The emergence of discrete and systematic communication in a continuous signal-meaning space

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Research question

How do *discreteness* and *systematicity* arise in communication systems? We explore the emergence of languages in a continuous signal-meaning space.

Previous work

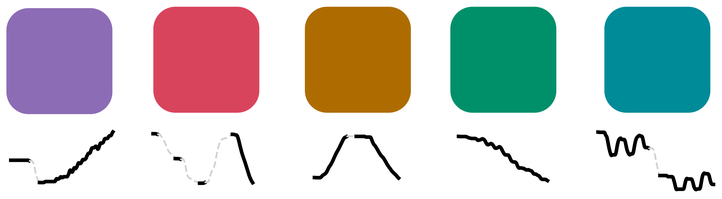
- Discrete signal or meaning space in a communication game.[2]
- Continuous or discrete signal/meaning spaces, without communication.[1, 3, 4, 5]

Experiment

Participants played a **communication game** with another participant where they generalized from five **learned** signal-color pairings to a larger range of colors.

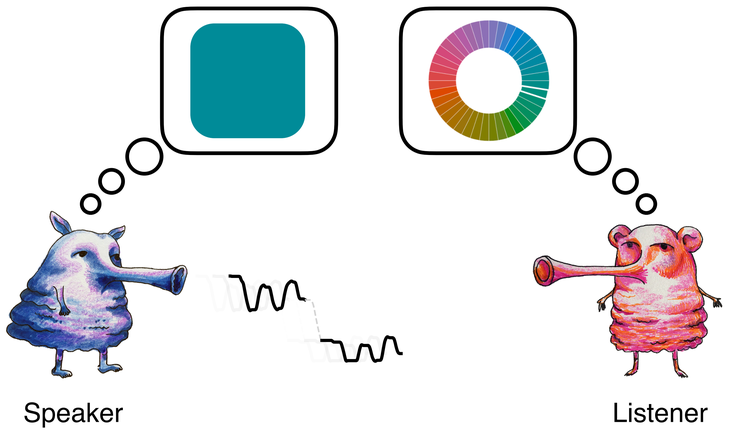
Learning phase

All participants individually learn the same five signal-color pairings and advance based on a learning criterion.

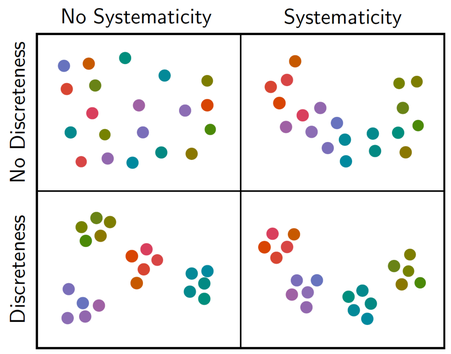


Communication phase

Players generalize the learned language to 40 color chips; alternating speaker and listener roles with joint rewards.



Hypotheses



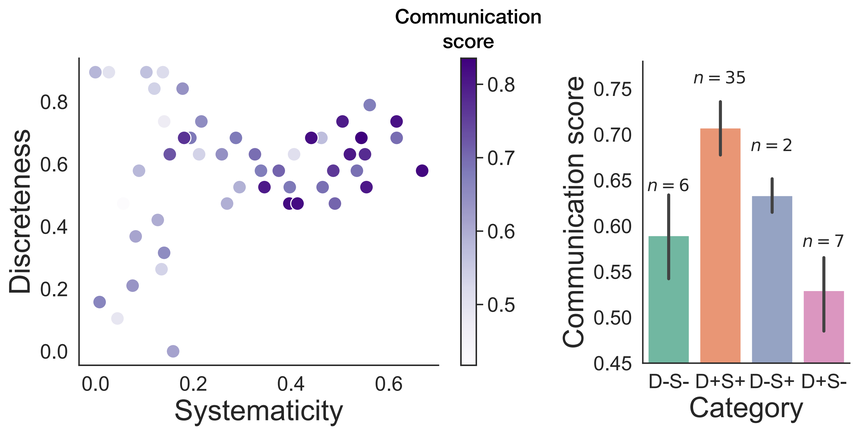
Use **dynamic time warping** to quantify differences between signals

Systematicity: difference between signals corresponds to difference between clusters

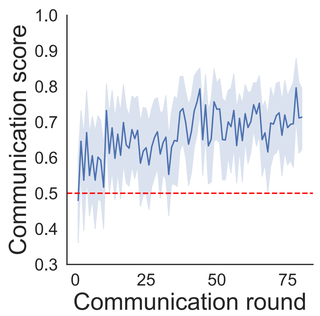
Discreteness: signals cluster into groups

Results

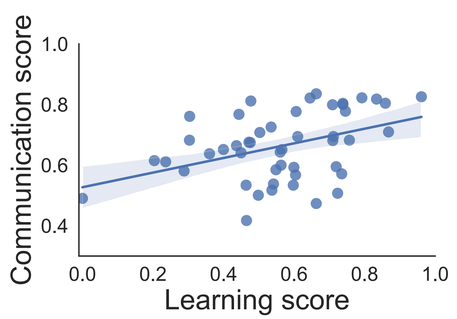
Discrete and **systematic** communication systems emerge more frequently and achieve **better communicative performance**.



Communication gets better over repeated interaction (rounds)

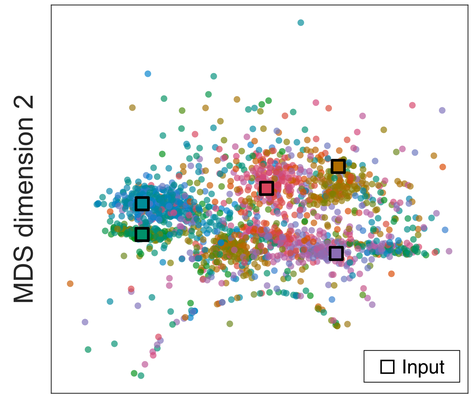


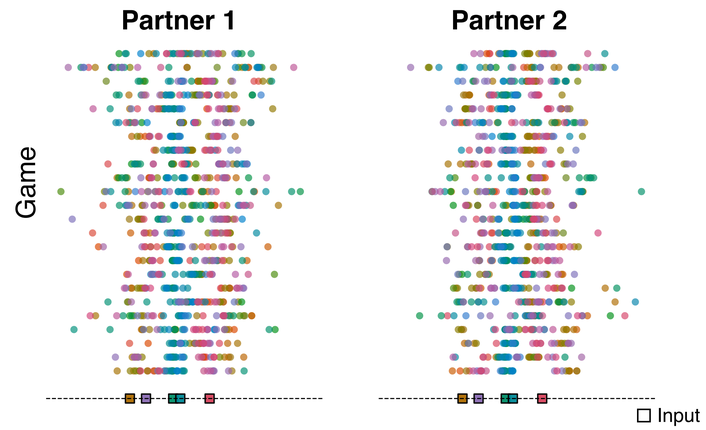
Better learning leads to better communication



2D and 1D signal embeddings

Embeddings of communication phase signals





Discussion

- Participants used communicative strategies that helped them achieve better **communication accuracy**, and the best strategy (discreteness + systematicity) was also the most common.
- Our findings suggest a cognitive bias toward symbolic communication and non-arbitrary form-meaning associations.

Further directions: multiple generations, within-signal analyses, different signal-color initializations

References

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