Communicative reduction in referring expressions within a multi-player negotiation game

Veronica Boyce, Michael C. Frank

Stanford University, contact: vboyce@stanford.edu

Goals

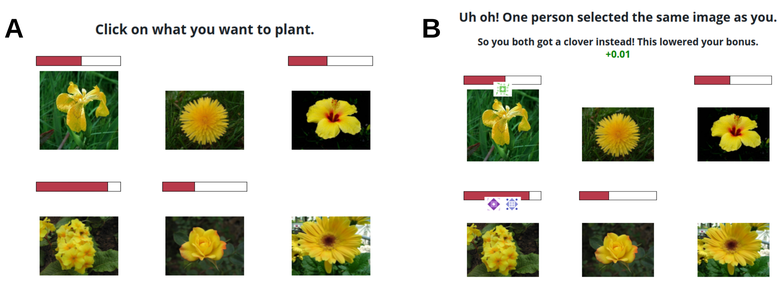
The ability to form novel conventions is a key signature of efficient linguistic communication.

In dyadic reference games (Clark & Wilkes-Gibbs 1986, Hawkins et al. 2020), speaker-listener pairs show the following patterns:

- **reduction** as utterances shorter over time,
- **convergence** within groups to a shared nickname,
- **divergence** between groups as different nicknames develop.

Do these patterns occur for reference expressions in strategic games with more complex goals?

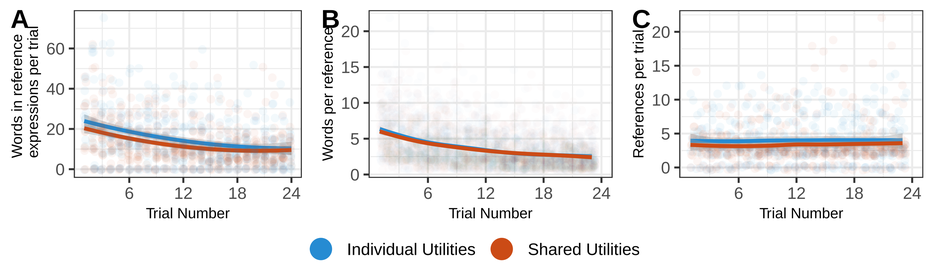
Experimental design



Participants were assigned to 3-player games. During selection (A) each participant saw 6 flowers, 4 with value bars. Players could communicate in a chat box before each selecting a flower. Then they saw feedback (B) indicating who chose what. When multiple players selected the same flower, they received a lower value rather than the indicated value.

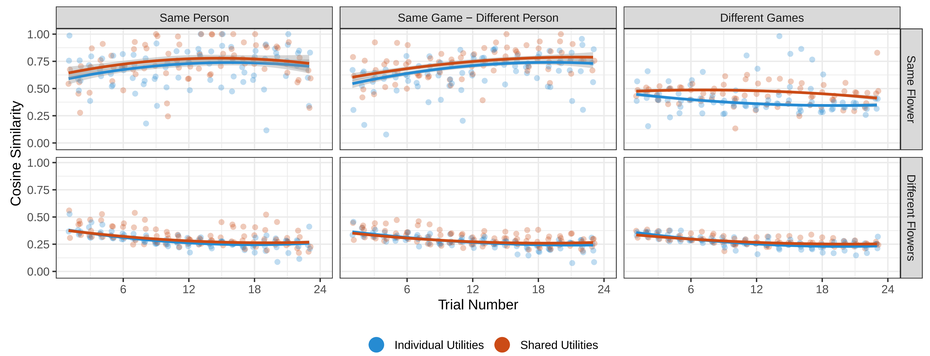
In *individual utility* games (18 games), each player earned points for the flowers they selected; in the *shared utility* games (21 games), the points were averaged together, and all players in a game got the same reward. Each group played 24 trials with images drawn from a set of 12 flowers. This data was first presented in Mankewitz et al. (2021).

Referring expressions reduced over time



Descriptions got shorter over time, but the number of descriptions stayed constant.

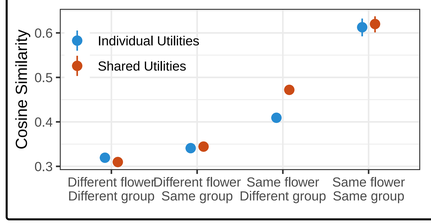
Referring expressions converged within groups



Similarity between two descriptions was measured by the cosine between their S-BERT embeddings (Reimers & Gurevych, 2019).

- Similarity increased for the same flower within games (top left, center).
- Similarity decreased slightly for the same flower across games (top right).
- Descriptions for different flowers became more distinct (bottom).

Shared utilities games diverged less



Shared utility games diverged less from each other in how to refer to each flower, both during game (above, top right) and in post-game descriptions (left), possibly due to the shared utilities encouraging coordination and thus comprehension.

Examples

Descriptions of different flowers from different games. Images shown in experimental design: flower 1 upper left, flower 2 lower center, flower 3 lower left.

Flower	Game	Trial	Expression
1	1A	2	not sure what kind of flower it is but the droopy-ish one
1	1C	4	droopy iris flower
1	1B	21	droopy
2	2B	2	the red middle with spike
2	2B	3	the red center
2	2A	20	red middle
2	3C	6	the one with the dark red centre
2	3A	13	the one with black background
2	3A	24	black background
3	1A	4	the big cluster of flowers with the orange in the middle
3	1A	23	cluster
3	2C	24	bundle
3	3B	24	multi flowers

Cosine similarities between pairs of descriptions.

Expression 1	Expression 2	Sim
the red center	red middle	0.78
droopy iris flower	multi flowers	0.56
droopy iris flower	droopy	0.56
cluster	bundle	0.25
red middle	black background	0.25
droopy iris flower	the red center	0.09
droopy	bundle	0.03

Conclusion

Reduction and and conventionalization occur even in strategic games with more open-ended negotiation and more complex goals than reference games.

References: Clark, H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. • Reimers, N., & Gurevych, I. (2019). Sentence-BERT: Sentence Embeddings using Siamese BERT-Networks. • Hawkins, R., Frank, M., & Goodman, N. (2020). Characterizing the dynamics of learning in repeated reference games. • Mankewitz, J., et al. (2021). Multi-party referential communication in complex strategic games.