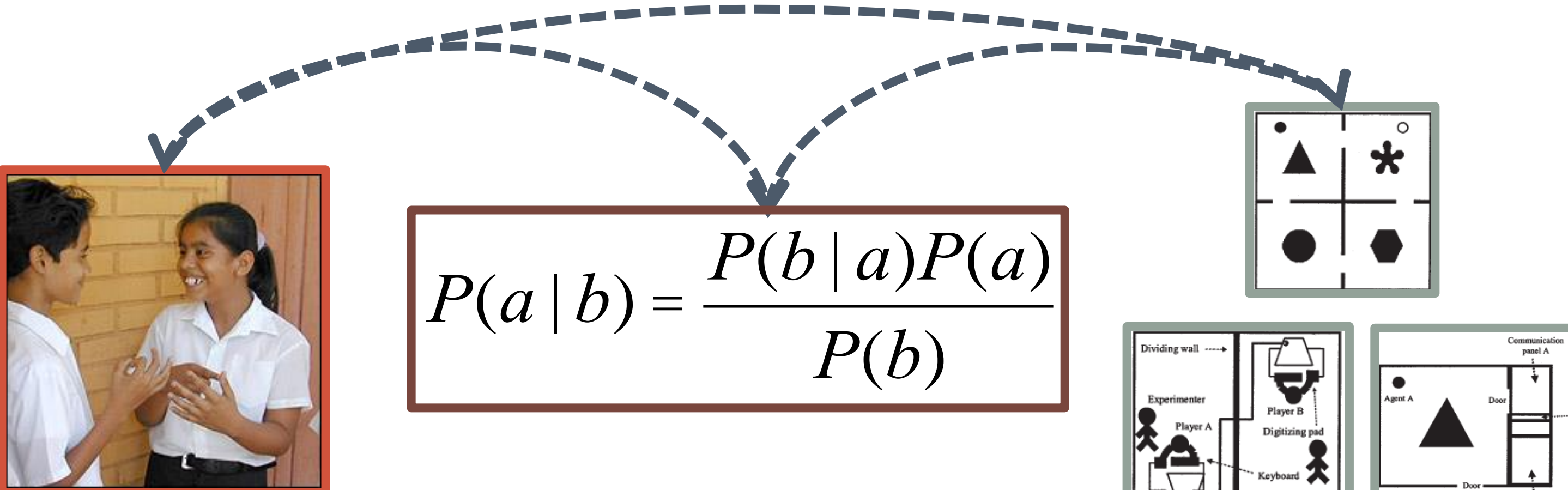


INTRODUCTION

From what kinds of learners, and interactions among learners, does language emerge?

Most data on the question come from computational models¹ and experiments² -- rarely from naturalistic data.

Weak integration of these approaches.



Systems created by Deaf individuals, either by:

- Deaf communities -- give rise to natural signed languages, some of which emerged recently (e.g. ~35 y.o. Nicaraguan Sign Language, NSL⁴; cf. ~200 y.o. American Sign Language)
- Homesigners -- deaf individuals, isolated from other Deaf, who create gestural systems for use with hearing families

For example, w.r.t. how linguistic conventions emerge among interacting individuals:

- Many agent-based models³, few links to experiments (e.g. above)
- And no direct, longitudinal data from naturally emerging systems on conventionalization



PRESENT STUDY

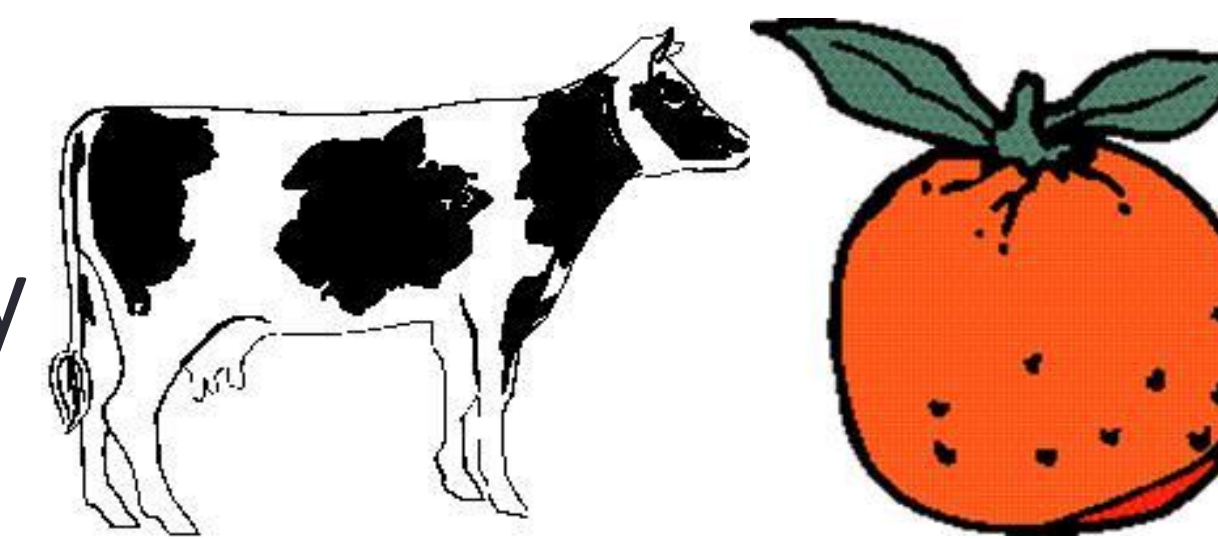
- Show conventionalization in Nicaraguan homesign systems, and compare to prior, indirect evidence of conventionalization in NSL
- Use agent-based model of conventionalization to test hypothesis that differences in patterns of interaction among users (partially) explain differences in homesign and NSL conventionalization

METHODS

Family 1	Family 2	Family 3	Family 4
Homesigner (M)	Homesigner (F)	Homesigner (M)	Homesigner (M)
Friend (M)	Mother	Mother	Younger brother
Mother	Younger brother		Younger sister
Older brother	Younger sister	Hearing families and friends	

Procedure

- Elicited gesture responses to 22 cross-linguistically and -culturally basic objects
- Tested 2002, '04, '06, '11



Coding

- Multi-gesture responses common (62% of all responses)
- Coded each gesture for Conceptual Component (CC), or aspect of item's meaning gesture represents



'cow' → HORNS + MILKING

Measuring conventionalization

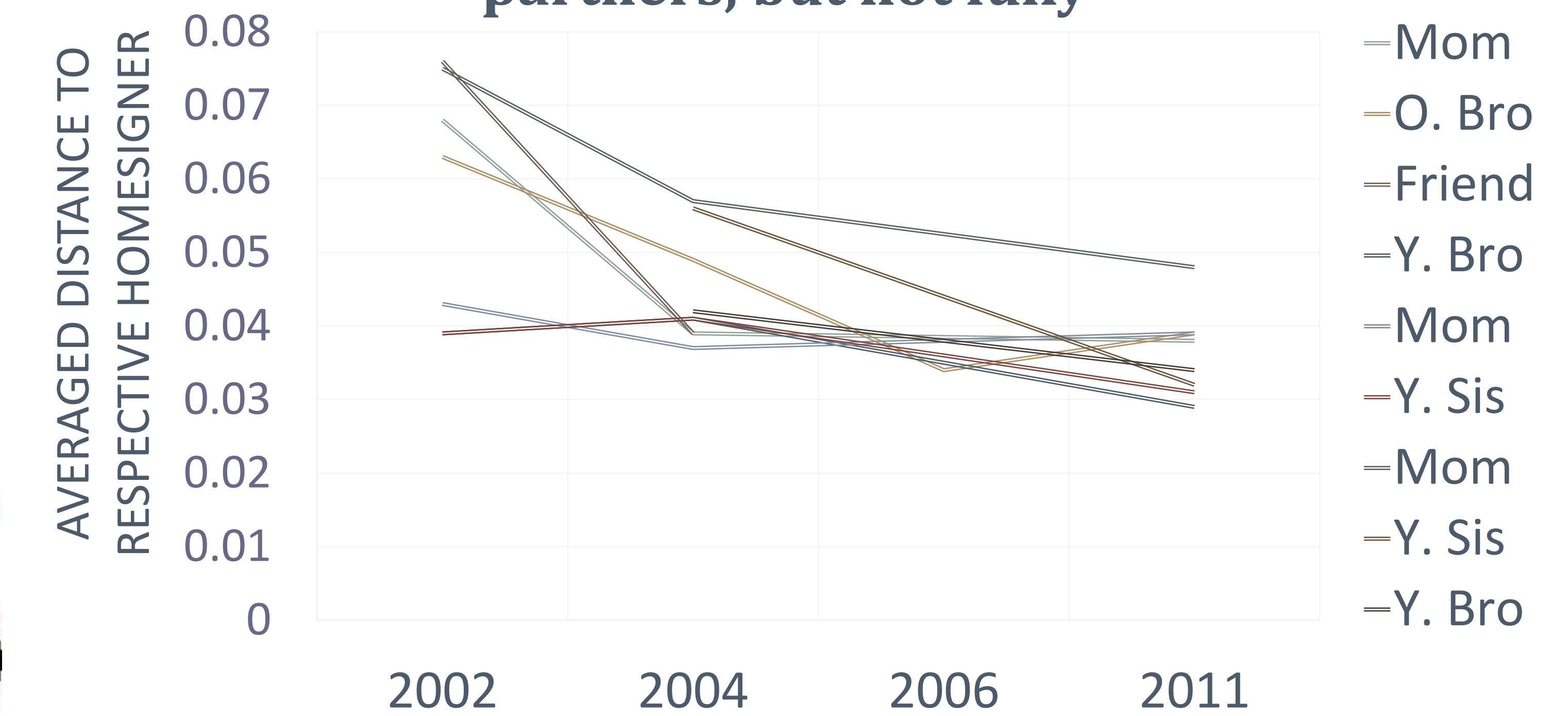
- Response is binary vector of CC's
- Conventionalization is distance between two responses

'cow'	HORNS	MILKING	DRINK	Distance from HSer
Homesigner	1	1	0	n/a
Sister	1	1	1	1
Mother	0	1	1	2

RESULTS (SEE FIGURE AT TOP RIGHT)

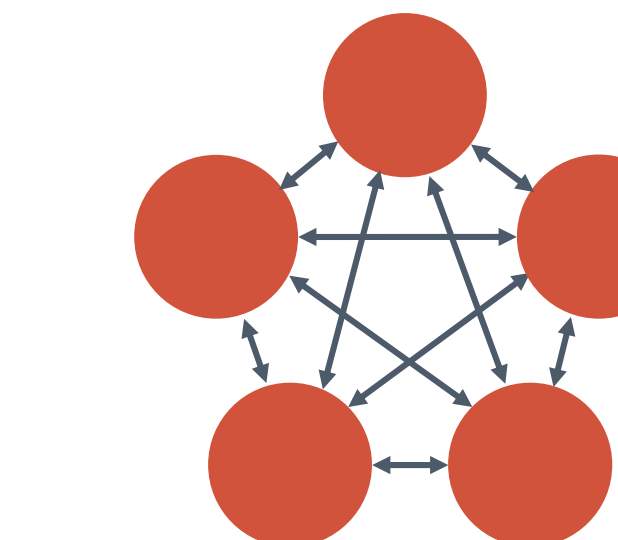
- Gradual convergence between homesigners and partners.
 - All 9 slopes of $HS-CP \text{ distance} = f(\text{year of testing})$ are negative (Wilcoxon Signed Rank, $W=0, p<.01$).
- But convergence not complete
 - 2011 HS-CP distances still significantly greater than 0; all tests significant ($W's \geq 91, p's \leq .001$).
- Cf. NSL, which conventionalized in <15 years⁴
 - 1978 – Deaf community formed in Managua
 - 1993 – 'standardization seminars' held in rest of Nicaragua to spread signs developed in Managua
- Because of NSL users' richer patterns of interaction?
 - Use agent-based model to test this hypothesis

Homesigners converge with respective partners, but not fully



AGENT-BASED MODEL

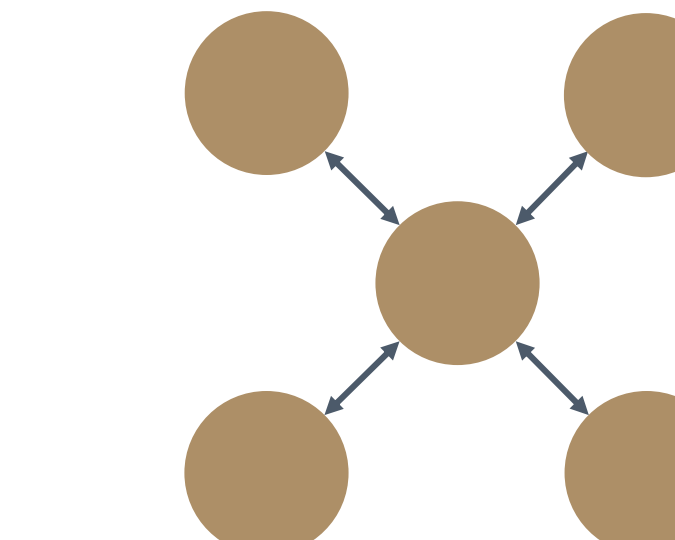
NSL-type agent interactive structure



Avg. # interaxns required(% simulations reaching convent w/in 2M interaxns)

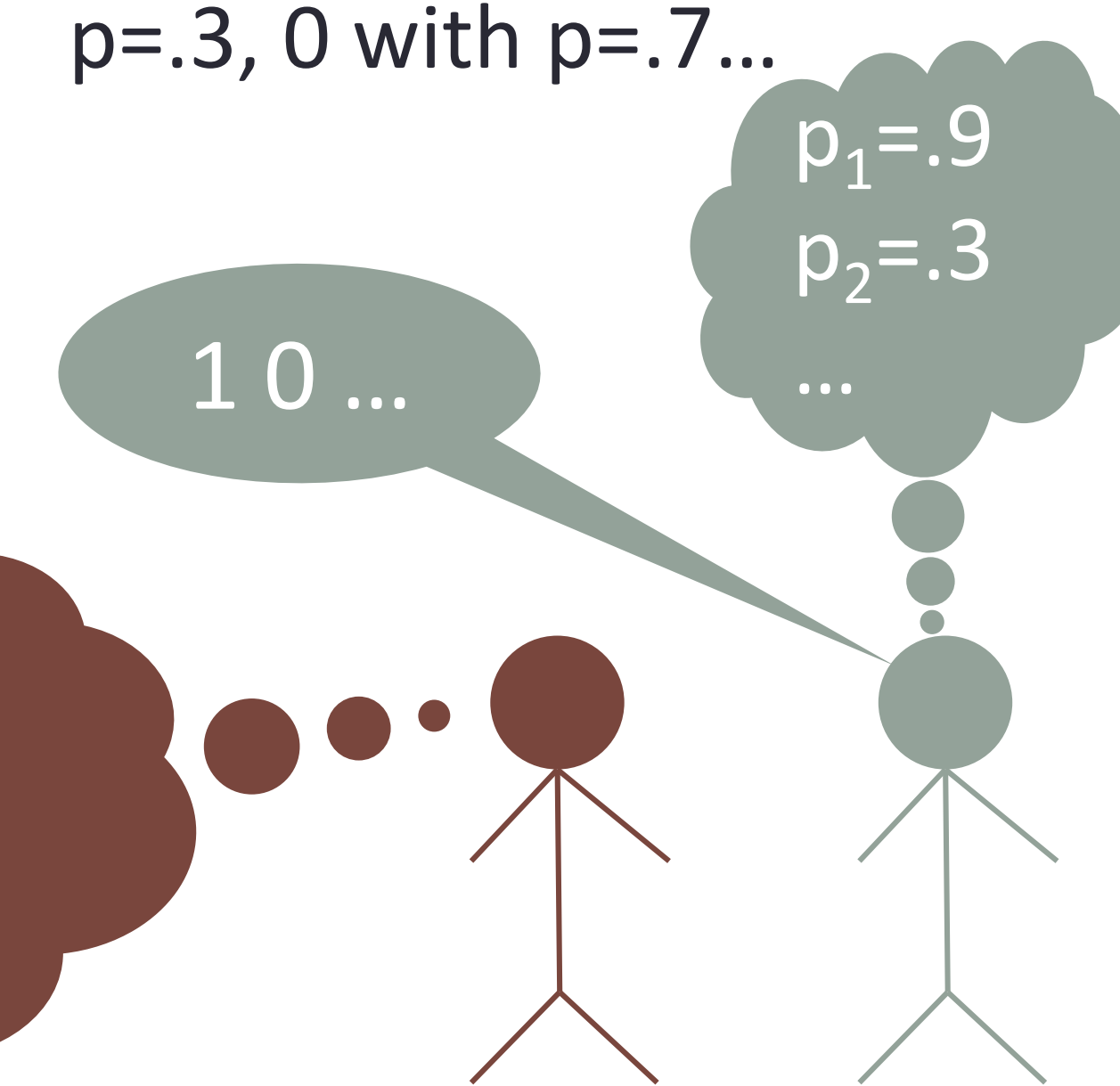
260K(100%)

Homesign-type agent interactive structure



698K (80%)

Agents have probabilistic belief about word pronunciation: vector of binary random variables:
 • E.g. CC#1 is 1 with $p=.9$, 0 with $p=.1$; CC#2 is 1 with $p=.3$, 0 with $p=.7$...



Convergence faster in NSL-type interactive structure

$$p_1' = p_1 + \gamma(1 - p_1)$$

$$p_2' = (1 - \gamma)p_2$$

...

CONCLUSION

Behavioral results: Homesign systems' lexicons are conventionalizing slower than did NSL's

Modeling results: Multi-agent reinforcement learning model suggests richer patterns of interaction among agents hasten conventionalization

More integration of computational, experimental, and naturalistic data will lead to unprecedented insight into language emergence