LANGUAGE EVOLUTION AND CHANGE FROM A SOCIAL NETWORKS PERSPECTIVE

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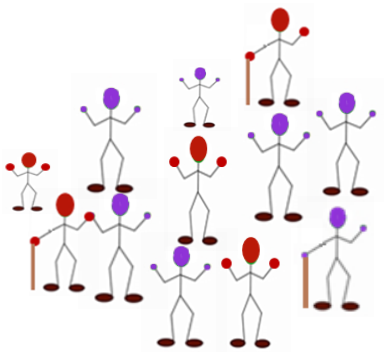
CLASP seminar

Dutch



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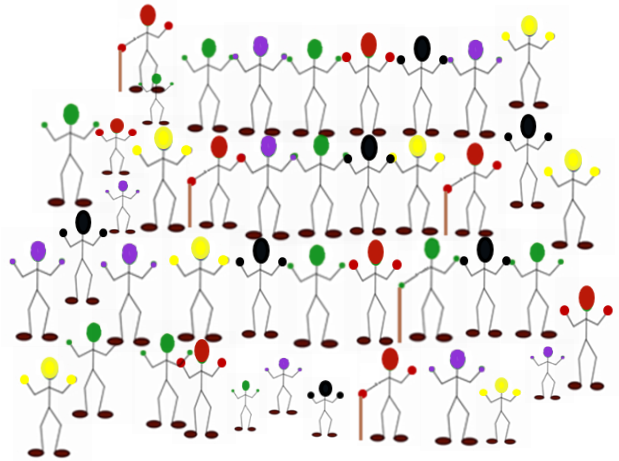

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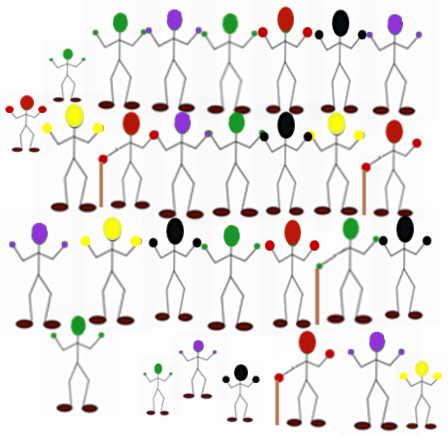

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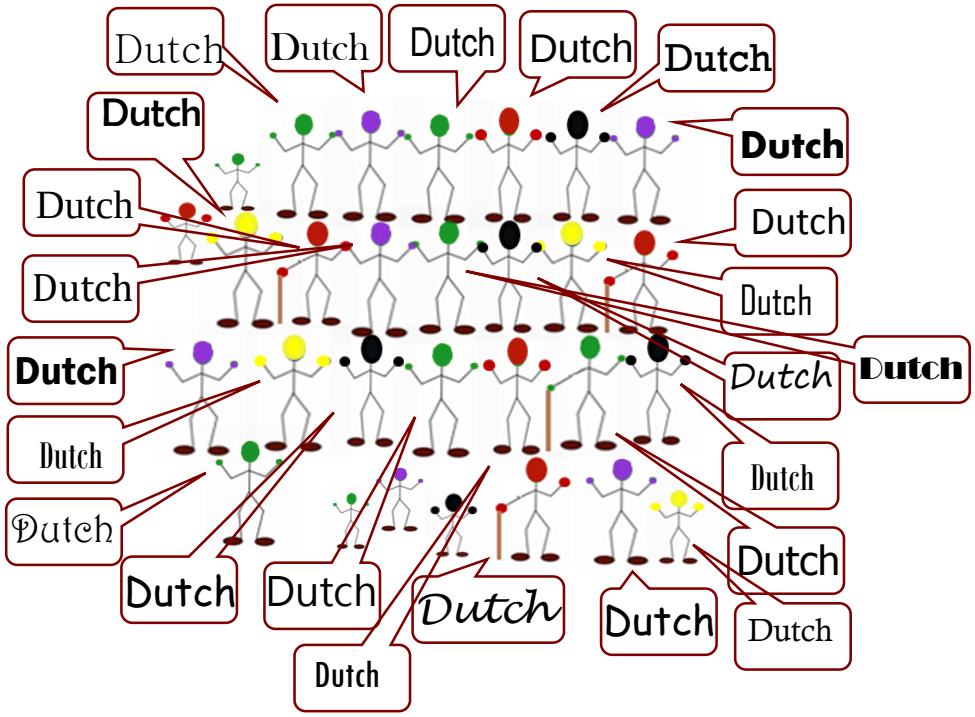
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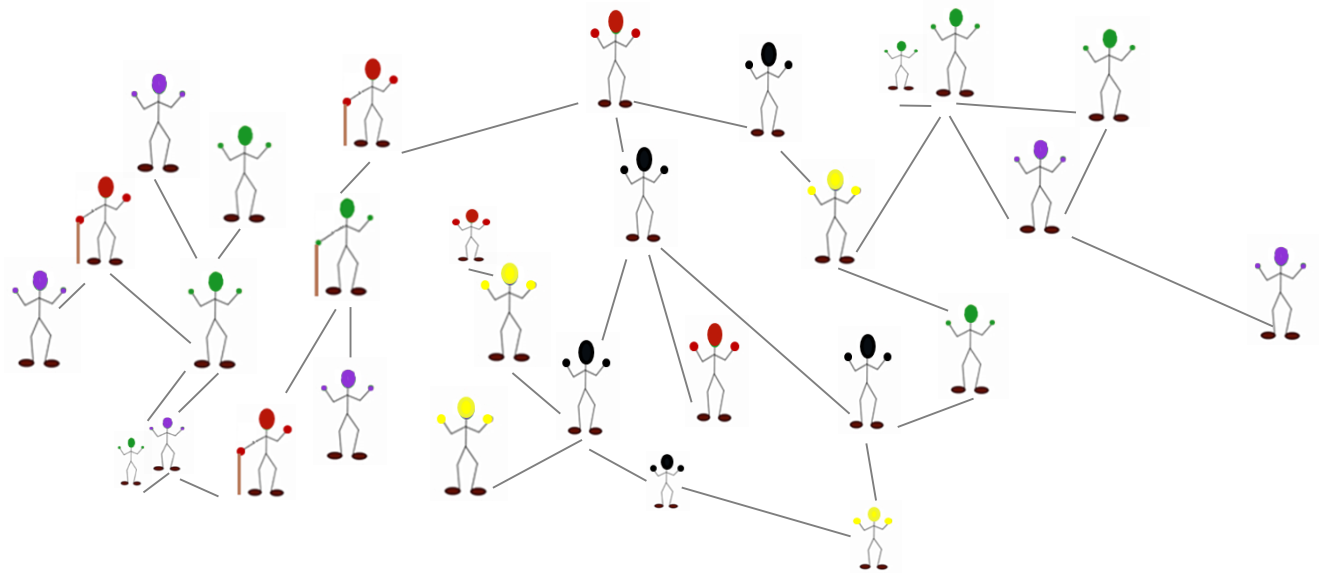


Community network structure influences how information travels

TODAY'S PLAN

- Community structure and language evolution
  - Study 1: Community size and emergence of compositionality
  - Study 2: Community size (& density) and categorization

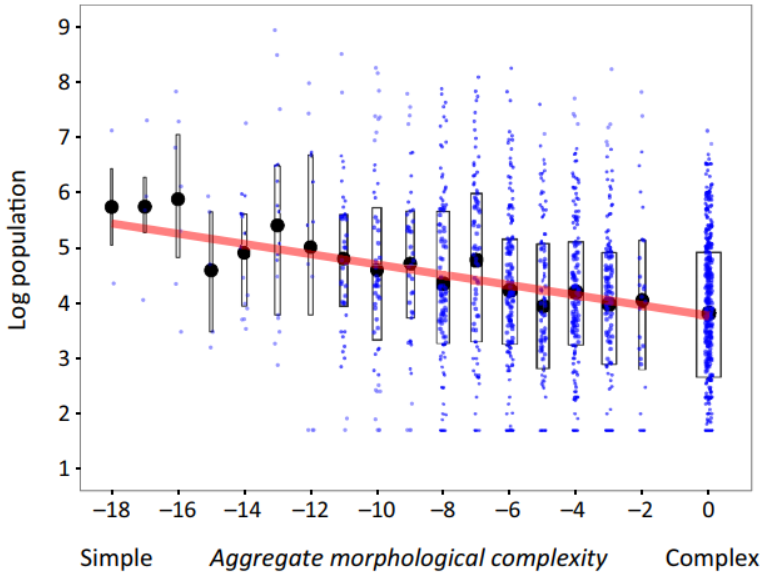
- Individuals' network properties and language change
  - Study 3: Individuals' network size and malleability
  - Study 4: Malleability and language change

DOES COMMUNITY SIZE INFLUENCE THE STRUCTURE OF THE COMMUNITY LANGUAGE?

LINGUISTIC NICHE HYPOTHESIS

Languages adapt to their (social) environment.

Languages spoken by more people have less complex morphology.



(Lupyan & Dale, 2016)

LINGUISTIC NICHE HYPOTHESIS

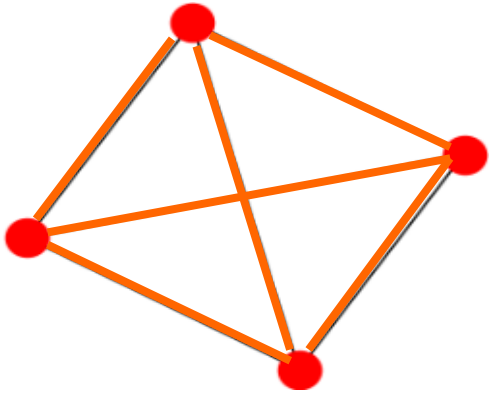
Why?

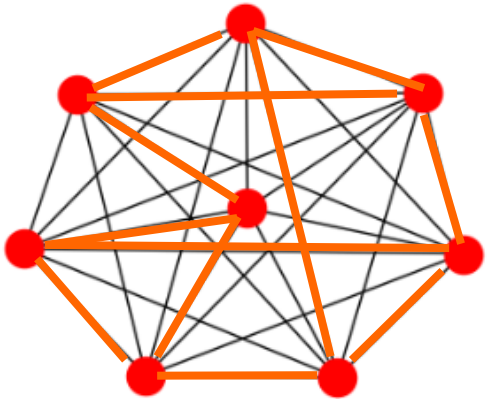
- Lupyan & Dale argued that # of speakers is a proxy for % of L2 speakers:
  Language needs to be simple because adult learners struggle with learning morphology
- Some evidence for the proposal
- But # of speakers alone might play a role – influences flow of information, ease of alignment, shared history

STUDY 1: EMERGENCE OF COMPOSITIONALITY

Groups of either 4 or 8 participants play in interchanging dyads

Limor Raviv





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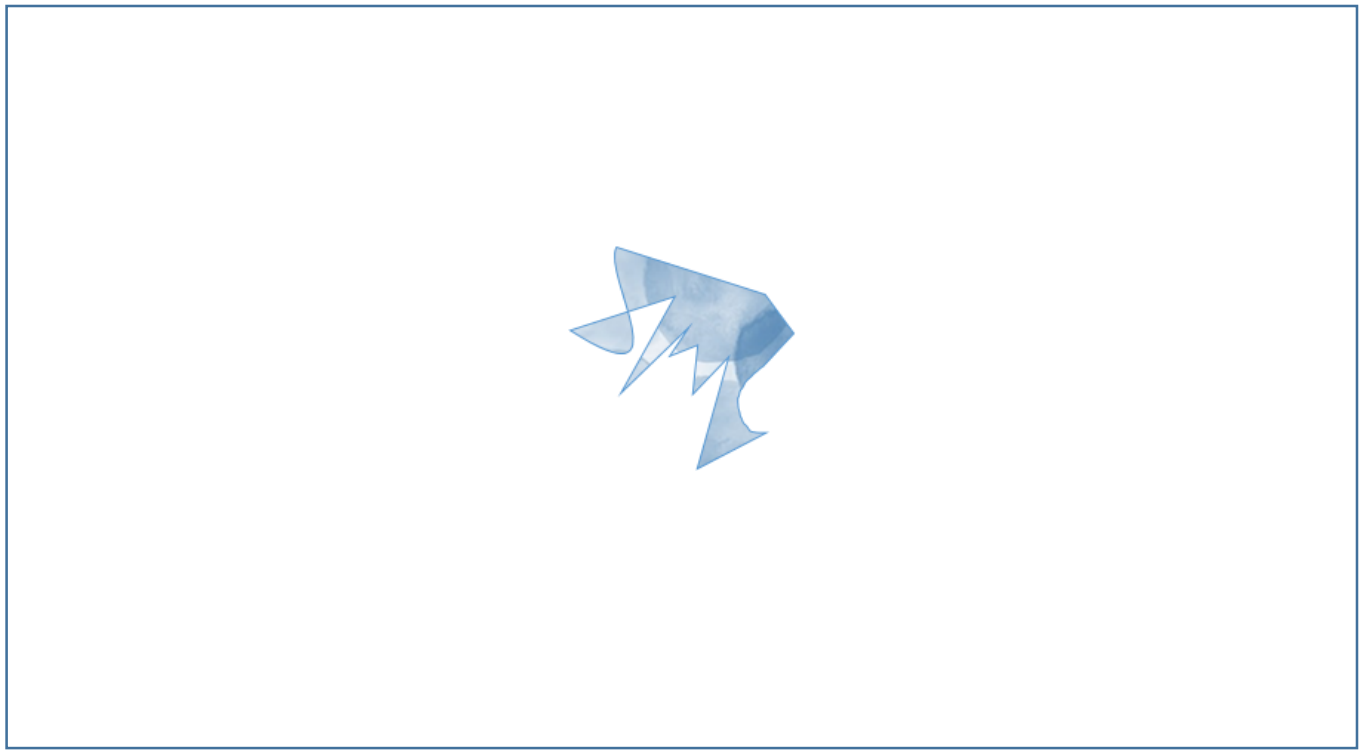
STUDY 1: EMERGENCE OF COMPOSITIONALITY



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STUDY 1: EMERGENCE OF COMPOSITIONALITY

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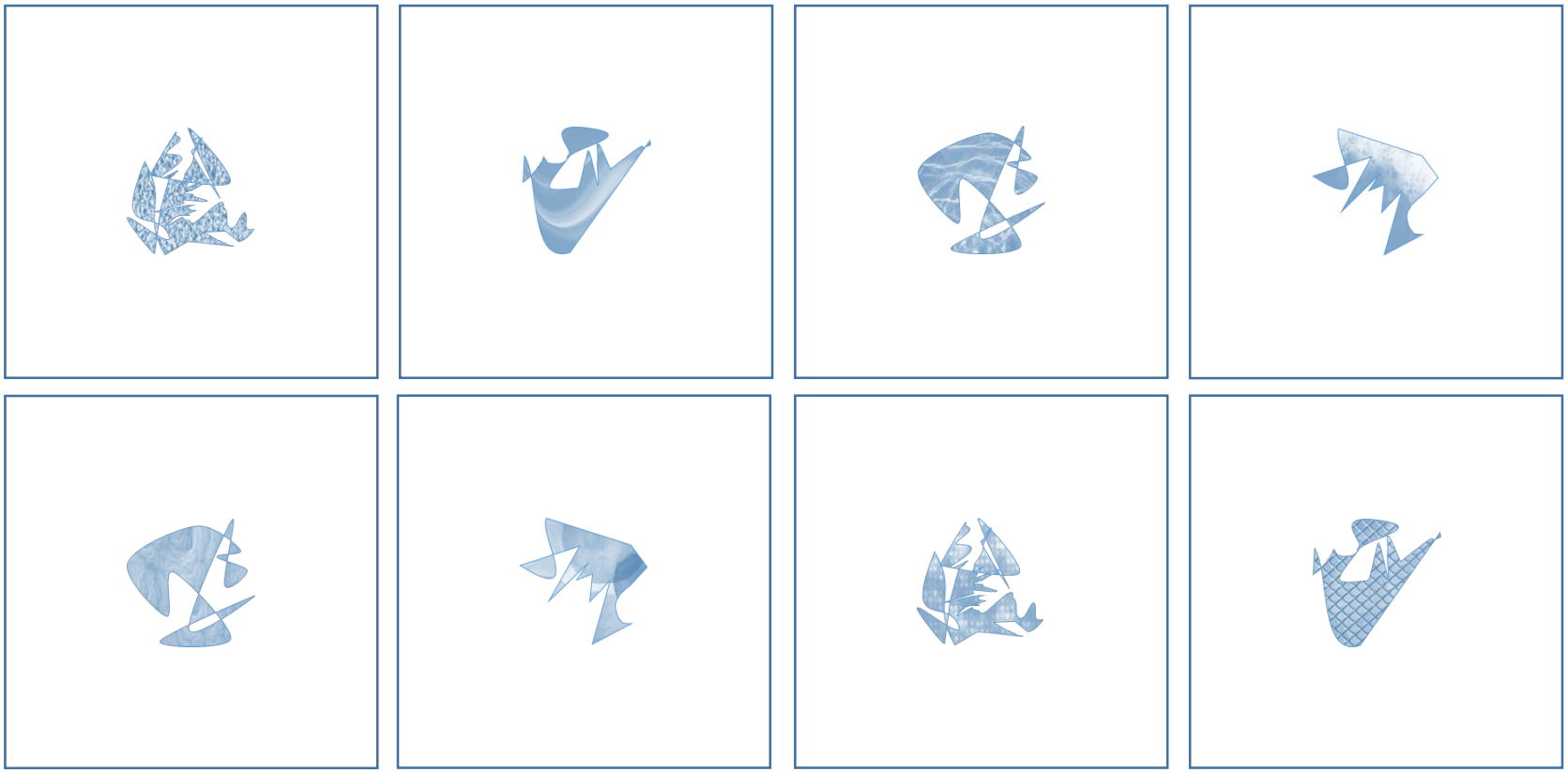

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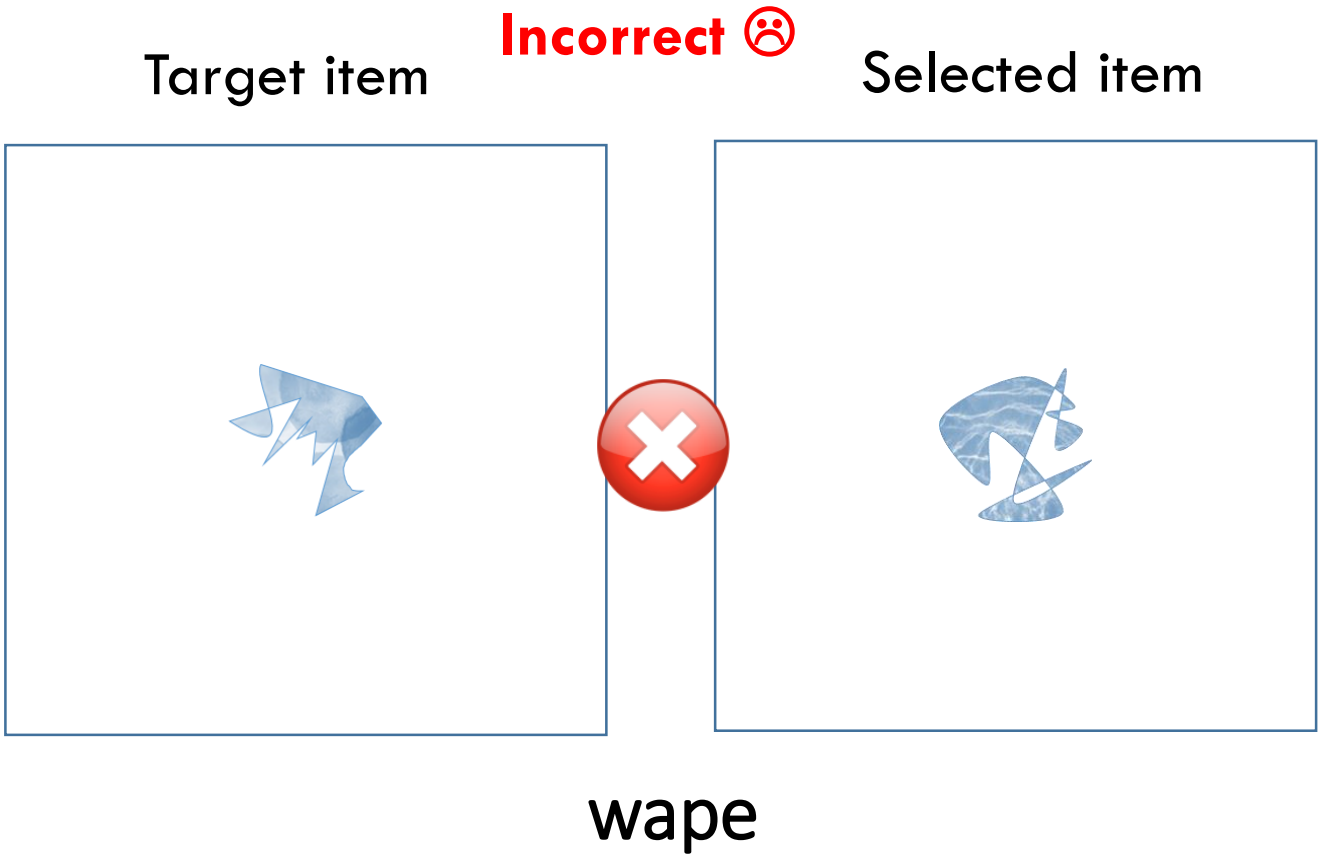

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STUDY 1: EMERGENCE OF COMPOSITIONALITY

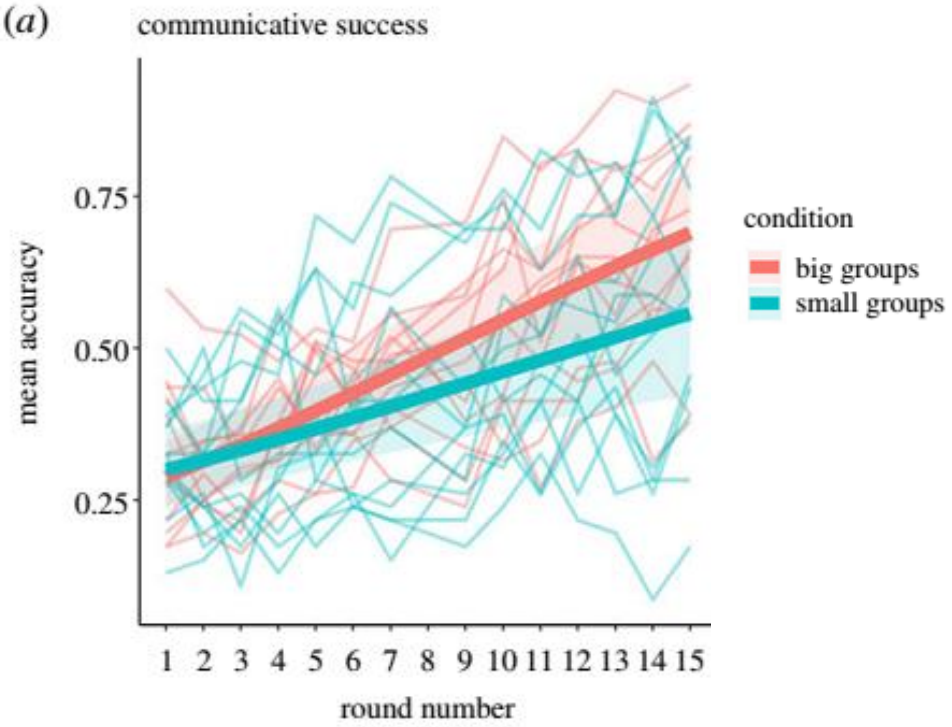
Measures:

- Accuracy
- Convergence
- Stability
- **Structure**

STUDY 1: EMERGENCE OF COMPOSITIONALITY

Accuracy

- Accuracy increased with time
- Small and large communities are equally successful even though members of larger communities interact less with each other member



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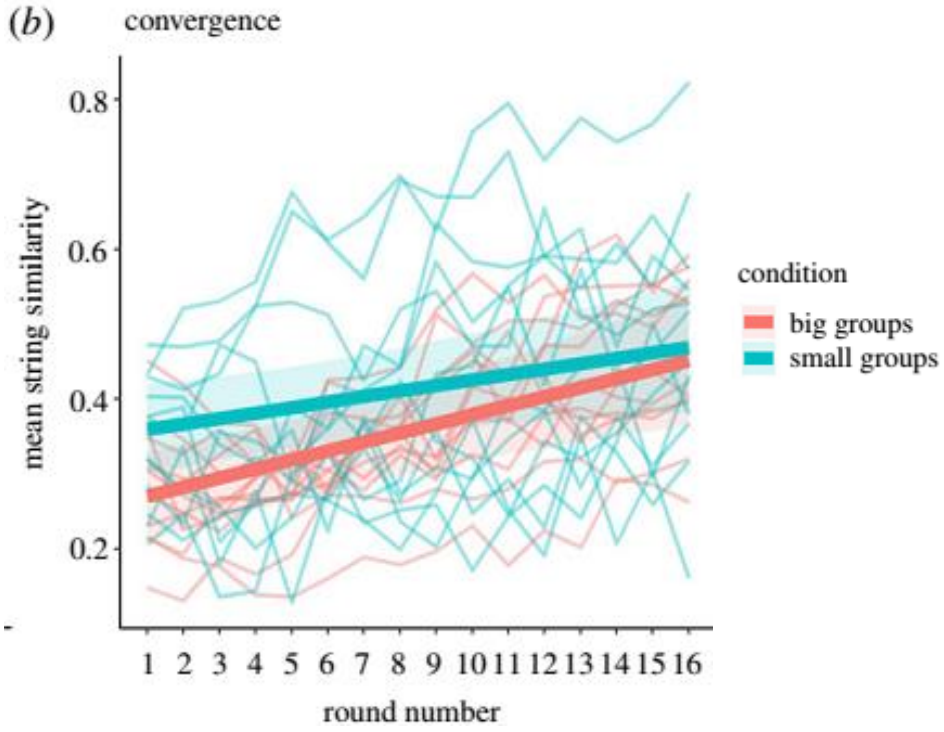
STUDY 1: EMERGENCE OF COMPOSITIONALITY

Convergence

- Measures how aligned the speakers are
- Convergence increased with time
- Small and large communities are equally converged by the end even though members of larger communities interact less with each other member



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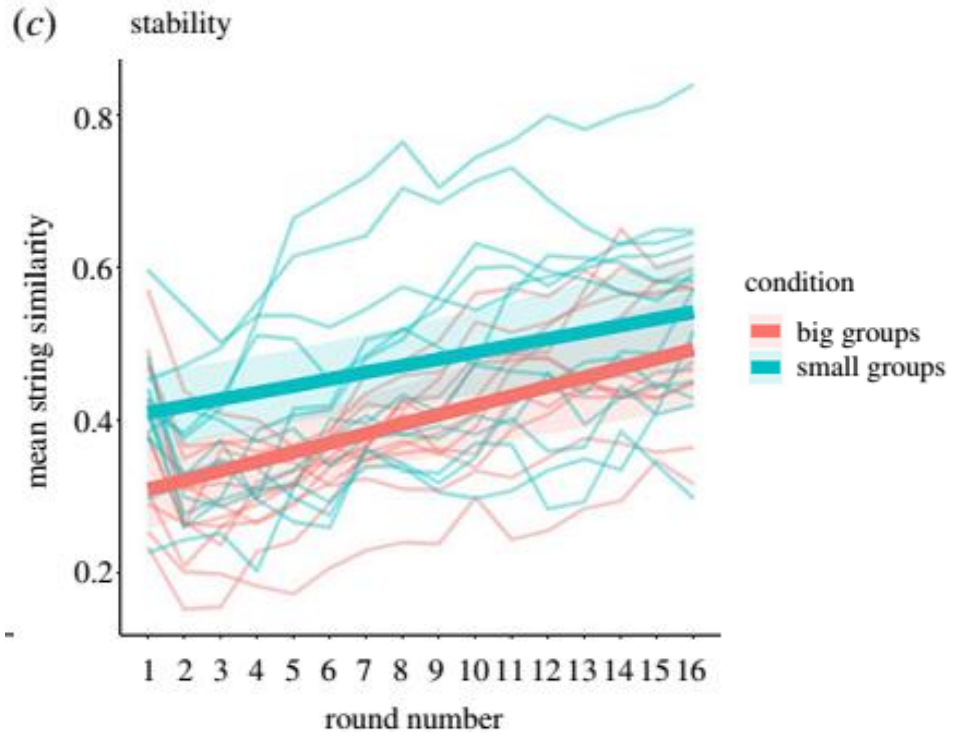
STUDY 1: EMERGENCE OF COMPOSITIONALITY

Stability

- Measures stability of the language across rounds
- Stability increased with time
- Small and large communities have equal stable languages by the end



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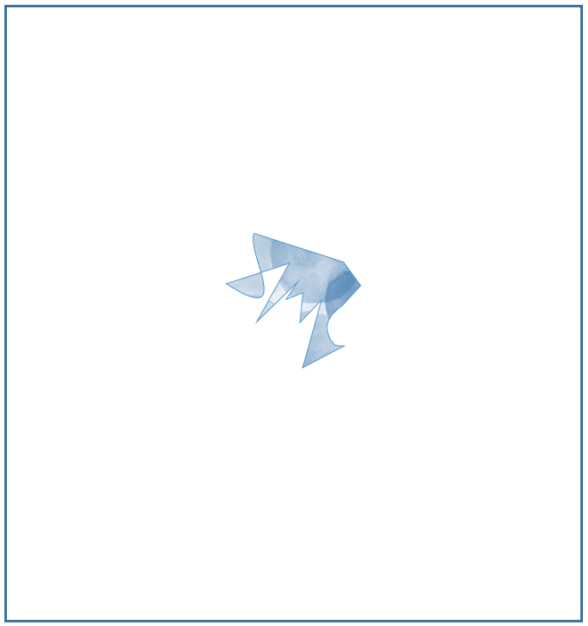
STUDY 1: EMERGENCE OF COMPOSITIONALITY

Structure

Are similar meanings expressed more similarly than distant meanings?



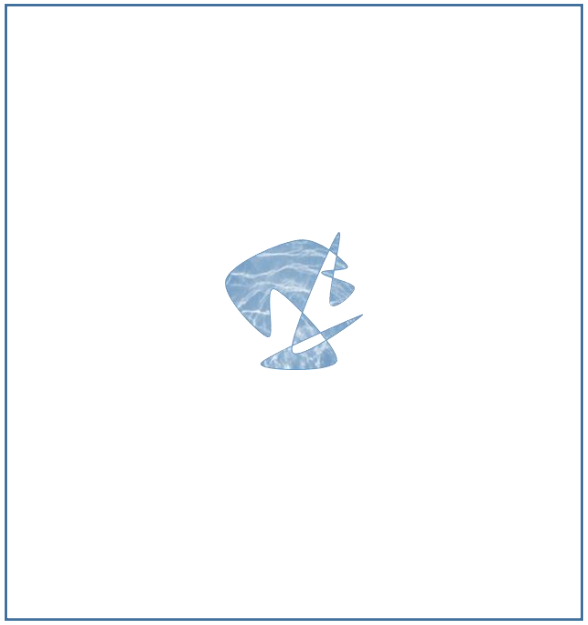
TAWE

Semantic distance=1.5

Shape: 1
(diff=1, same=0)
Angle: 0.5
(90° out of max 180°)

Linguistic distance=0.75

Normalized Lev. distance
(3 changes / 4 characters)



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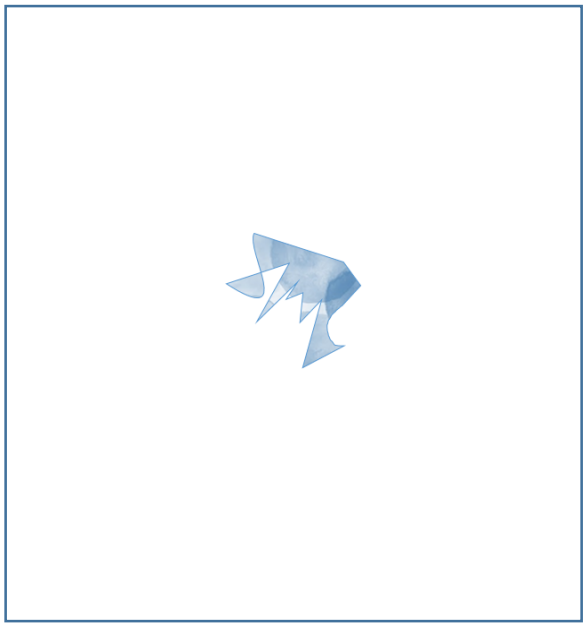
STUDY 1: EMERGENCE OF COMPOSITIONALITY

Structure

Are similar meanings expressed more similarly than distant meanings?



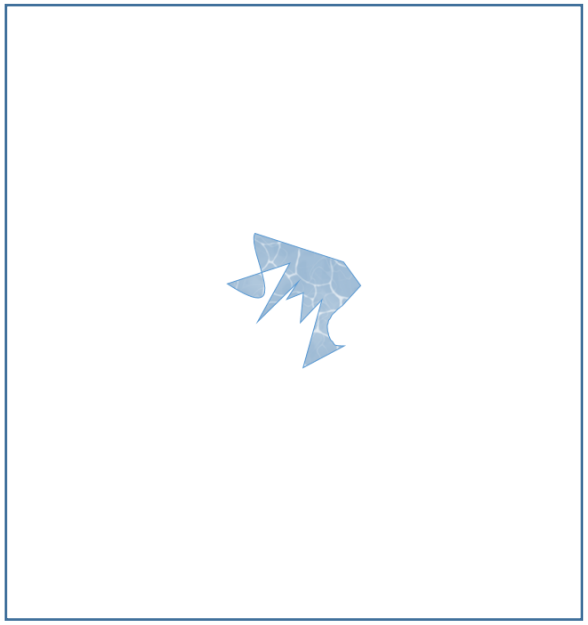
TAWE

Semantic distance=0.25

Shape: 0
(diff=1, same=0)
Angle: 0.25
(45° out of max 180°)

Linguistic distance=0.25

Normalized Lev. Distance
(1 change / 4 characters)



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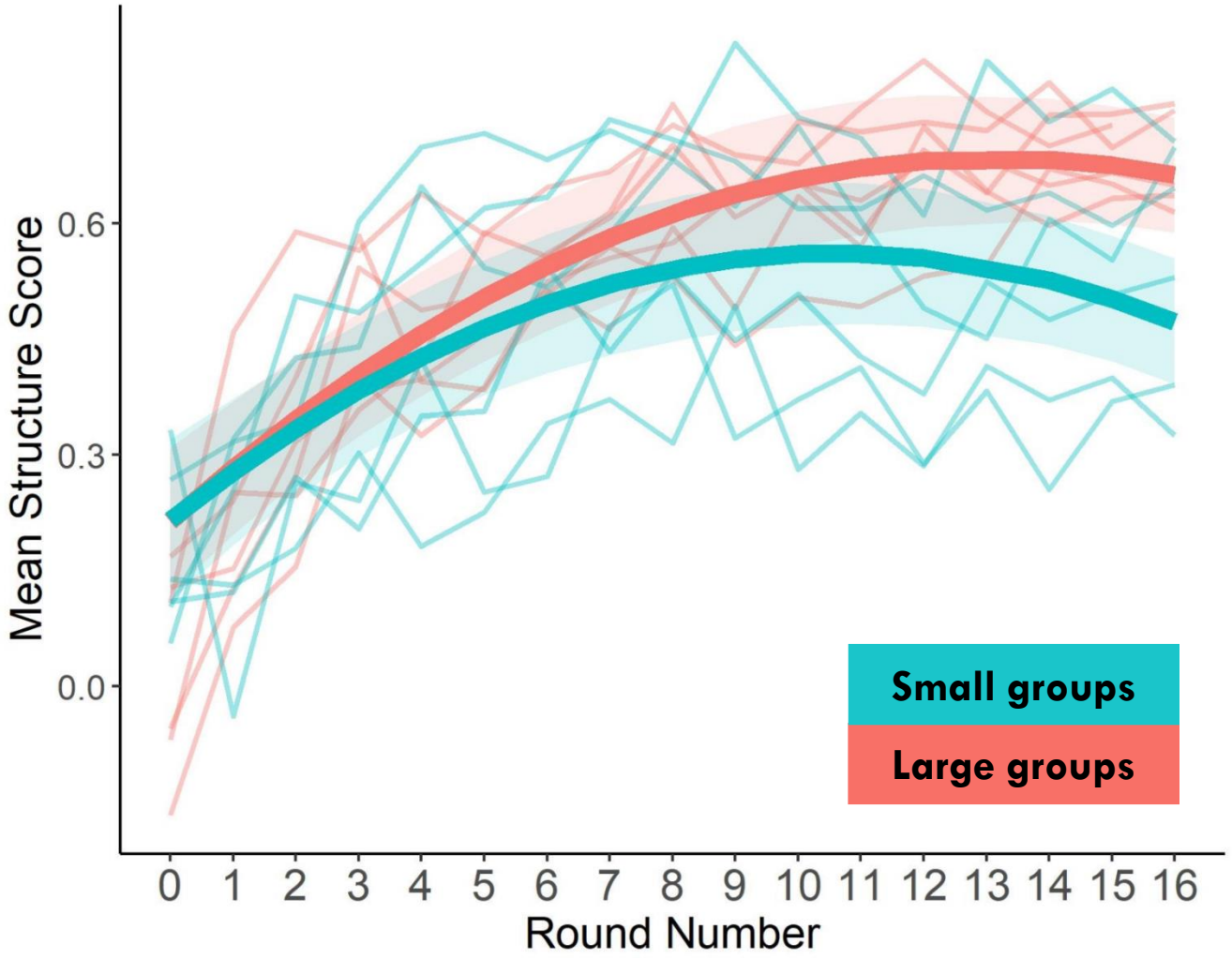
STUDY 1: EMERGENCE OF COMPOSITIONALITY



Larger groups create more structured languages

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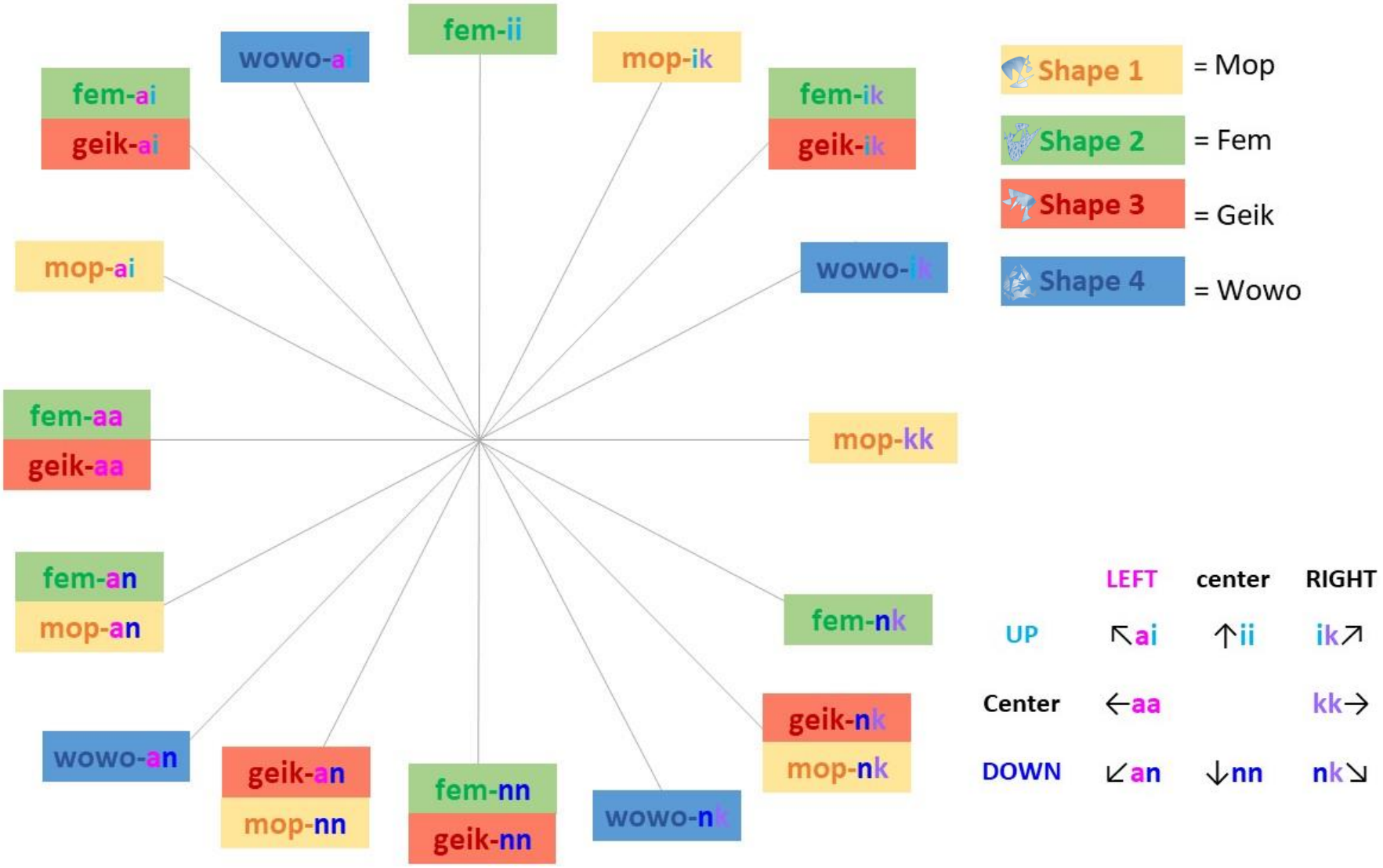

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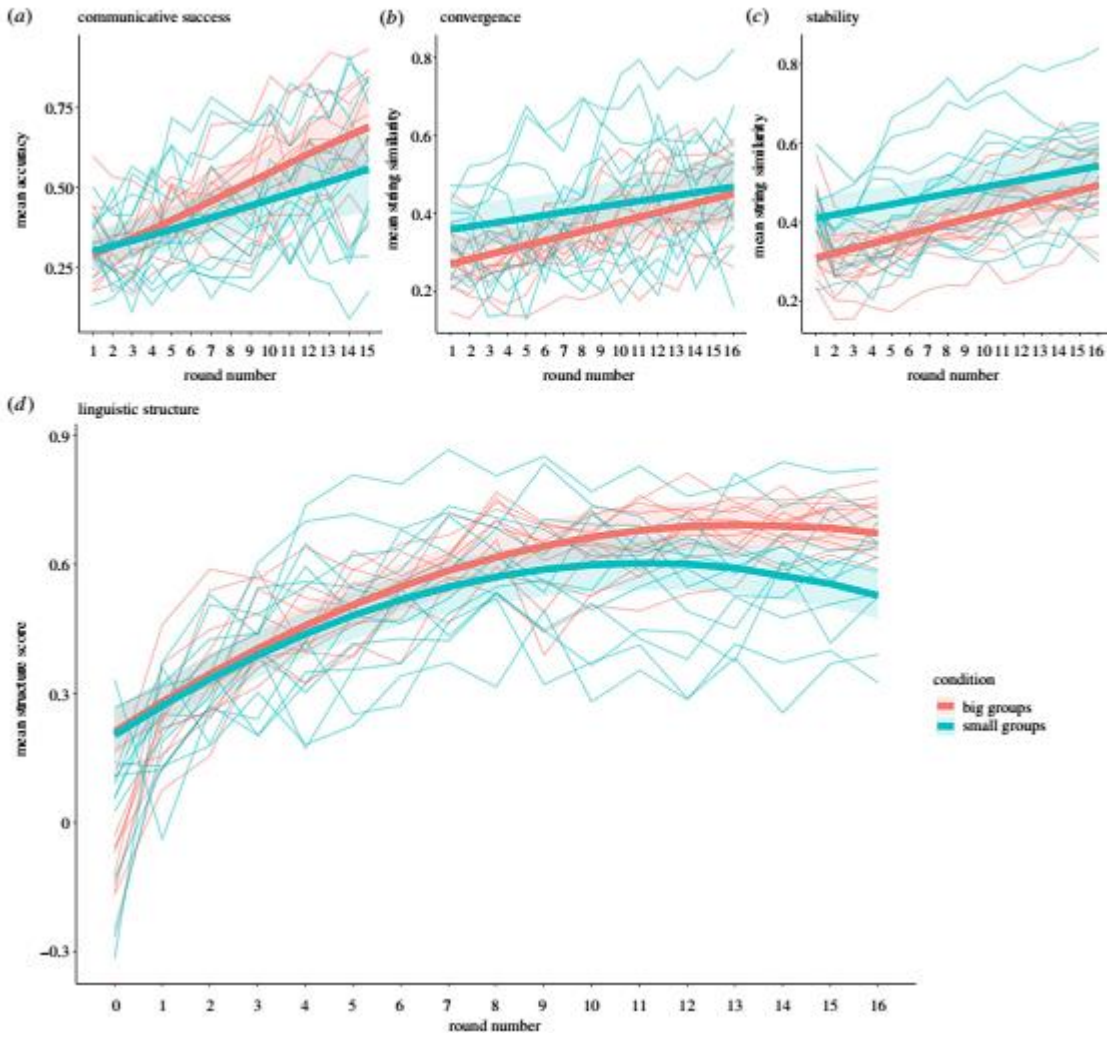
STUDY 1: EMERGENCE OF COMPOSITIONALITY



- For all measures, smaller communities are more variable
- Are small communities more vulnerable to drift?

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STUDY 1: EMERGENCE OF COMPOSITIONALITY

Why?

- We create structure in the input as a result of learning and memory biases, and to enable productivity (e.g., Kirby, Cornish & Smith, 2008).
- Larger communities exhibit greater variability – also in Study 1
- The greater input variability in a round, the greater the increase in structure in the next round

STUDY 1: EMERGENCE OF COMPOSITIONALITY

Conclusions

- Cross-linguistic differences in morphological complexity might be due to differences in community size
- The emergence of grammar might have been promoted by an increase in community size
- Languages of larger communities might be more similar to each other than languages of smaller communities

DOES COMMUNITY STRUCTURE INFLUENCE THE COMMUNITY'S CATEGORIZATION SYSTEM?

STUDY 2: CATEGORIZATION

- Languages differ in how granular their categories are

- The granularity of the categories can influence performance
  - Making more distinctions facilitates perception, enhances memory, influences inferences

STUDY 2: CATEGORIZATION

In the animal kingdom:

- Primates that live in larger groups have larger call repertoire (McComb & Semple, 2005)
- Community complexity correlates with the size of call repertoire in marmots (Blumstein & Armitage, 1997)
- Colony size correlates with call complexity in both bats (Wilkinson, 2003) and chickadees (Freeberg, 2006)

In humans:

- Phonological inventory correlates with community size (debated) (Hay & Bauer, 2007)

STUDY 2: CATEGORIZATION

- Would larger communities have more categories similarly to the correlation between size and call repertoire?

OR

- Would larger communities have fewer categories because it's simpler?

- Would larger communities have better structured categories?

- Would sparsity play the same role as size?

STUDY 2: CATEGORIZATION

Agent-based models

- Communities of 100 (small) or 200 (large) members
- Scale-free structure
- Sparse vs dense (m= 20 / 50)
- 50,000 rounds (enough for stabilization)
- Meaning space: 20 x 20 grid

STUDY 2: CATEGORIZATION

Communication round:

- Each agent interacts with someone from their network
- A meaning (cell) is randomly selected for communication
- Producer searches past history for a label for that cell.
  If none exists, selects label used for closest meaning.
  If none exists, generates a string of 3 random phonemes.
- Addressee interprets label according to past experience with label weighted by past success (S) of label for that meaning

$$x = \frac{\sum_{i=1}^{k} x_i * s_i}{\sum s} \; ; \quad y = \frac{\sum_{i=1}^{k} y_i * s_i}{\sum s}$$

If no experience with past label, select meaning farthest from any label (mutual exclusivity principle)

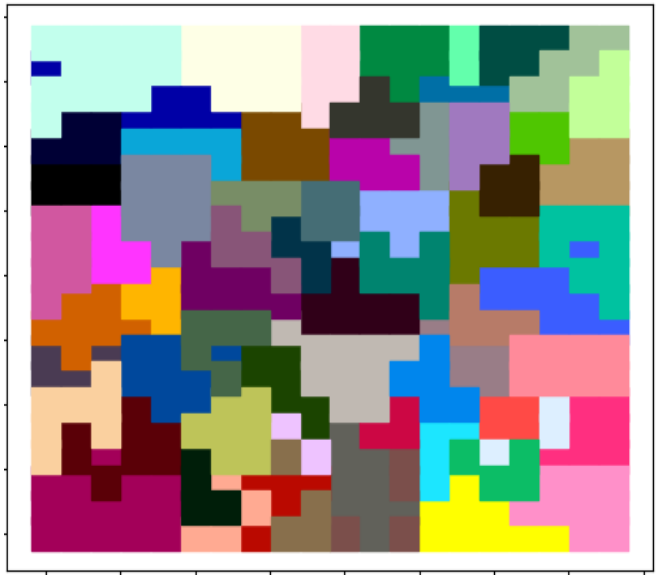
STUDY 2: CATEGORIZATION

Communication round cont'd:

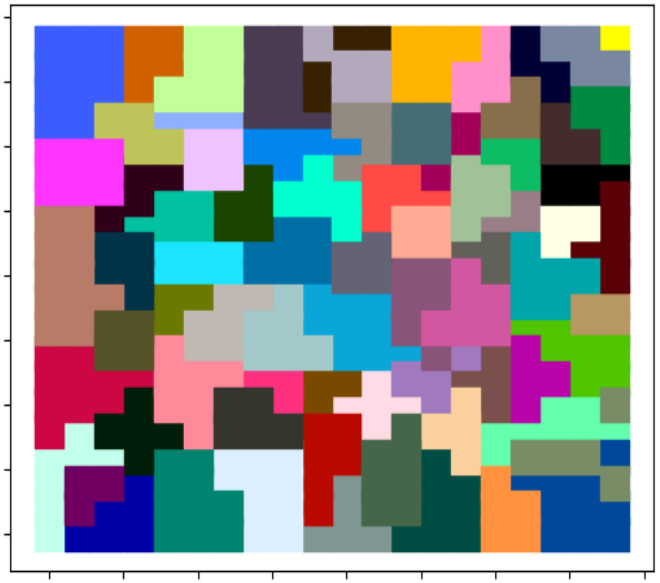
- Dyad members receive a score for their success according to distance between intended and selected meanings

$$S = 1 - \frac{\sqrt{(x_c - x_{i)}{}^2 + (y_c - y_{i)}{}^2}}{\max Distance}$$

STUDY 2: CATEGORIZATION



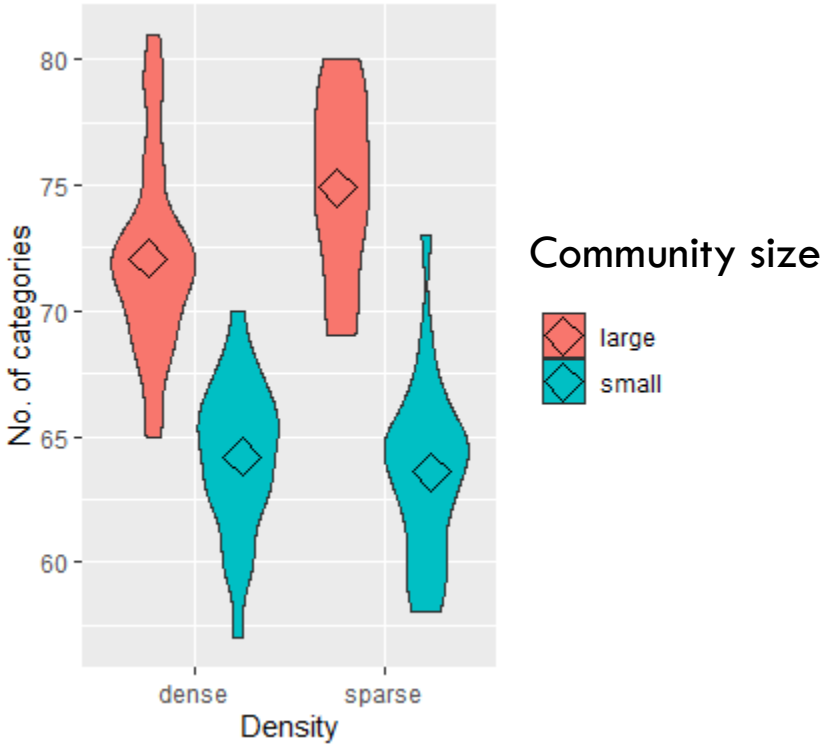
Typical small community



Typical large community

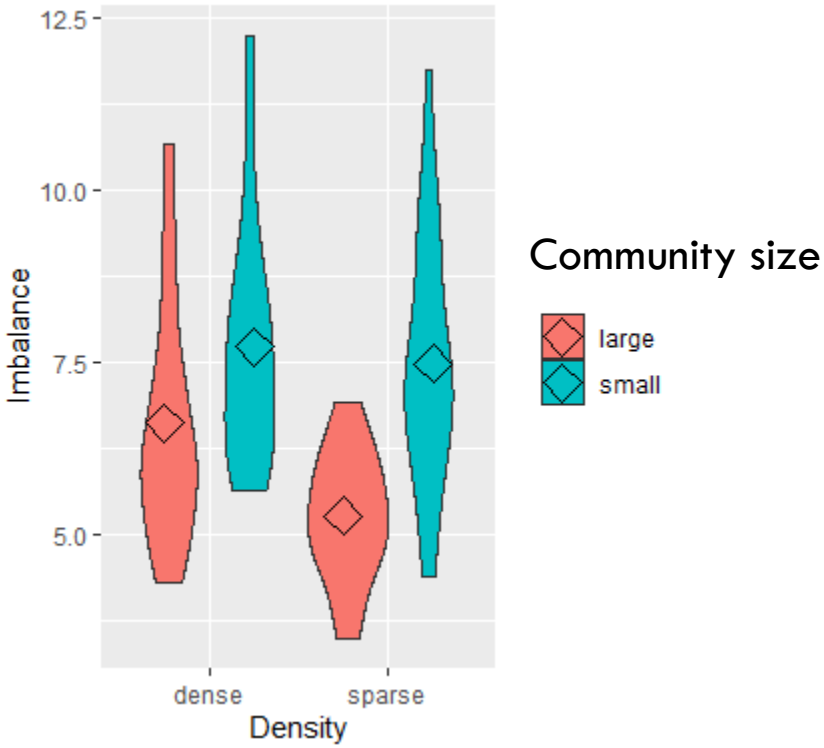
STUDY 2: CATEGORIZATION

- Larger communities created more categories
- Density had a small effect but only in the larger communities



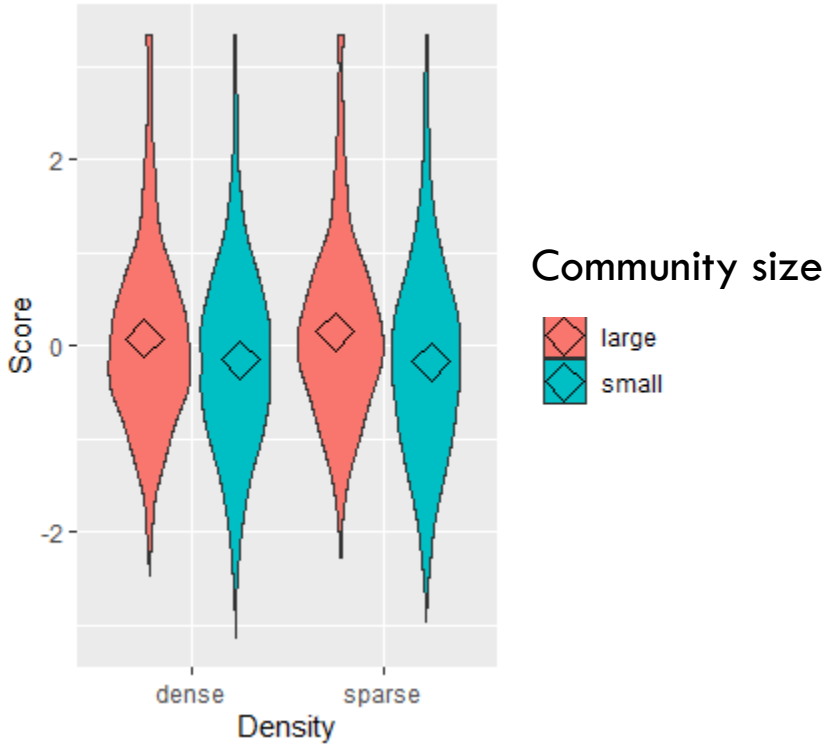
STUDY 2: CATEGORIZATION

- Larger communities created better structured categories (more balanced)
- Density increased imbalance, but only for larger communities



STUDY 2: CATEGORIZATION

- Larger communities communicated more successfully
- Sparsity increased communicative success but only for larger groups

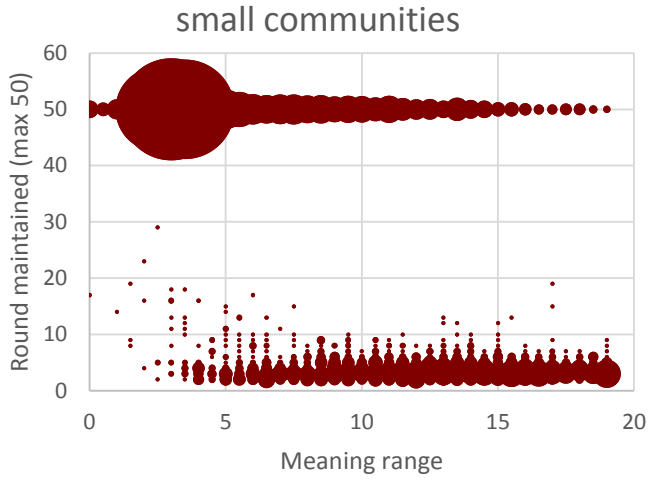


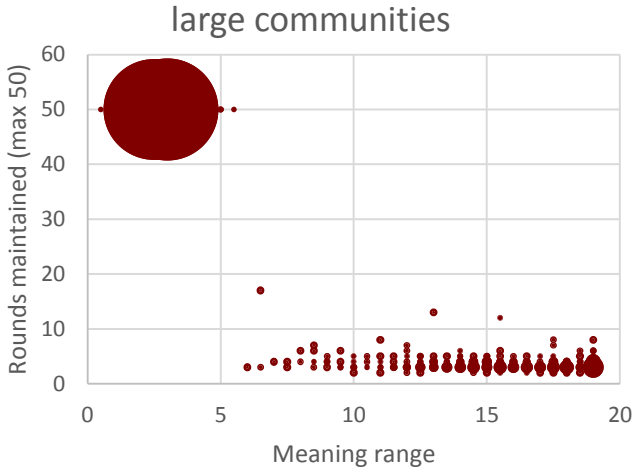
STUDY 2: CATEGORIZATION

Why?

- Larger communities experienced greater obstacles for diffusion
  - A lower proportion of generated labels spread to the entire community
  - Members of larger communities had lower overlap in the meaning they gave a label
- These obstacles imposed greater pressure for label meanings to narrow which enabled more granular distinctions

STUDY 2: CATEGORIZATION





Analyses confirmed:

Larger communities ➡ lower meaning overlap ➡

greater narrowing of category meaning ➡

higher likelihood of maintaining label (enabling more labels eventually)

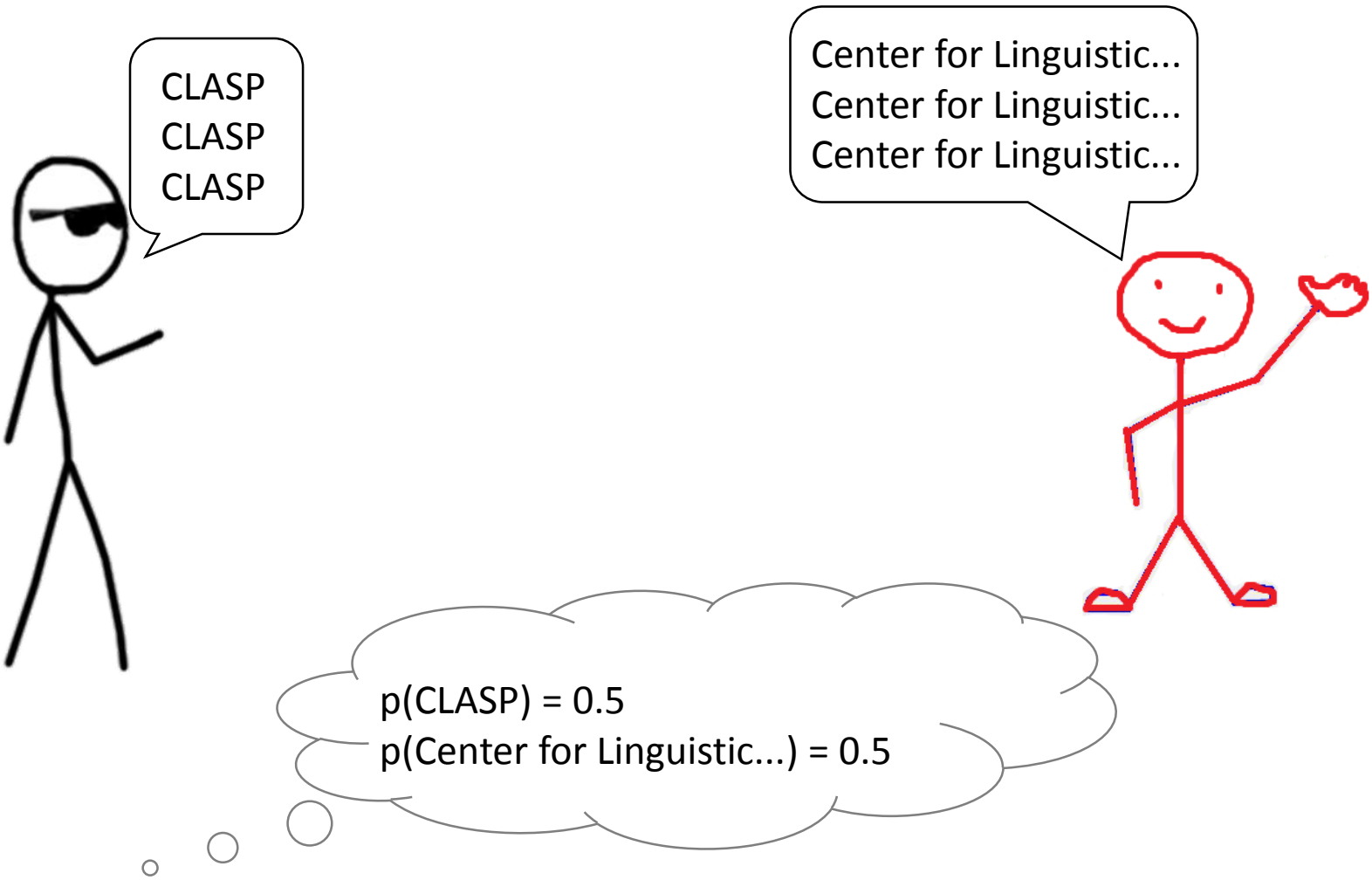
CONCLUSION

- Community structure, especially size, can influence the language that the community develops
- The greater difficulties that larger communities experience (higher variability, harder to diffuse information) end up promoting the emergence of more efficient systems
- Differences in community structure might explain both cross-linguistic differences and how societal changes might have promoted language evolution

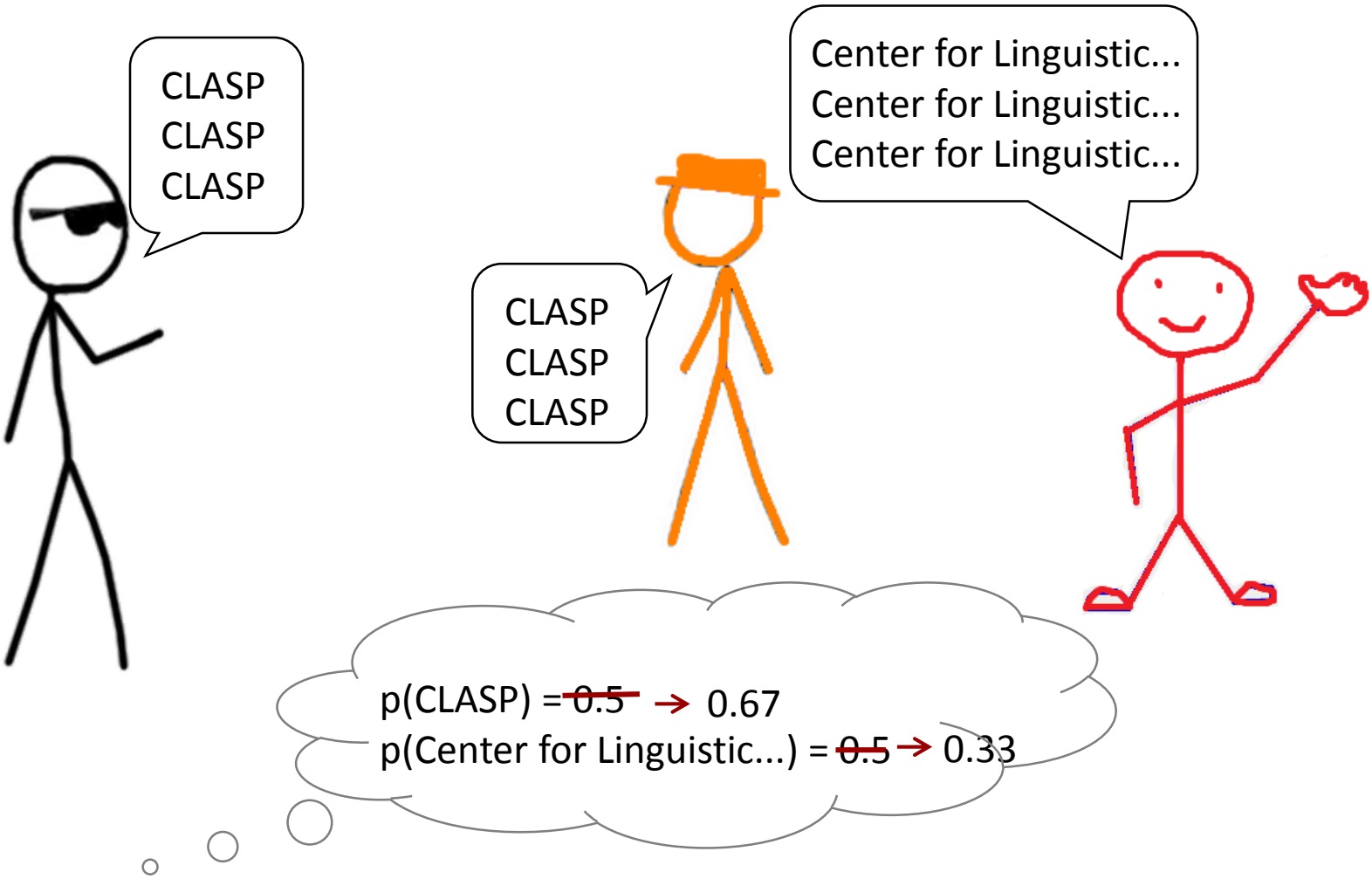
ZOOMING IN ON THE INDIVIDUAL

- Communities are comprised of individuals
- Individuals are the agents of change
- Understanding individuals' behavior and biases can contribute to understanding how phenomena emerge

SOCIAL NETWORK SIZE AND MALLEABILITY



SOCIAL NETWORK SIZE AND MALLEABILITY



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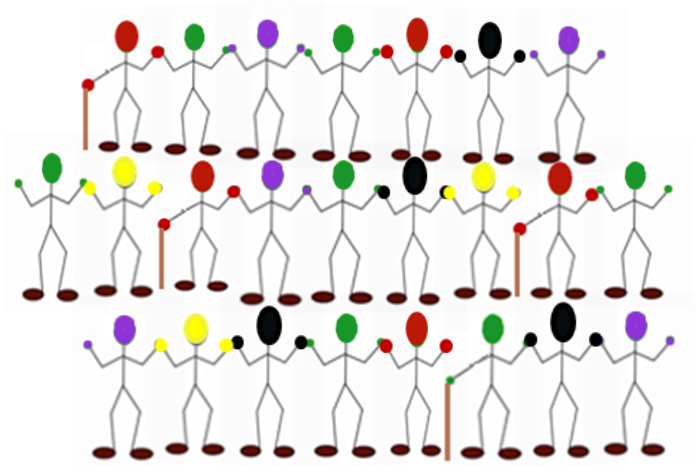


There is an inverse relationship between sample size and the weight given to any source

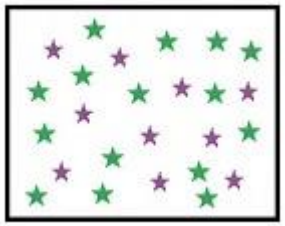
CLASP
CLASP
CLASP

p(CLASP) = ~~0.5~~ → 0.52
p(Center for Linguistic...) = ~~0.5~~ → 0.48

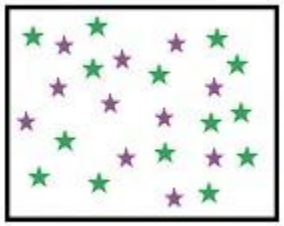
STUDY 3: SOCIAL NETWORK SIZE AND MALLEABILITY

Social network measure: How many people do you talk to in a typical week?

Baseline:



some of the stars are purple



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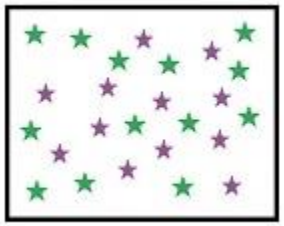

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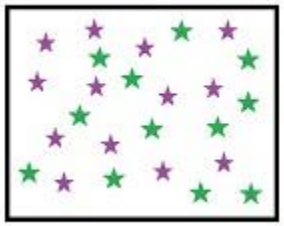

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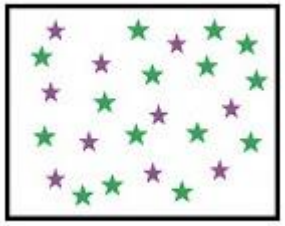
Exposure:



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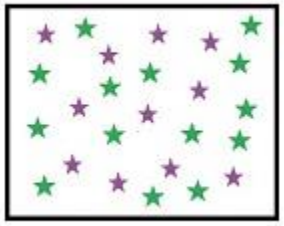

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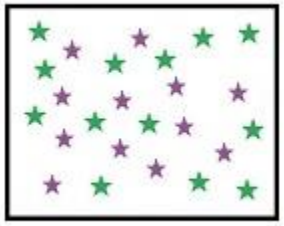

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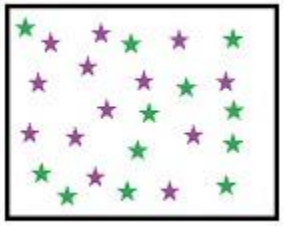


many of the stars are purple

STUDY 3: SOCIAL NETWORK SIZE AND MALLEABILITY

Prediction task

Predict array description (some / many) for:

- Same speaker: Tests learning of speaker's lexical boundary
- New speaker: Tests generalization of learned boundary

Prediction: Larger social networks should decrease generalization, but not ability to learn lexical pattern

Production task

Describe new star arrays

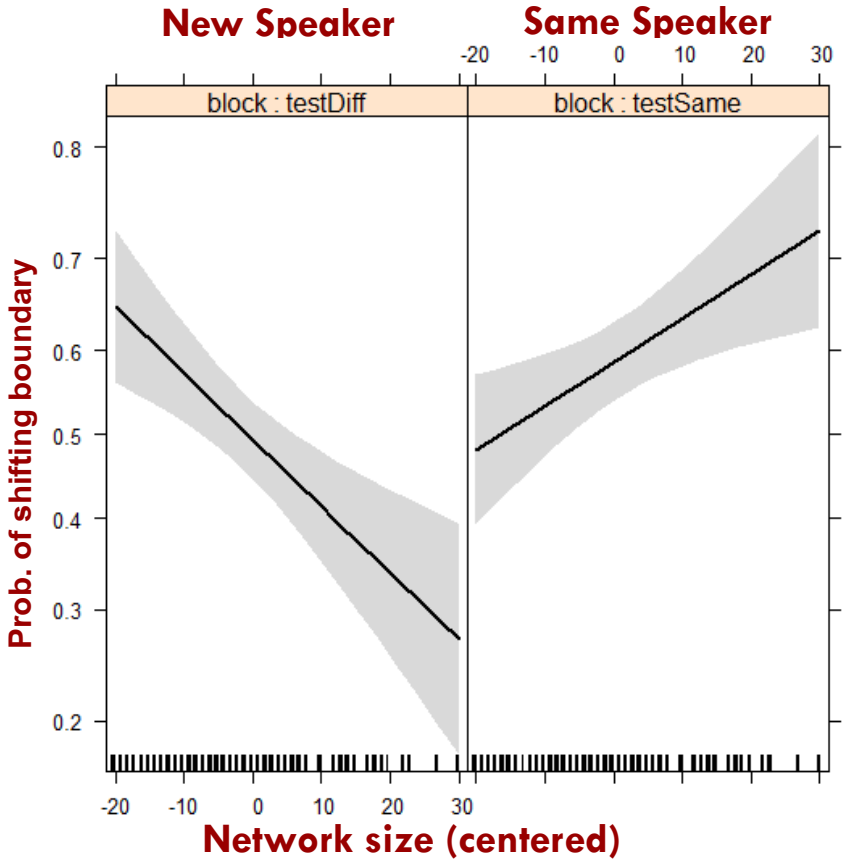
Prediction: Larger social networks should decrease adaptation in production

STUDY 3: SOCIAL NETWORK SIZE AND MALLEABILITY

Prediction task

Social network size x Speaker

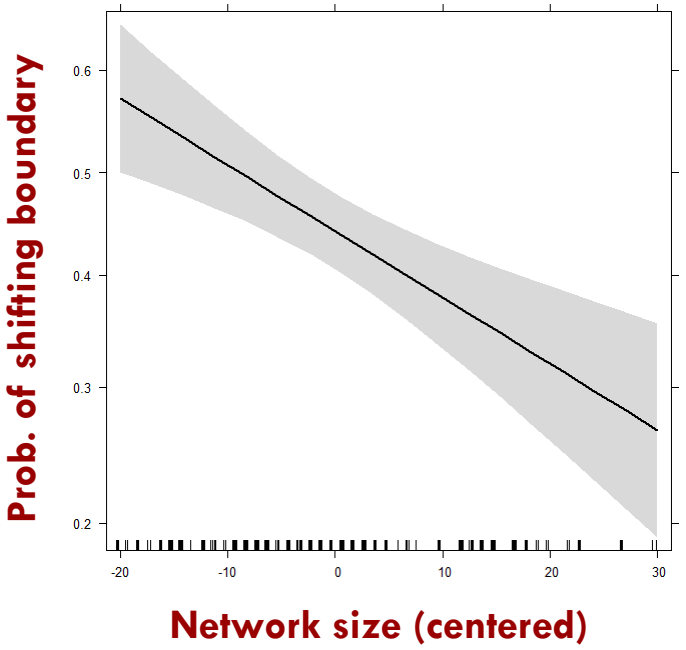
Participants with larger social networks were less likely to generalize the learned boundary to a new speaker, even though they were as likely to learn the speaker's lexical boundary



STUDY 3: SOCIAL NETWORK SIZE AND MALLEABILITY

Production task

Participants with larger social networks were less likely to shift their lexical boundary



STUDY 3: SOCIAL NETWORK SIZE AND MALLEABILITY

- Individuals with smaller network size have more malleable representations.
- The effect is specific to the New Speaker condition, minimizing the possibility that it's due to ability to do the task or approach to the task.
- I propose that this is because the informativity of each speaker is in reverse relation to the sample size.
- Converging evidence:
  - phonological boundary: /d/-/t/ [Lev-Ari (2017) *PlosOne*]
  - Twitter hashtag use [Monster & Lev-Ari (2018) *Cognitive Science*]

COULD THIS MEAN THAT PEOPLE WITH SMALLER SOCIAL NETWORKS ARE IMPORTANT FOR THE PROPAGATION OF LINGUISTIC CHANGE?

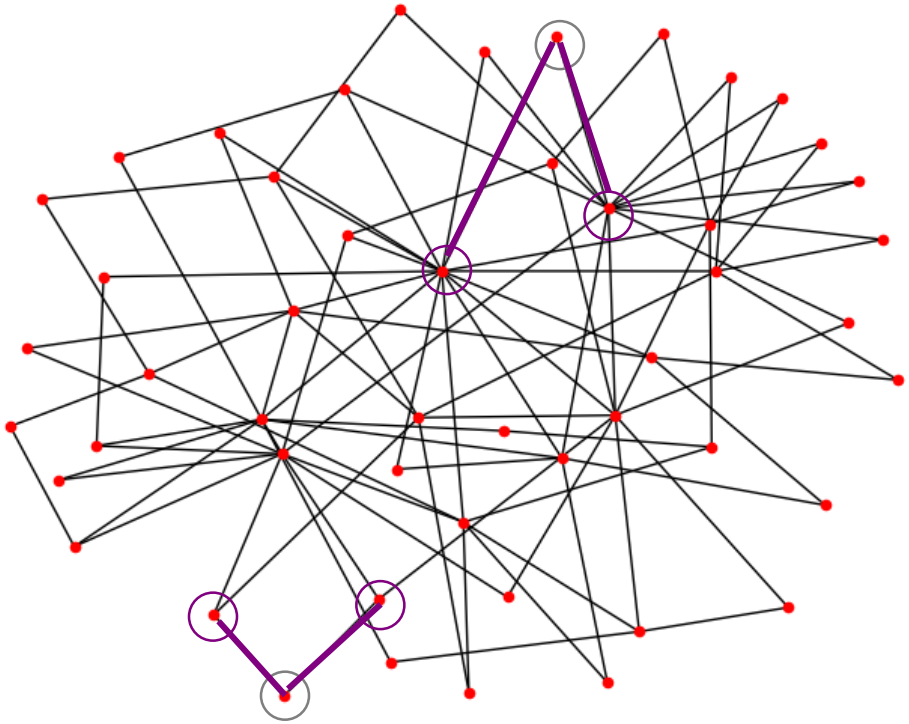
STUDY 4: SIMULATING LANGUAGE CHANGE

Scale-free communities of 1000 producing /ɑ/ and /a/

10 innovators with vowel merge (only /ɑ/)

Innovators have neighbors with small/large social networks

innovator with neighbors with large social networks

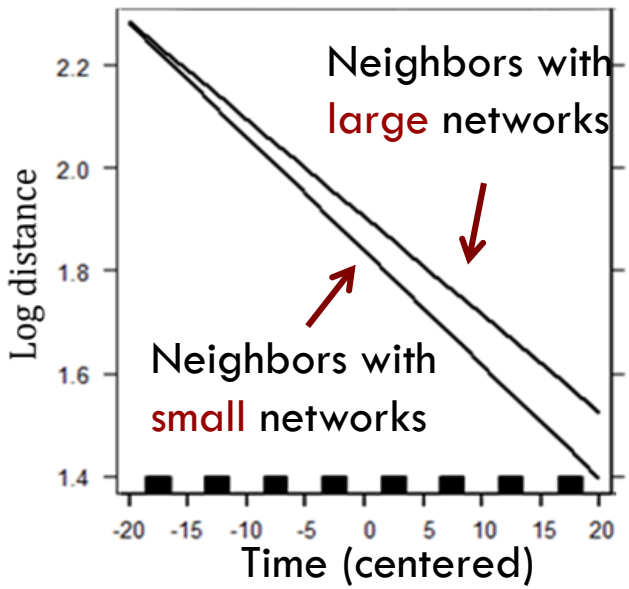


innovator with neighbors with small social networks

STUDY 4: SIMULATING LANGUAGE CHANGE

- 50,000 rounds of interaction
- interlocutors provide each other with one token of each vowel
- individuals update representation according to received input
- received tokens are assigned a weight inversely proportional to network size
- distance between vowels measured every 5000 rounds

When innovators have neighbors with small social networks, there's greater and steeper language change



NETWORK SIZE, MALLEABILITY & LANGUAGE CHANGE

Implications for language change:

- Individuals with smaller social network might play an important role in the propagation of linguistic changes.
- People learn from non-central members, and the latter are in fact crucial to the diffusion of information and trends (Bakshy et al., 2012 ; Granovetter, 1973)
- The role of individuals with small network size might be particularly strong in cases where the innovation is imperceptible and carries no social meaning.

TAKE-HOME MESSAGE

The social structure of the community can influence linguistic structure and linguistic stability

Student involved in Exp. 1:

- Limor Raviv

RAs

Participants

Psychology Department