Simplicity, data and inter-related systems: A computational account of kinship term acquisition

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Children's early verbal knowledge is "off"

- What's an uncle?
  - "He's a man." (5;4 yo)
- What's a mother?
  - "A big girl" (4;6 yo)
- What's an aunt?
  - "It's a lady that helps you a lot of times . . ." (6;2 yo)

- What's an uncle?
  - "Your mother or father's brother." (22;2 yo)

Benson & Anglin (1987)

Our Approach

- Formalize conceptual development as logical program induction.

$$f(\,\text{🍴🔪🥄🥄}\,) = \text{🥄🥄}$$

concept

object ⟷ "spoon"

word

Peirce (1868)
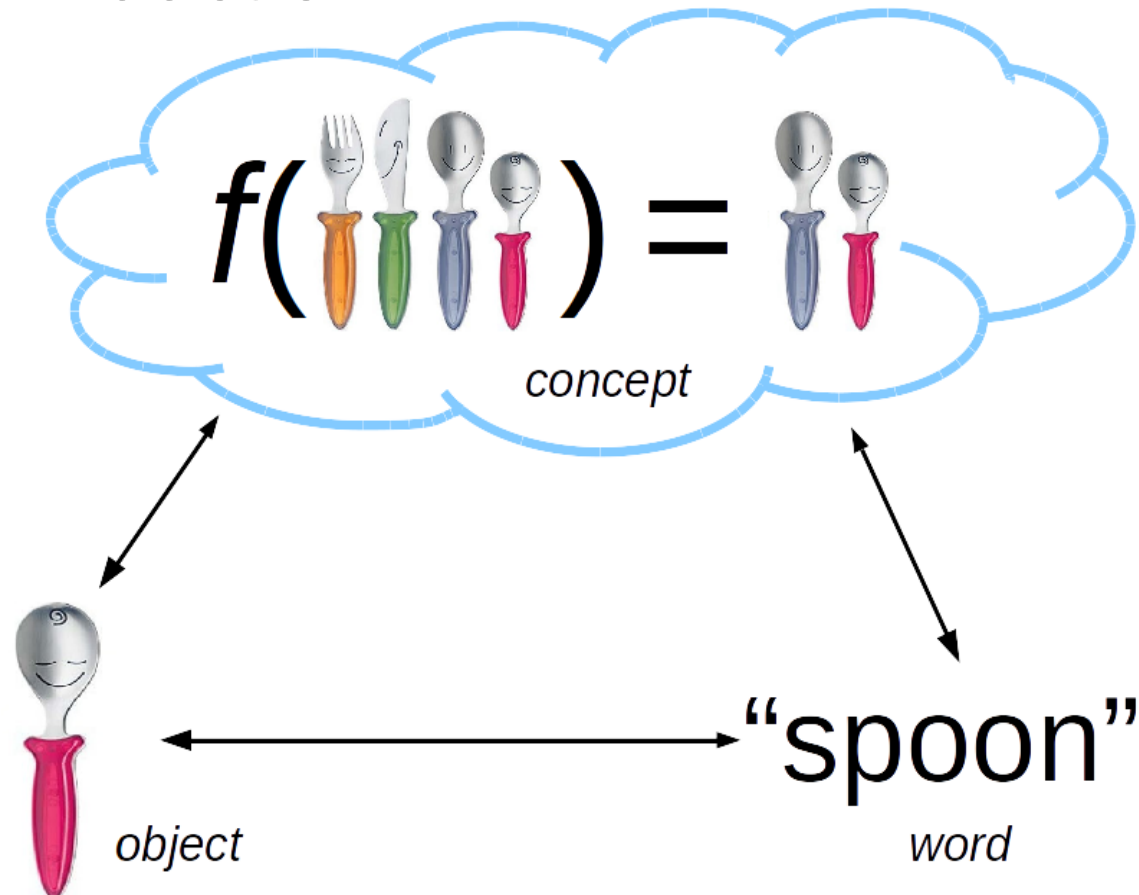
Ideal Learner Model

- Computational Level Analysis (Marr, 1982)

  - Specify a **Hypothesis Space** of concepts

  - Specify a **Prior** over hypotheses

  - Specify a **Likelihood** function

  - Specify the environment

- In a Bayesian learning model, learning corresponds to the movement of probability mass over a hypothesis space.
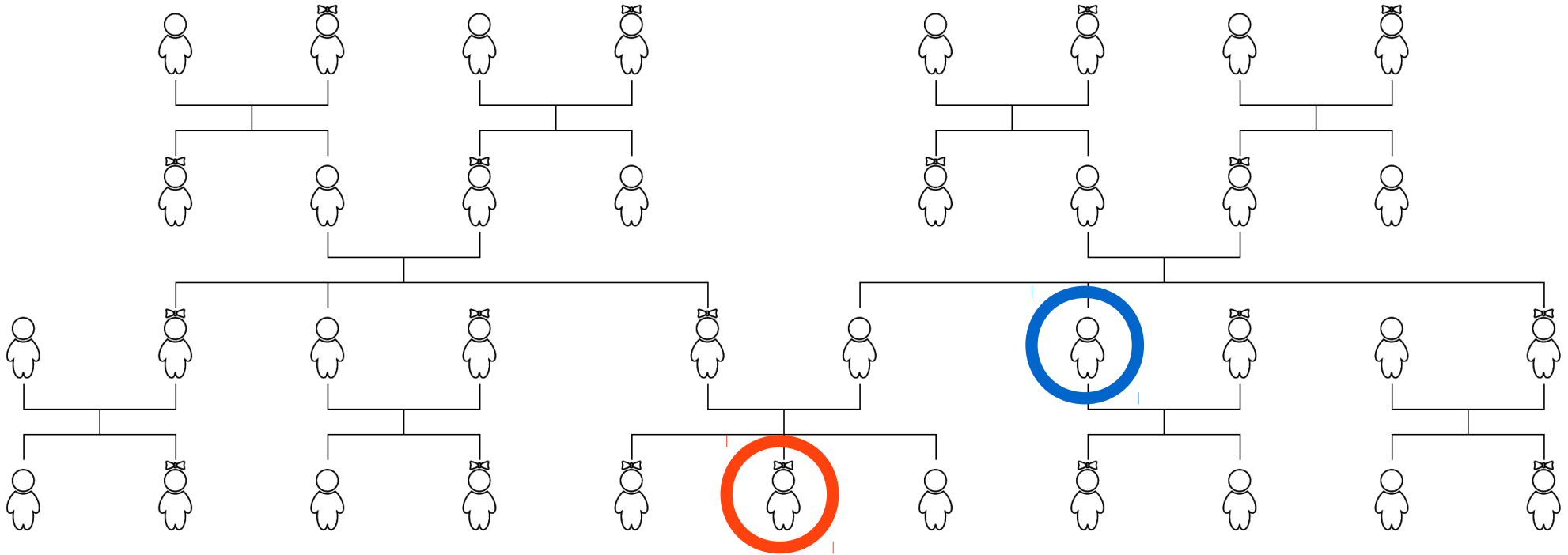
Hypothesis Space & Prior

Tree Moving	Set Operations	Gender	Age	Inputs
Child Parent Spouse	Union Intersection Difference Complement	Female Male SameGender	SameGeneration ParentGeneration GparentGeneration	All Speaker Individual

For example:
1. All
2. Tito
3. SameGeneration(Tito)
4. Male(Parent(Speaker))

Where does data come from?
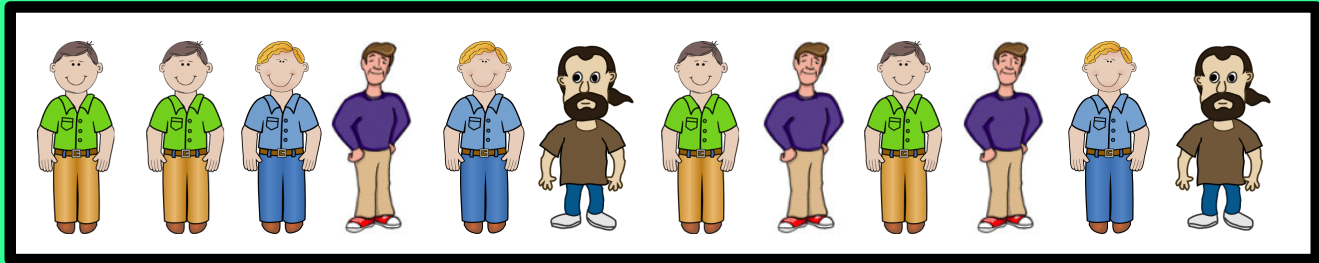
- Context:

- Data Point:

  - Context
  - Speaker 🔴

  - Word *uncle*
  - Referent 🔵

How do we fit to the data?

- Size Principle Likelihood (e.g., Tenenbaum & Griffiths, 2001; Xu & Tenenbaum, 2007)

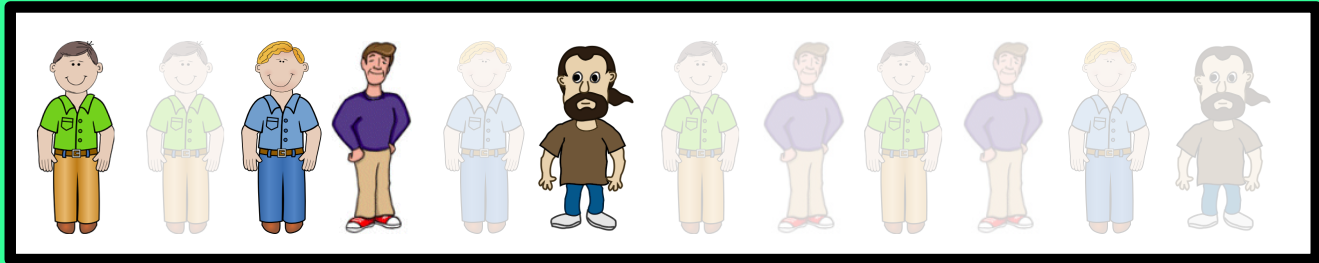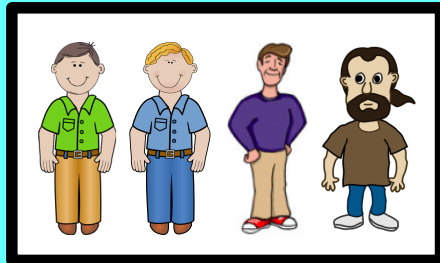Data Distribution:

How do we fit to the data?

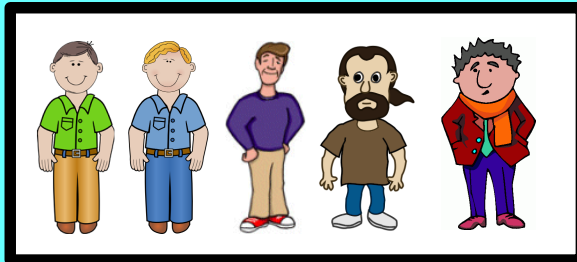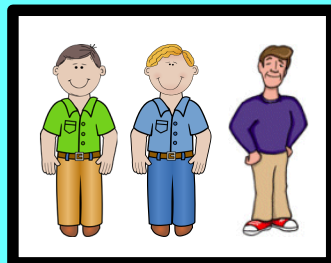- Size Principle Likelihood (e.g., Tenenbaum & Griffiths, 2001; Xu & Tenenbaum, 2007)
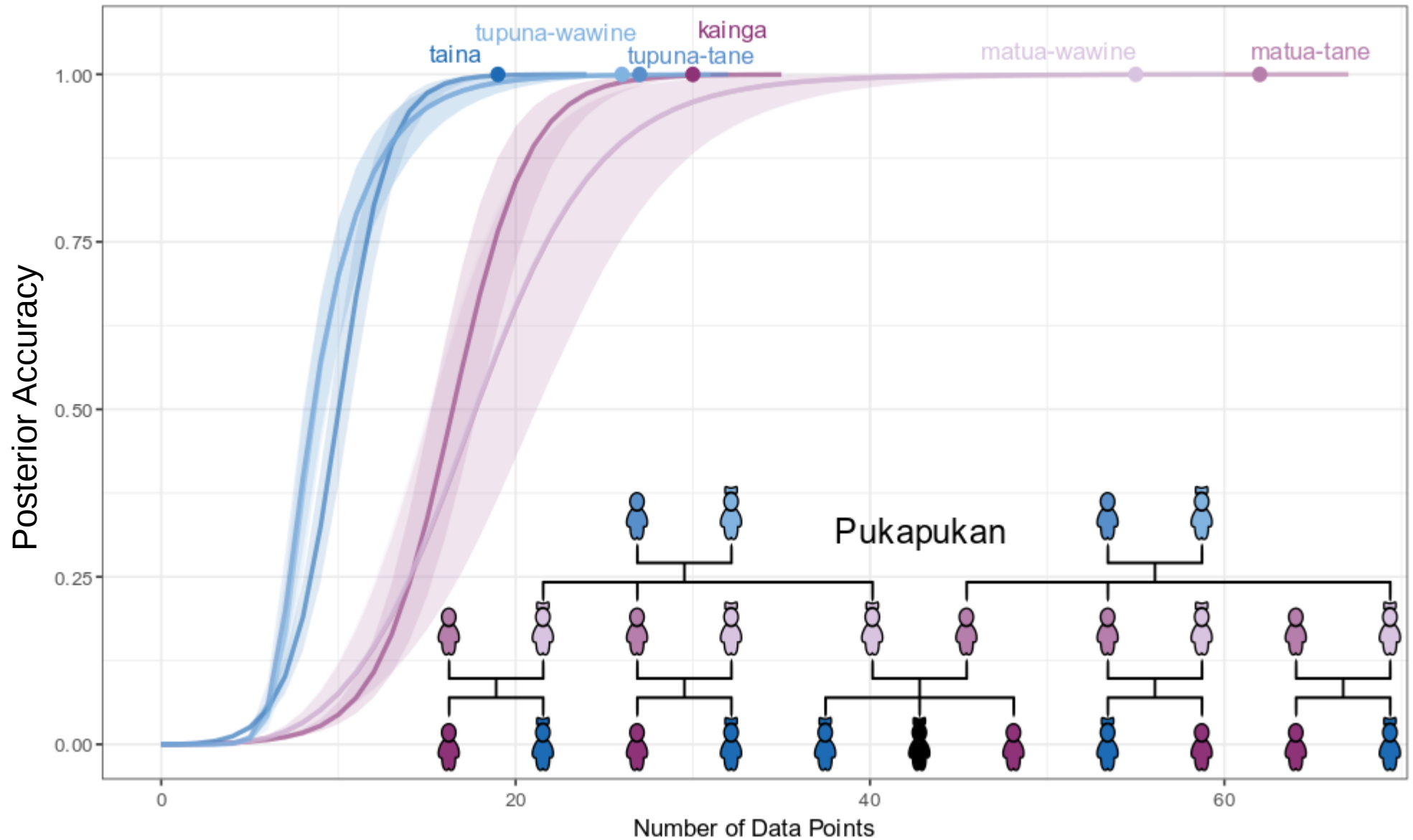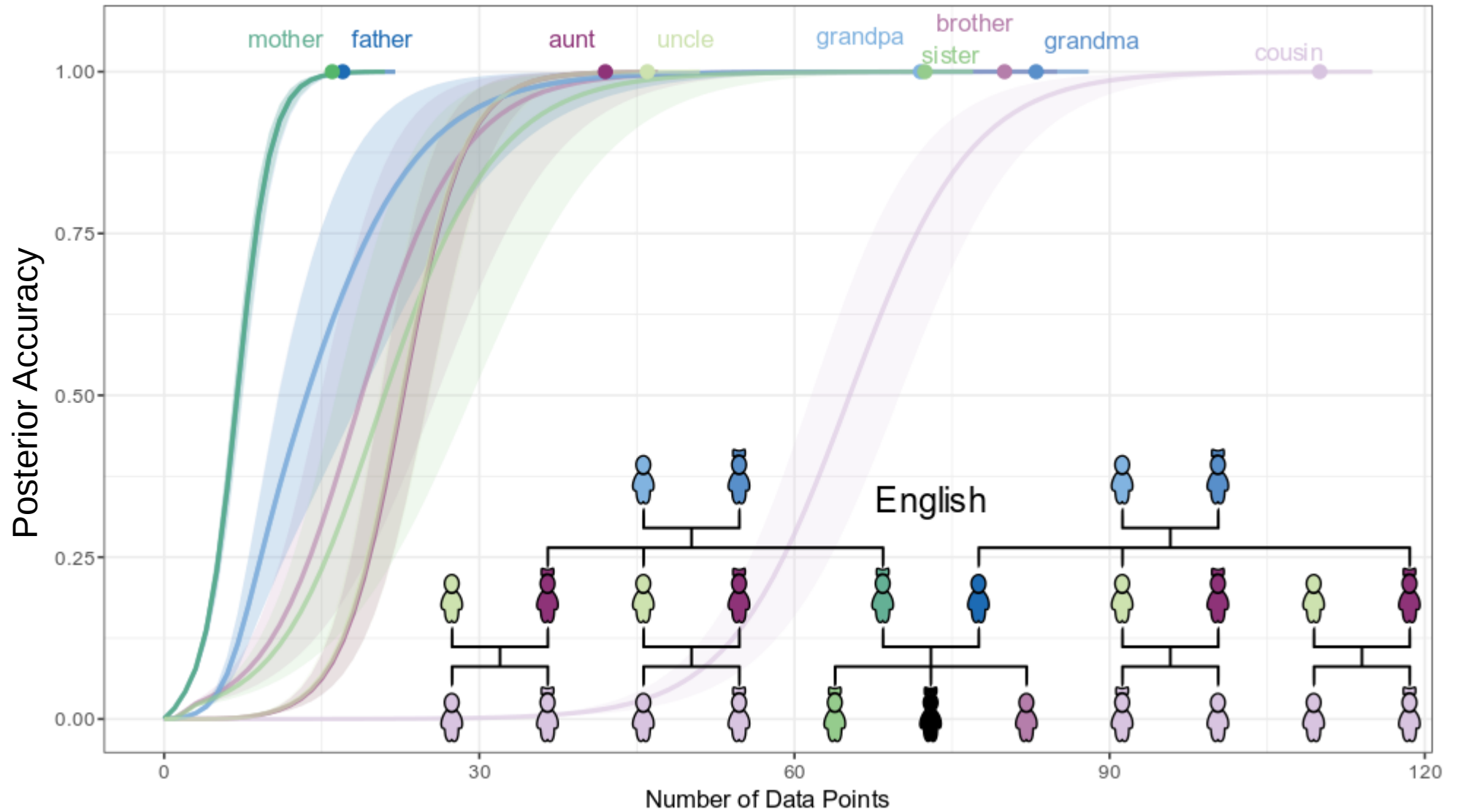
Kinship Acquisition Phenomena

- O: Kids learn **their** kinship system

- O: Young kids prefer concrete referents

- O: Older kids over-generalize

- O: Generalization shifts from characteristic features to defining features

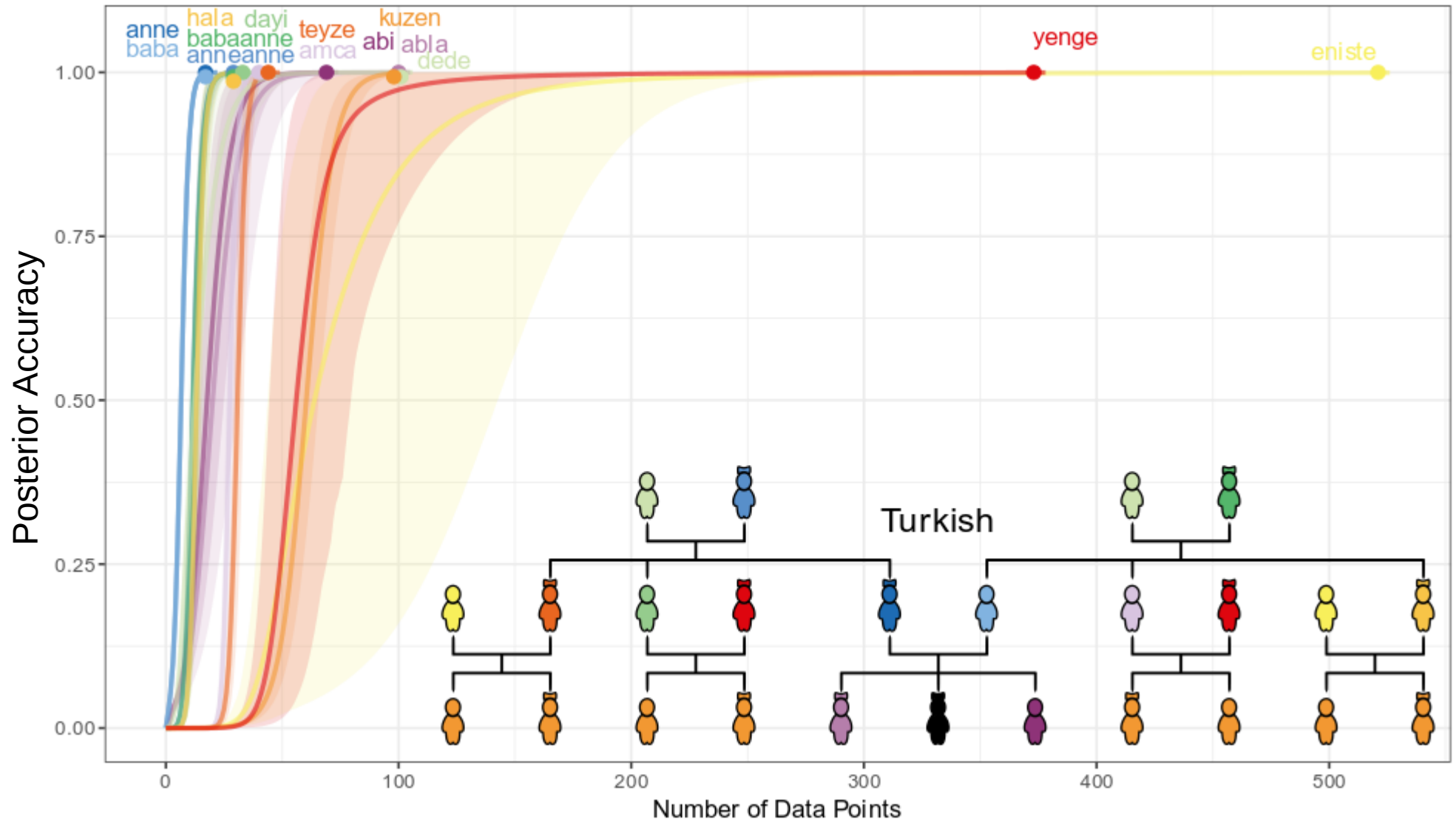- O: English kinship terms are acquired in a roughly consistent order

O: Kids learn **their** kinship system

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O: Young kids prefer concrete referents

I: What is an uncle?

S: Uncle Anthony

I: Tell me everything you know about an uncle.

S: Uncle Henry

I: Anything else?

S: You know … Yogi's an uncle … Yea … Booboo's an uncle.

I: Is Booboo an uncle?

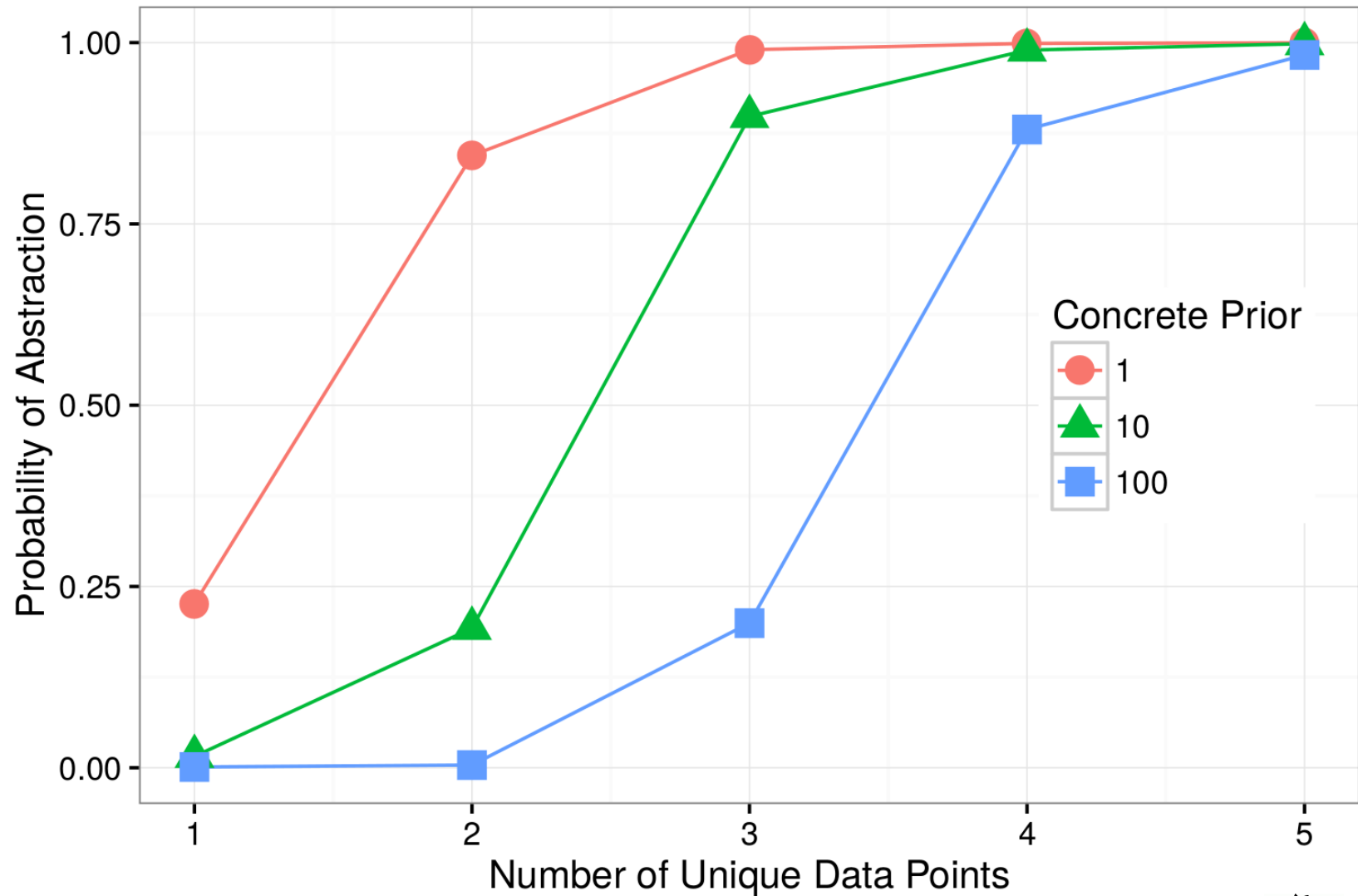S: No, he's a Booboo boy …

I: What kind of a thing is an uncle?

S: Um … um … Yogi.

3;0 YO
(Benson & Anglin, 1987)

O: Young kids prefer concrete referents

O: Older kids over-generalize

I: What is an uncle?

S: Uncle. I don't know ...

I: Tell me everything you know about an uncle.
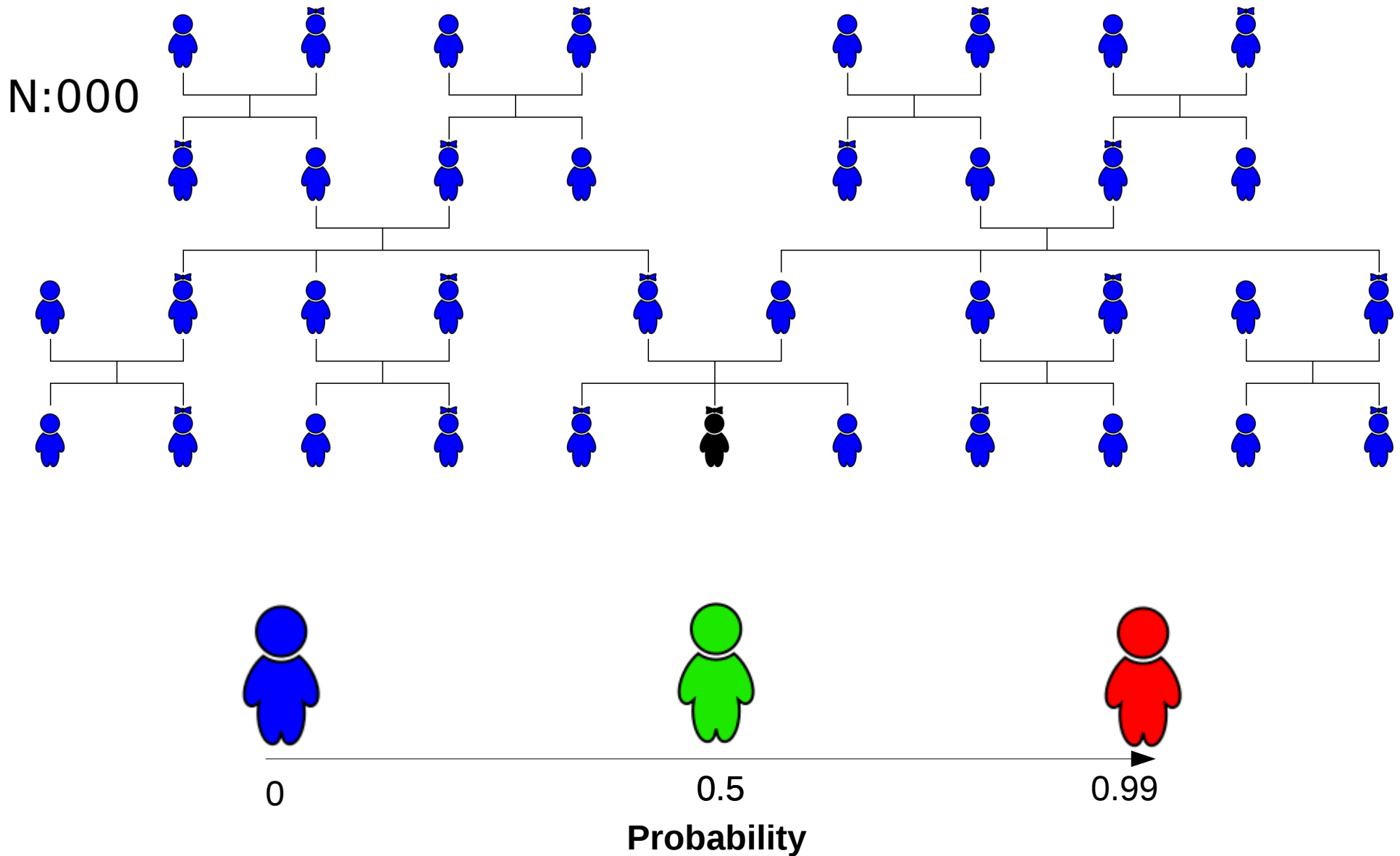
S: He's a man.

I: What kind of a thing is an uncle?

S: He's a man.

5;4 YO
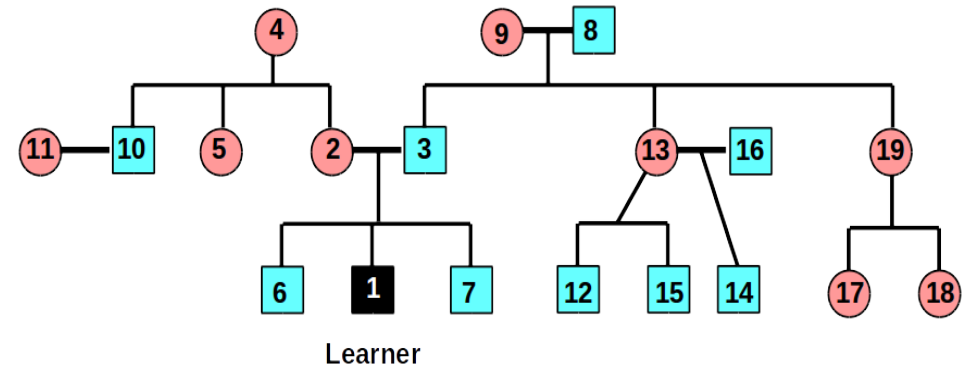(Benson & Anglin, 1987)

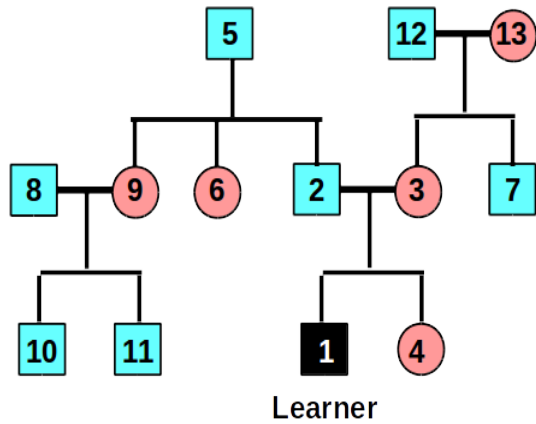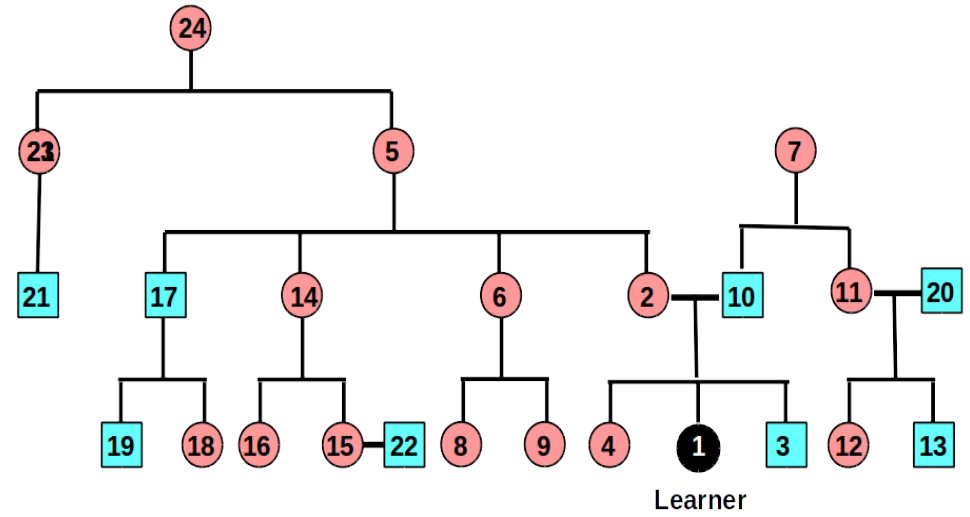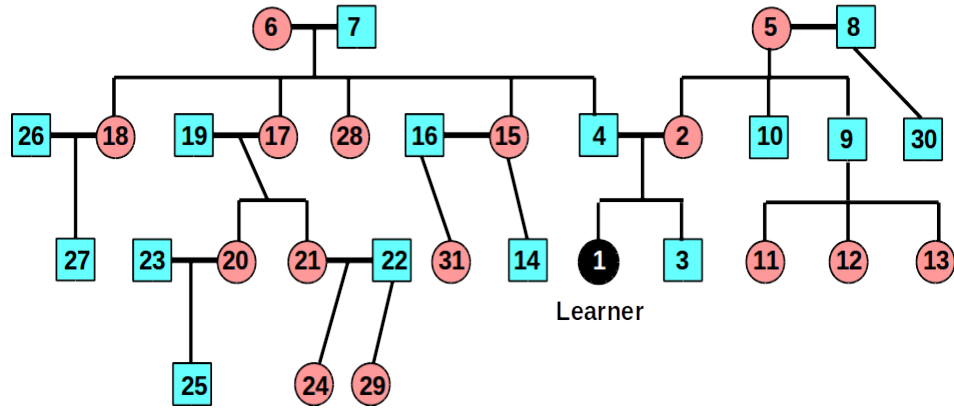# O: Older kids over-generalize

N:000

O: Generalization shifts from characteristic to defining features

- This man your daddy's age loves you and your parents and loves to visit and bring presents, but he's not related to your parents at all. He's not your mommy or daddy's brother or sister or anything like that. Could that be an uncle?

- Suppose your mommy has all sorts of brothers, some very old and some very, very young. One of your mommy's brothers is so young he's only 2 years old. Could that be an uncle?

Defining ONLY 3

+c/−d

Both Required 2

−c/+d

UNCLE

Characteristic ONLY 1

K 2 4

Keil & Batterman (1984)
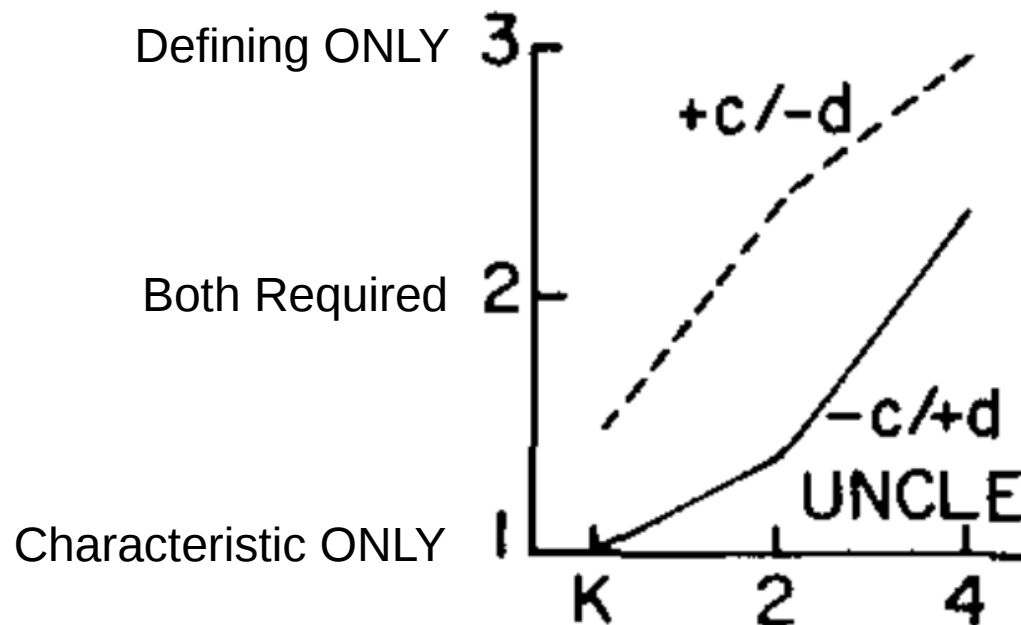
Family Tree Data Collection (N=4)

Feature Matrix Data Collection (N=4)

Characteristic-to-Defining Shift
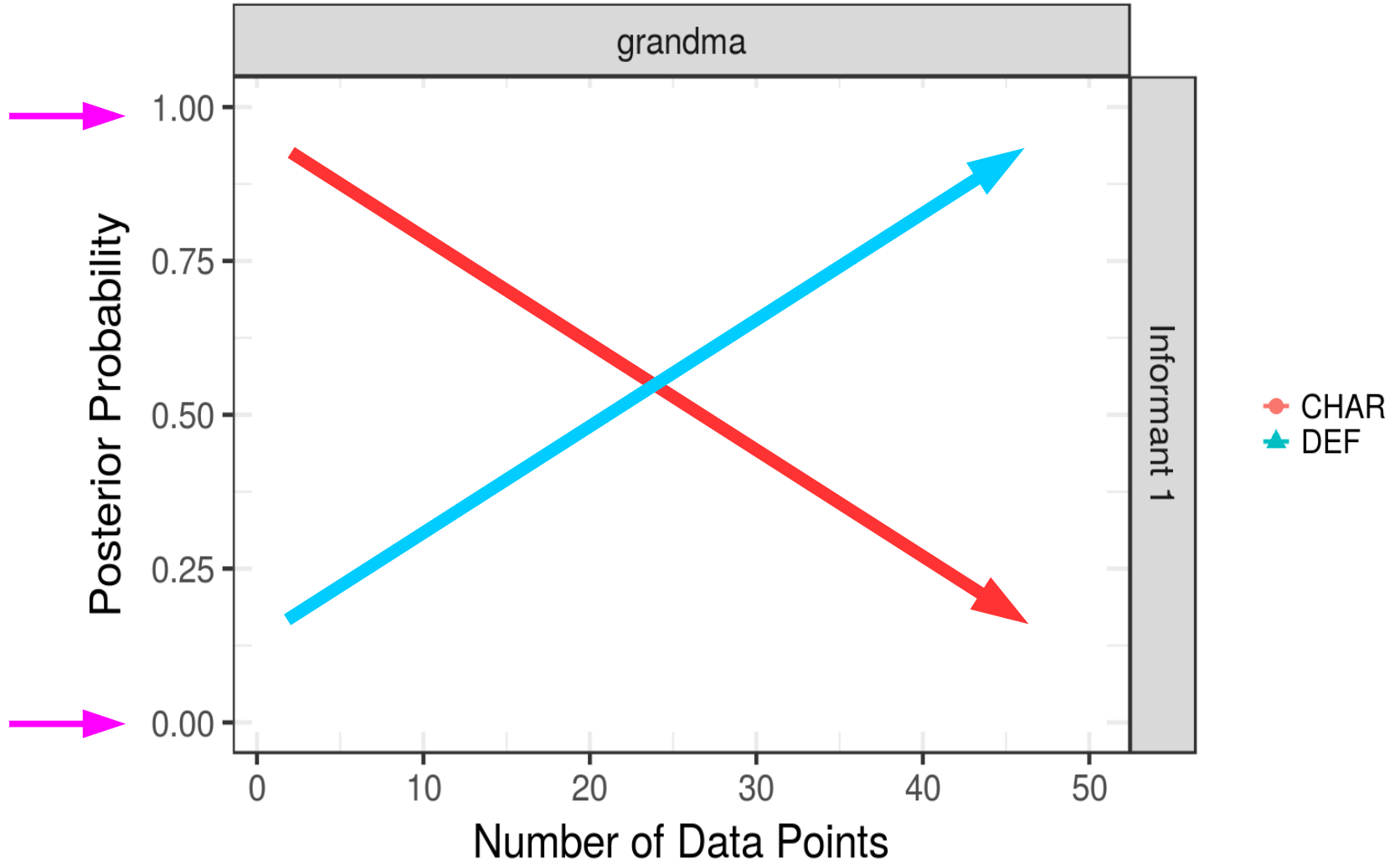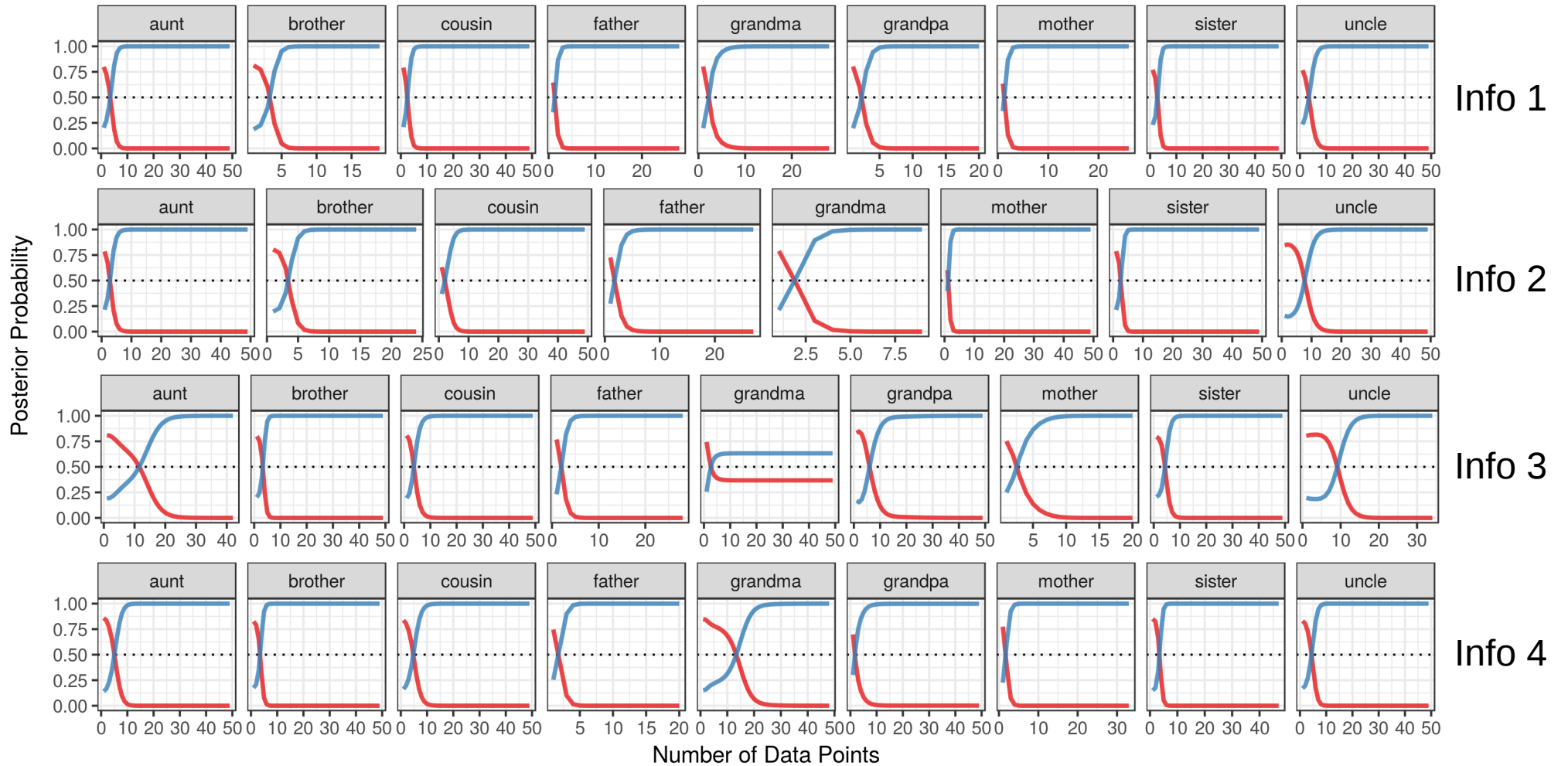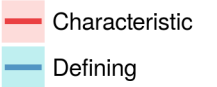
Characteristic-to-Defining Shift

O: "Consistent" Order of Acquisition

Empirical Order	Word	Original H&C Order & Formalization	Log Prior	CHILDES Freq.
1	*mother*	Level I: [X PARENT Y][FEMALE]	-9.457	6812
1	*father*	Level I: [X PARENT Y][MALE]	-9.457	3605
2	*brother*	Level III: [X CHILD A][A PARENT Y][MALE]	-13.146	41
2	*sister*	Level III: [X CHILD A][A PARENT Y][FEMALE]	-13.146	89
3	*grandma*	Level II: [X PARENT A][A PARENT Y][FEMALE]	-13.146	526
3	*grandpa*	Level II: [X PARENT A][A PARENT Y][MALE]	-13.146	199
4	*aunt*	Level IV: [X SIB A][A PARENT Y][FEMALE]	-19.320	97
4	*uncle*	Level IV: [X SIB A][A PARENT Y][MALE]	-19.320	68
4	*cousin*	Level IV: [X CHILD A][A SIB B][B PARENT Y]	-18.627	14

Haviland & Clark (1974)

O: "Consistent" Order of Acquisition
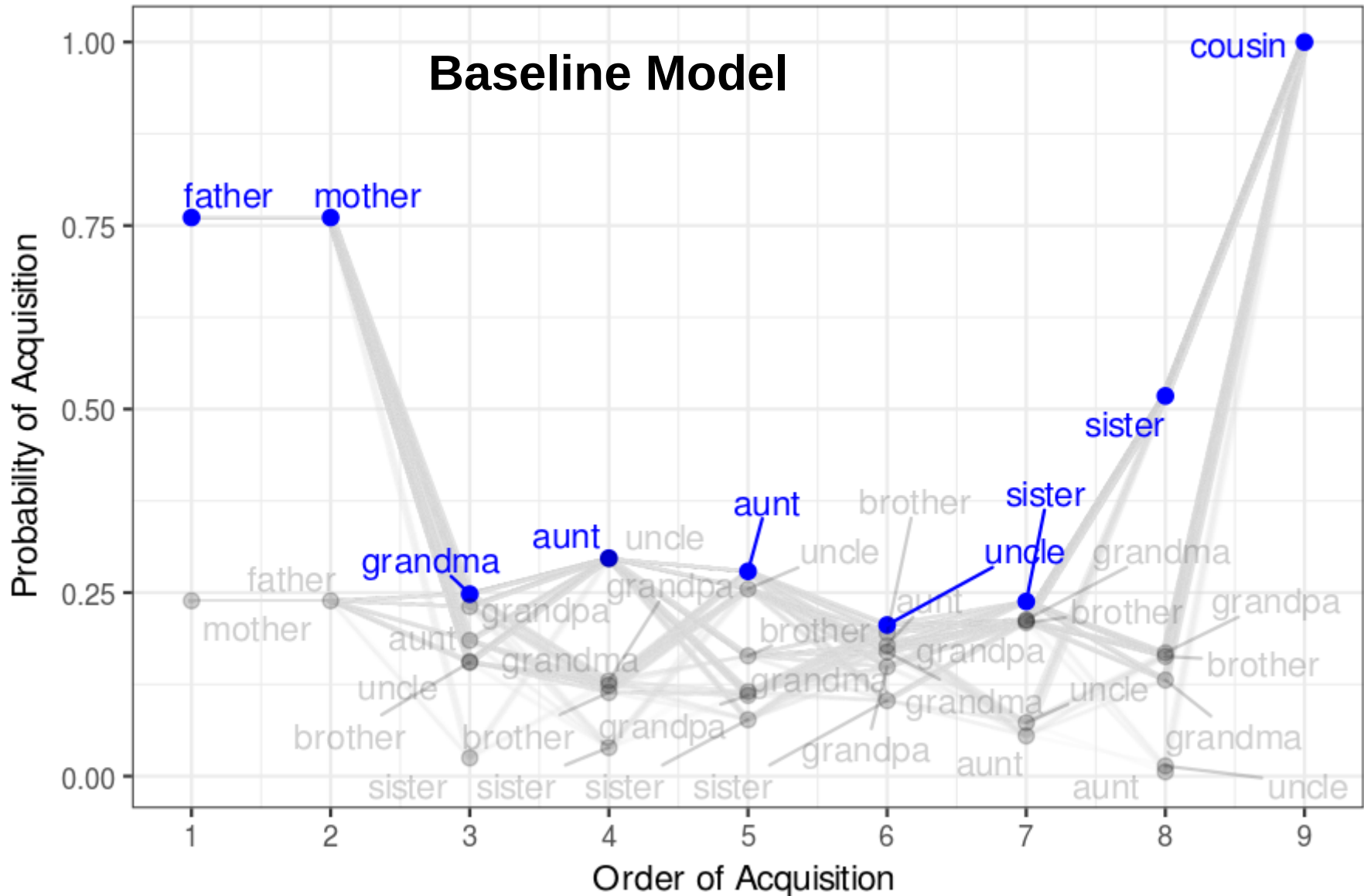
Where does data come from?

- Context:

- Data Point:
  - Context
  - Speaker ⭕
  - Word *uncle*
  - Referent ⭕

Benson & Anglin (1987)
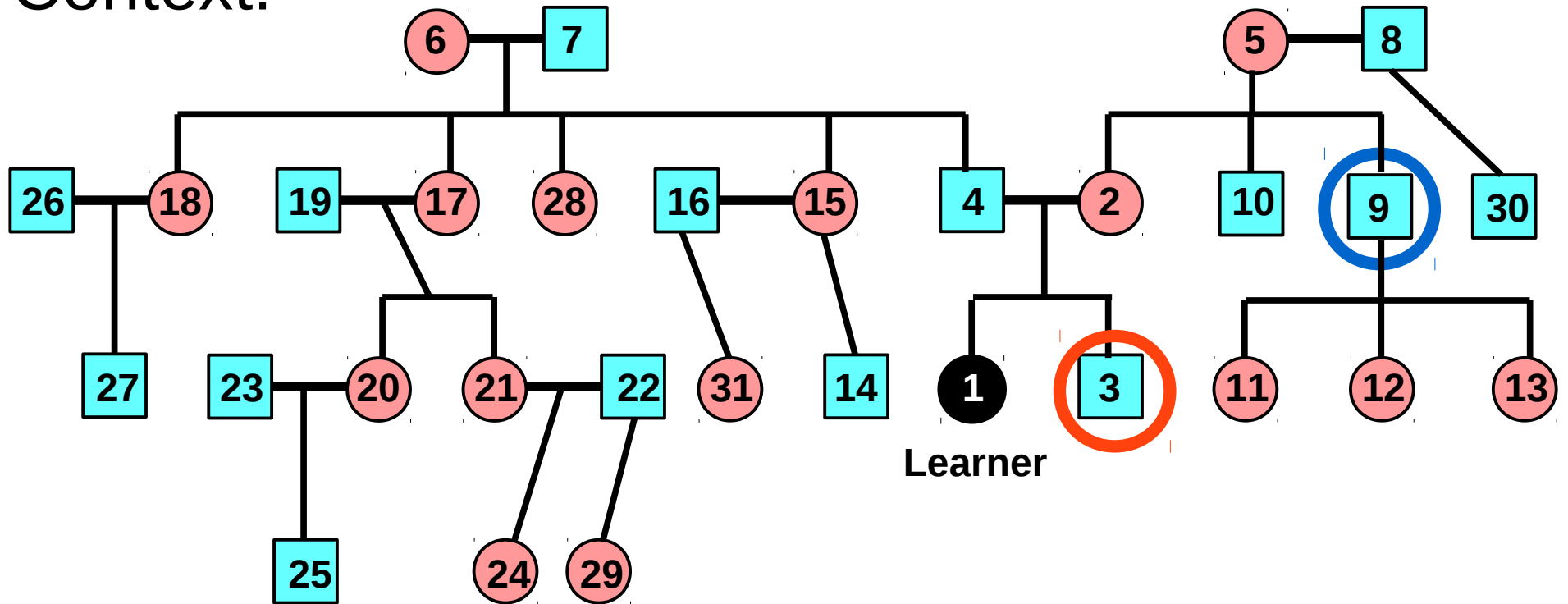
O: "Consistent" Order of Acquisition
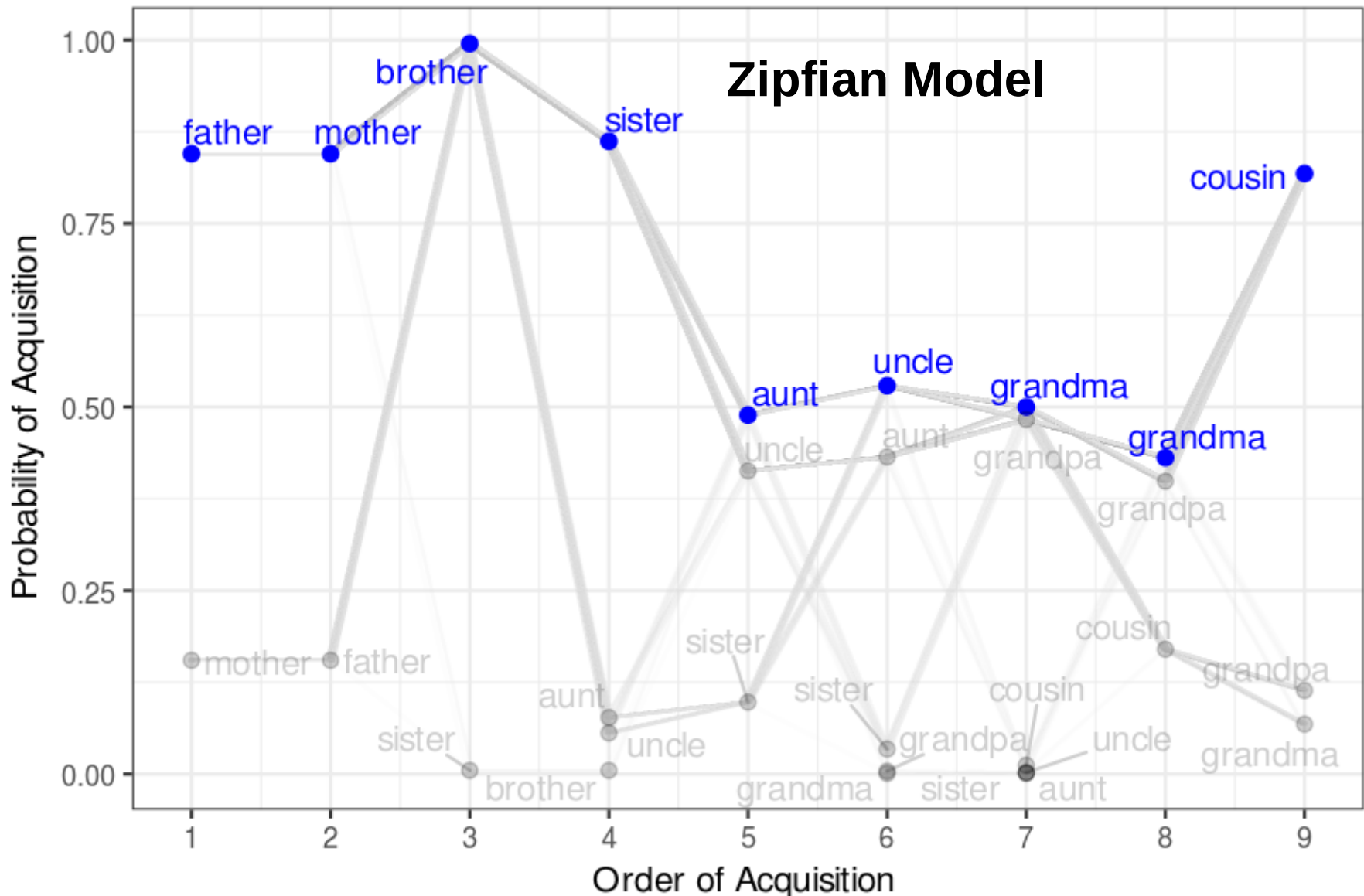
Hypothesis vs. Lexicon

Context =
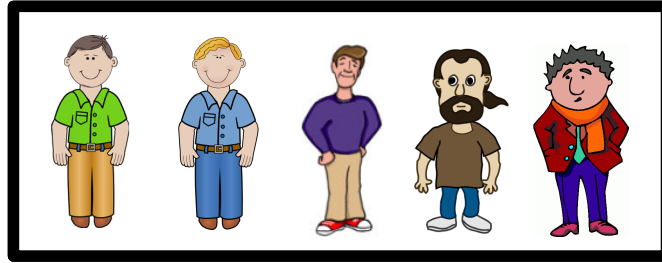
H(Context) = L(*uncle*, Context) = { }
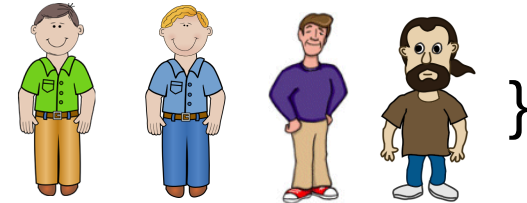
H(Context) = L(*father*, Context) = { }

L(Context) = { *uncle:*
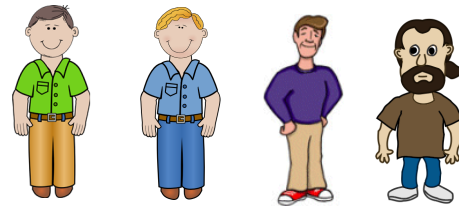
father: }

O: "Consistent" Order of Acquisition
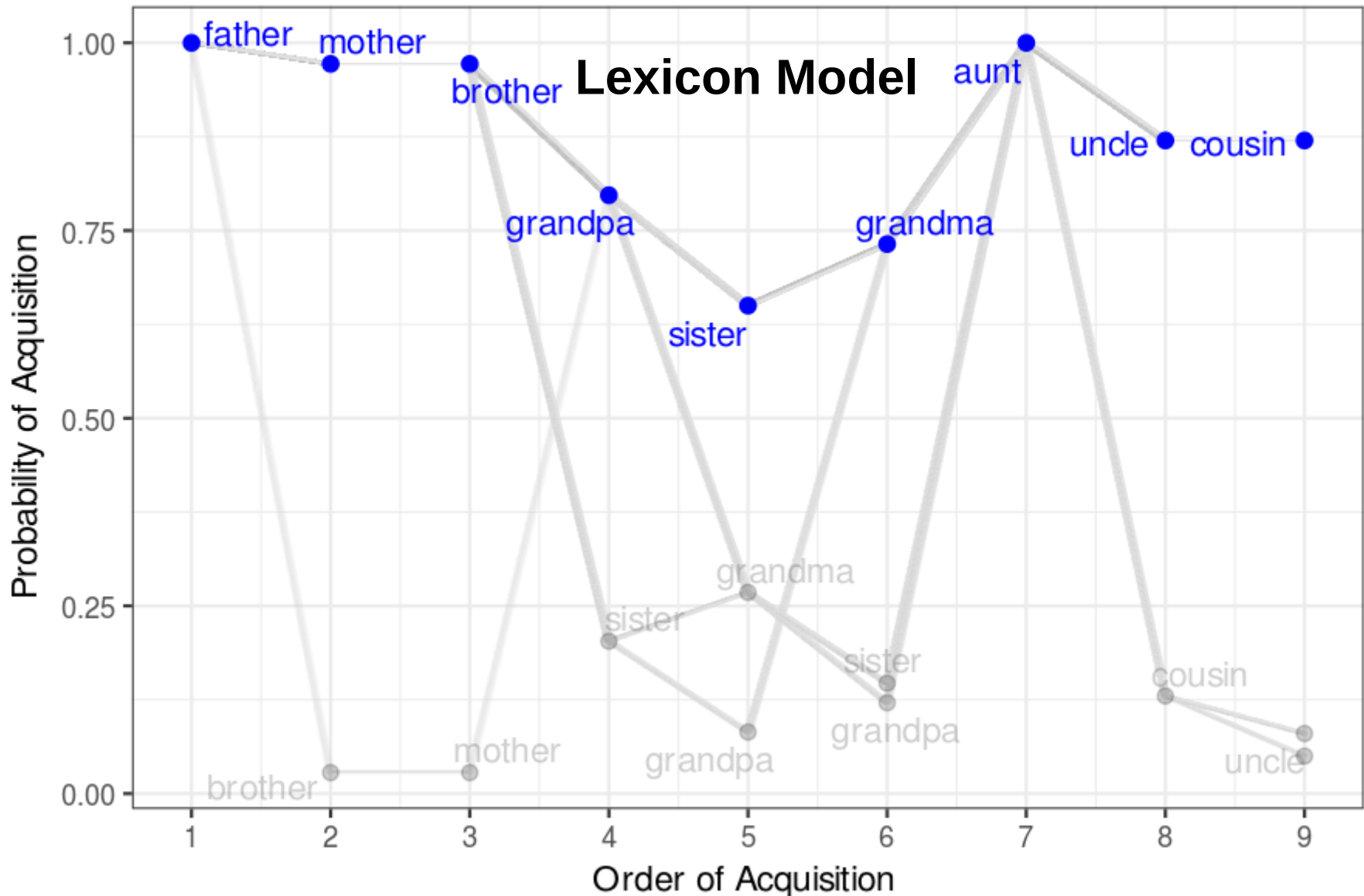
Take-Aways

- Model provides convergent evidence:

	Simplicity	Data / Environment	Inter-related Systems
Learnability		X	
Concrete Preference	X		
Over-generalization	X	X	
Characteristic-to-Defining Shift		X	
Order of Acquisition		X	X

- Model generates non-verbal predictions for word generalization.

- Model is a potential data analysis tool.

Acknowledgements

References

- Benson, N. J., & Anglin, J. M. (1987). The child's knowledge of English kin terms. First Language, 7(19), 41-66.

- Haviland, S. E., & Clark, E. V. (1974). 'This man's father is my father's son': a study of the acquisition of English kin terms. Journal of Child Language, 1(1), 23-47.

- Keil, F. C., & Batterman, N. (1984). A characteristic-to-defining shift in the development of word meaning. Journal of verbal learning and verbal behavior, 23(2), 221-236.

- Peirce, C. S. (1868). On a new list of categories. In Proceedings of the american academy of arts and sciences (Vol. 7, pp. 287–298).

- Tenenbaum, J. B., & Griffiths, T. L. (2001). Generalization, similarity, and Bayesian inference. Behavioral and brain sciences, 24(4), 629-640.

- Xu, F., & Tenenbaum, J. B. (2007). Word learning as Bayesian inference. Psychological review, 114(2), 245.

Further Details

- Mollica, F., & Piantadosi, S. T. (2015). Towards semantically rich and recursive word learning models. https://colala.bcs.rochester.edu/people/FrankMollica/Papers/mollica2015towards.pdf

- Mollica, F., Wade, S., & Piantadosi, S. T. (2017). A rational constructivist account of the characteristic-to-defining shift. https://colala.bcs.rochester.edu/people/FrankMollica/Papers/mollica2017rational.pdf