3.1 SYNTACTIC: STRUCTURE DEPENDENCE

MINI REVIEW OF MONDAY

- Linguistic representations are hierarchical in structure
- Rules that manipulate linguistic elements rely on this structure
  - Rules are **structure-dependent**
- Structure-independent rules cannot capture the full range of complex yes/no questions in English

THE CORRECT HYPOTHESIS & THE HYPOTHESIS SPACE

(3)   a.   [$_{CP}$ Can the penguin [$_{CP}$ who is on the iceberg] t_{can} find a fish]?
      b.   [$_{CP}$ The penguin [$_{CP}$ who is on the iceberg] can find a fish].

- To form complex yes/no questions in English, "move the main clause auxiliary to a position at the front of the utterance"
  - This is a structure–dependent rule
- The hypothesis space includes anything that can correctly get us from 3b to 3a
  - This can include structure–dependent AND structure–independent hypotheses
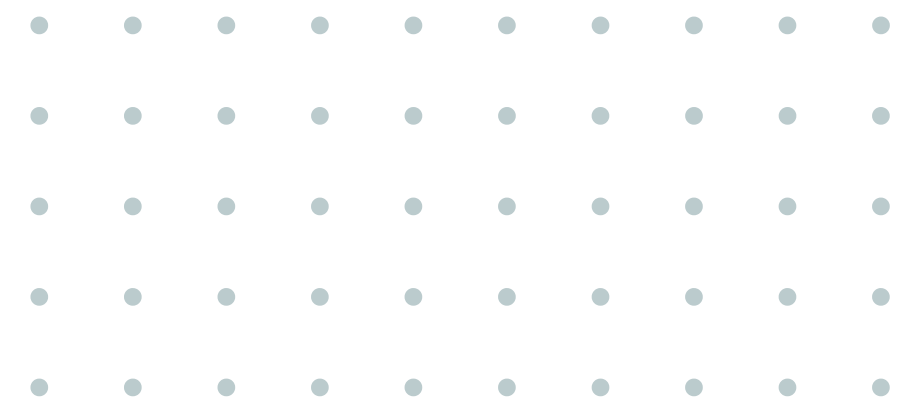
AVAILABLE DATA

- Initial focus was on "individual knowledge pieces," like yes/no question formation
- Available data initially considered only related to yes/no questions

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"Various analyses of children's possible input suggested that **the vast majority of their data were ambiguous between the correct structure-dependent rule and other competing rules**, including structure-independent ones".

LEVERAGING AVAILABLE DATA & AGE OF ACQUISITION

- Initial ideas:
  - Children can only use direct positive evidence
  - Only unambiguous data was informative
- Children as young as 3 know structure–dependent rules are needed to form yes/no questions (Crain & Nakayama, 1987)
- Insufficient unambiguous data
  - Poverty of the stimulus?

INVESTIGATION 1: REALI AND CHRISTIANSEN (2005)

- Hypothesis space includes structure-dependent and structure-independent rules
- Modeled learner uses all available utterances (rather than just other yes/no questions)
- Relative frequencies of 2 word and 3 word sequences to determine if yes/no questions were grammatical
  - No structure-dependent rules needed
- Suggested there was not Poverty of the Stimulus (?)
- Turns out this model failed when more yes/no questions were included
 - Seems Poverty of the Stimulus DOES exist
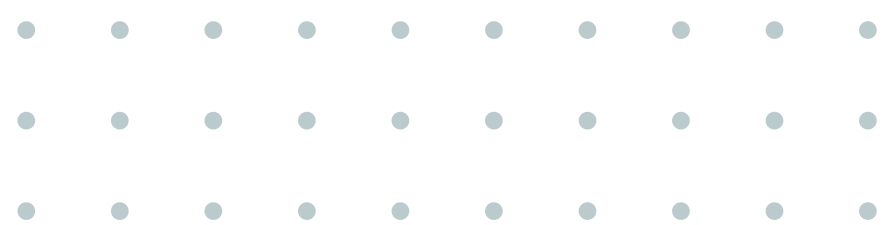
INVESTIGATION 2: PERFORS, TENENBAUM, ANDREGIER (2011)

- Modeled learner considered all representation types
  - Structure-dependent and structure-independent
- Available data was all utterances children encounter
- "In particular, the learner used Bayesian inference to identify the representation that balanced the complexity of the representation with the ability of that representation to encode the data. With this prior preference in hand, **the modeled learner successfully identified the correct structure-dependent representation** from those available in the hypothesis space, on the basis of the data children encounter."
- Simplicity bias

INVESTIGATION 3: ABEND ET AL. (2017)

- "implicitly defined a hypothesis space of infinite size via a set of predefined structure-dependent building blocks and constraints on how those building blocks can combine"
  - Structure-dependence was assumed but the correct rule was unknown
- Modeled learner used
  - all available utterances
  - syntactic and meaning information from utterances
  - meaning information from the surrounding non-linguistic context
- Biases
  - Simplicity
  - Efficiency (representations reuse common building blocks)
  - "Rational rules"
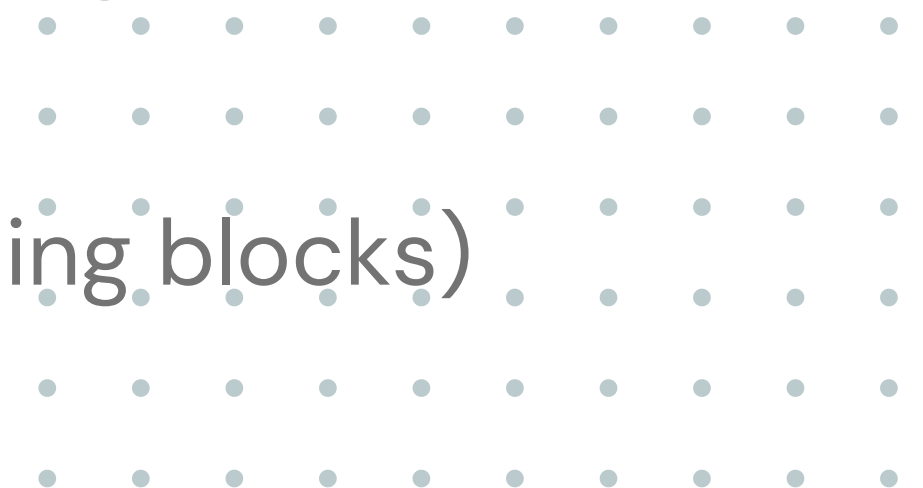
INVESTIGATION 4: FITZ AND CHANG (2017)

- "had their modeled learner use both syntactic and meaning information available in children's utterances"
- Rejected the assumption that children had a bias for structure-dependence
- What modeled learner knew:
  - meaning representations were hierarchically structured
  - sequences of words were generated from those underlying meaning representations
- "Neural network used to navigate the space of possible ways to generate observable sequences from underlying meaning representations"
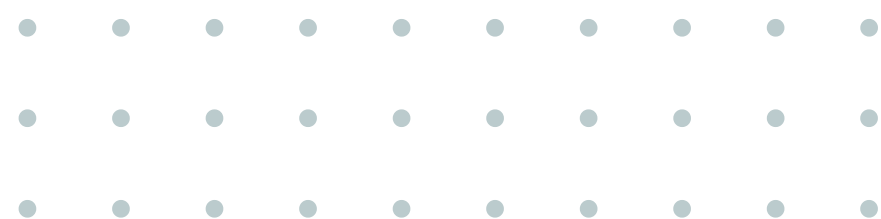
INVESTIGATION 5: MCCOY ET AL. (2018)

- Neural network approach
- Assume learner is trying to identify a particular structure-dependent representation
- learner generates an appropriate sequence of words corresponding to a complex yes/no question given the declarative version
  - One modeled learner relied on structure-dependence
- Not necessary for the learner to already have an explicit preference for structure-dependent representations in order to learn them
- Bias based on whatever was encoded implicitly in the neural network architecture

INTERPRETATIONS

- "restricting the relevant input easily leads to poverty of the stimulus that requires child–internal biases to solve"
- Useful biases
  - "consider any individual linguistic knowledge piece as part of a larger linguistic system"
  - "prioritize compact representations, the ability of those representations to encode the available data compactly, and representations that rely on reusable building blocks"
  - which structural building blocks to use
  - knowing about the tight relationship between syntax and meaning

Linguistic?