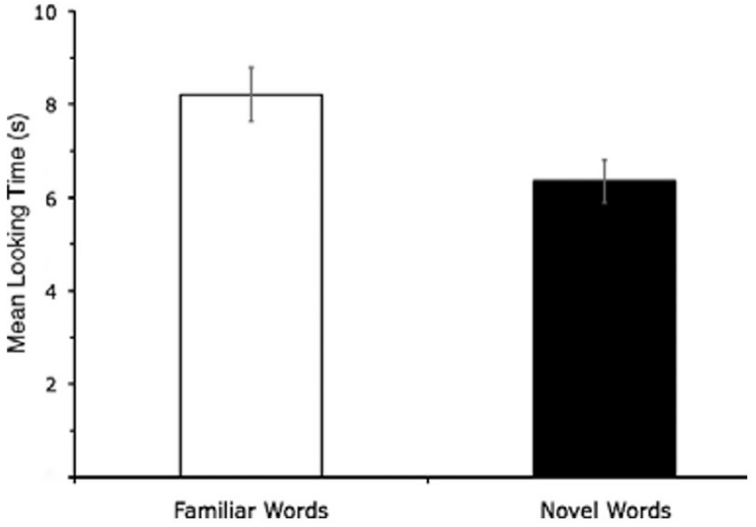
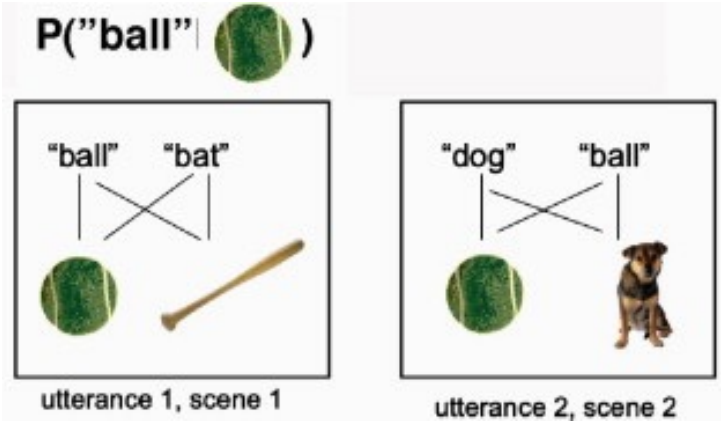


Figure 1. Results of Experiment 1: Mean looking times (±1 *SE*) to familiar words and novel words.

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 with no information about which word went with which referent
- 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

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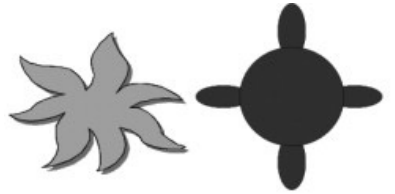

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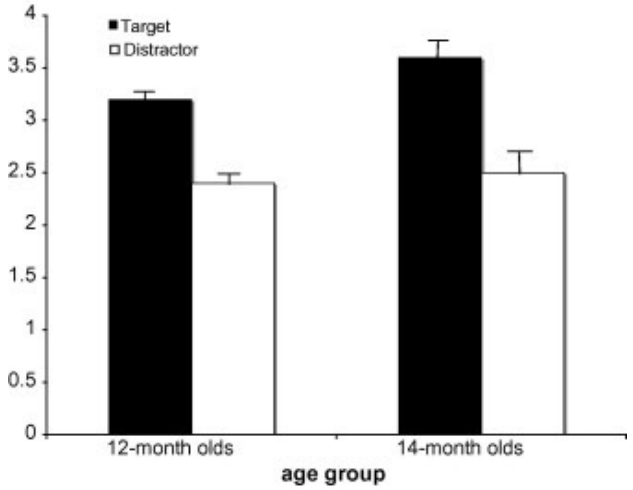


revisiting innateness vs. learning

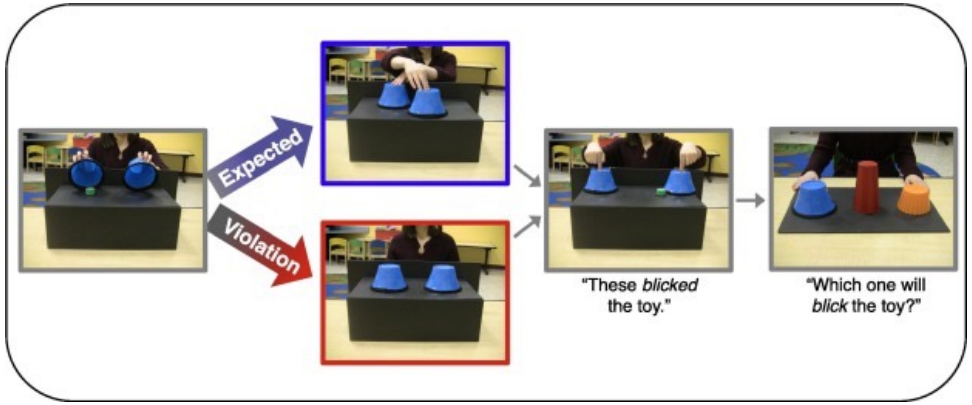
- statistical learning studies show that infants are able to extract regularities from environmental input
- this could suggest that some aspect of language learning is *innate*
- this is related to Chomsky's "poverty of the stimulus" argument
- but....you only need *one example* to falsify a theory!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

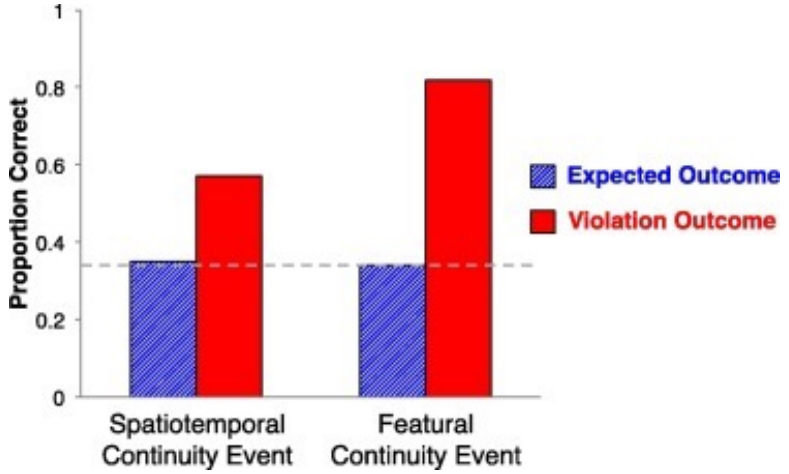
why track statistics?

- 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: but infants appear to track non-communicative statistics as well, such as for shapes, tones, etc. and newborn infants who cannot communicate also track them
  - infants want to generate predictions about the environment: infants are motivated to reduce uncertainty

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



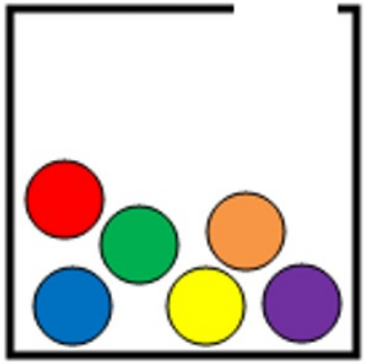


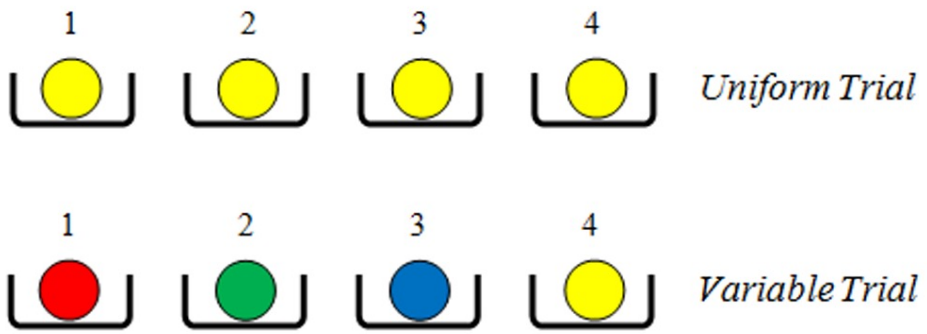
statistical learning and curiosity

- 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

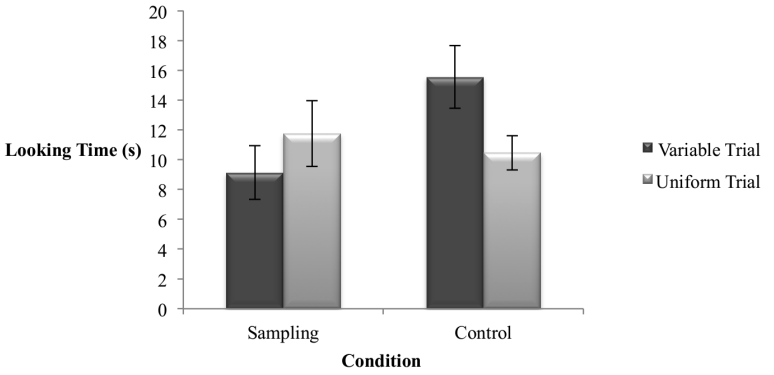
- Sim & Xu (2017) tested 13-month-old infants in a violation of expectation (VOE) and crawling paradigm
  - sampling condition: could be “uniform” or “variable”
  - control condition: experimenter looked into the box before drawing out the balls
- two experiments: looking time vs. crawling/reaching time
- predicted pattern??

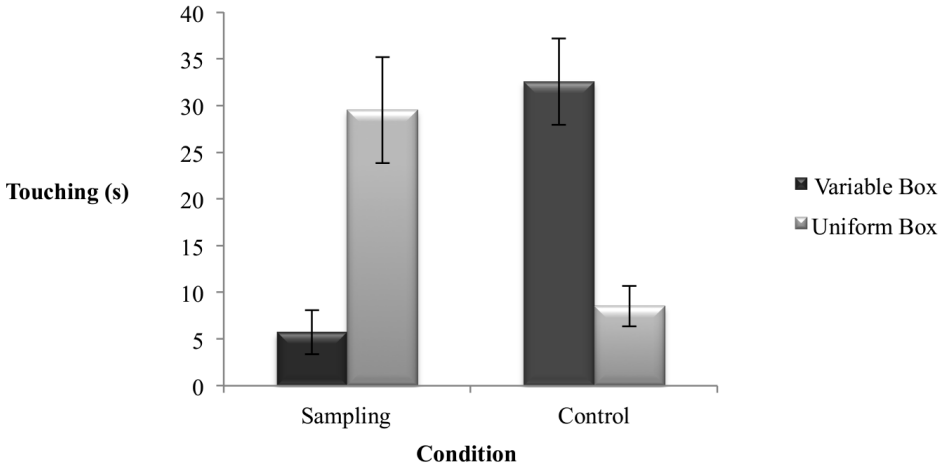


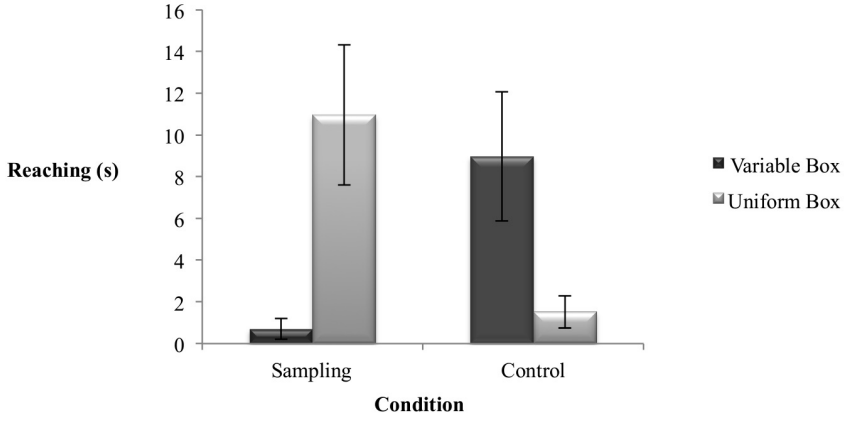


statistical learning and curiosity

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







error-free vs. error-driven learning

- the view that infants/humans generate expectations about language is referred to as the error-driven learning view
  - within this view, infants are generating expectations, calculating “prediction errors” and revising their expectations
  - this view is also consistent with the prediction-based view of associative learning (e.g., Rescorla-Wagner model)
- an alternative view is that infants/humans do not necessarily generate expectations or predict what happens next, but instead simply keep track of associations over time: the error-free learning view

big takeaways

- get in groups of 3 and report key takeaways from today
- takeaways document

next class

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