



Modeling Referential Coordination as a Particle Swarm Optimization Task

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Abstract

The question of how referential choice and interpretation are influenced by production cost remains unresolved in the literature. Recent research (Rohde et al., 2012; Degen & Franke, 2012; Frank & Goodman, 2012) investigates the conditions under which speakers coordinate the use of ambiguous expressions.

We take a novel approach to modeling referential coordination by simulating the results of one such study on referring expression costs (Rohde et al., 2012). The simulation uses a general-purpose optimization method, particle swarm optimization, to capture the previously reported referential choices and to extrapolate to new communicative conditions.

Our results replicate observed overinformativity behaviors (Brennan & Clark, 1996) and demonstrate that dyadic referential coordination can be framed as a constrained optimization problem in which agents may need only to maintain a simplified representation of the common ground and of each other.

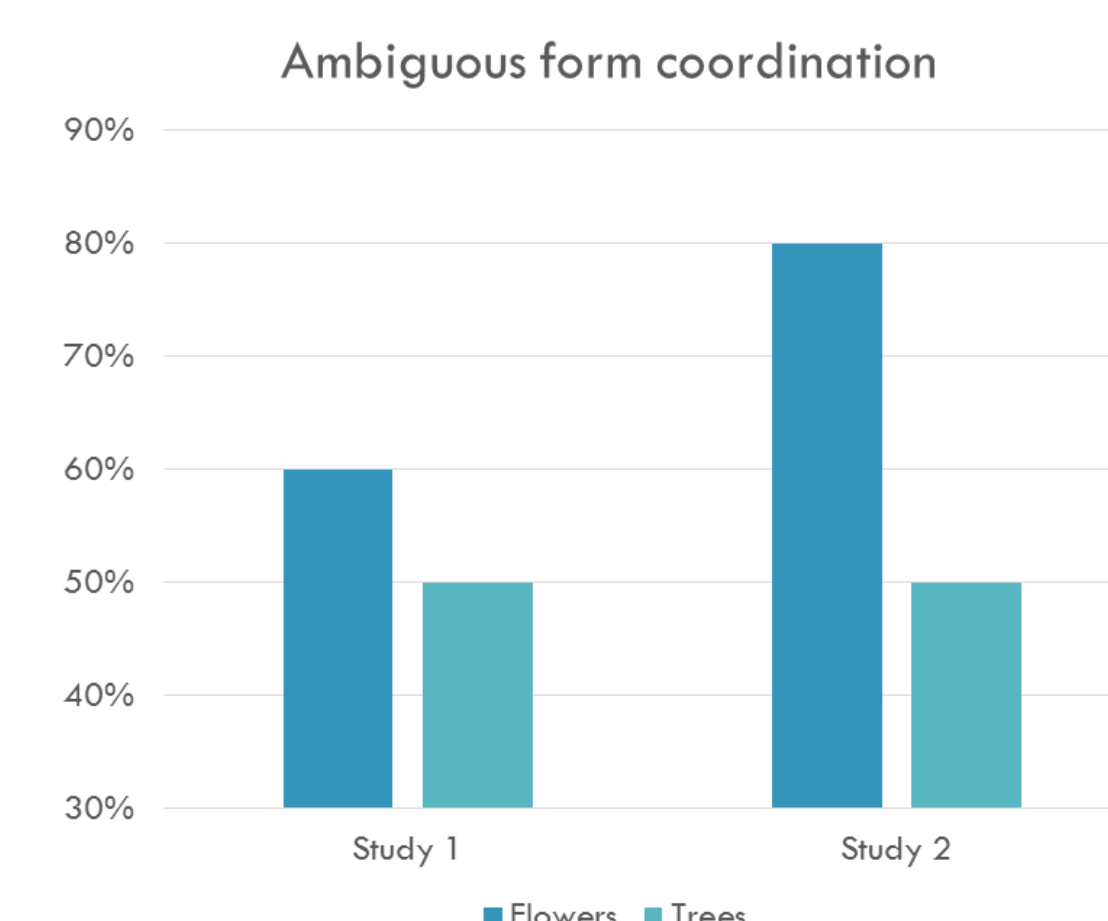
1. Goal

To understand the influence of production cost on referential coordination, specifically, coordination in a setting allowing the use of both high-cost unambiguous forms and low-cost ambiguous forms.

2. Previous work on referential coordination

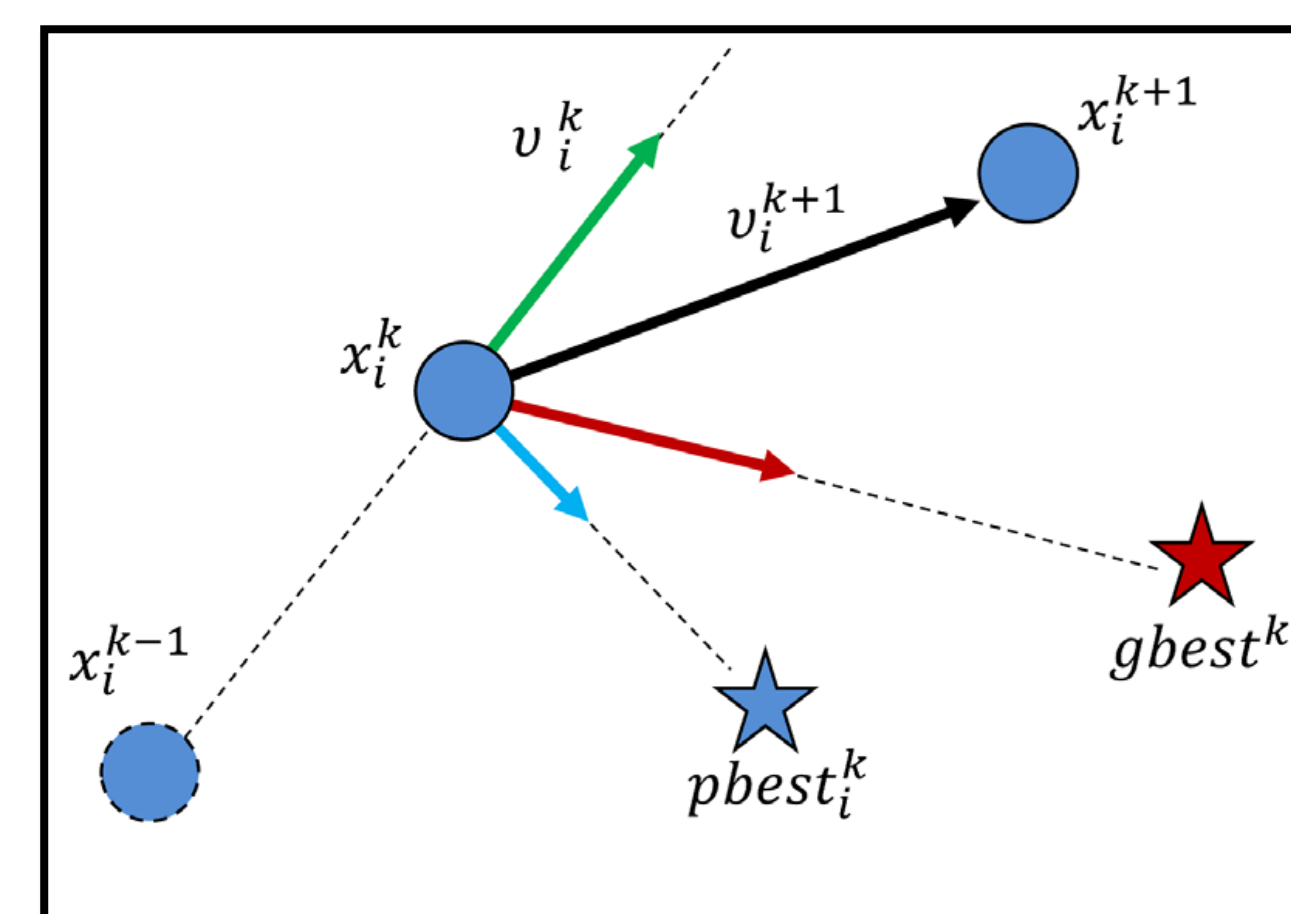
Rohde et al. (2012) present an iterated referential coordination language game in which players attempt to indicate an object to their partner via one of several possible referring expressions, spending points to communicate but gaining points when communication is successful.

Name	Study 1 Cost	Study 2 Cost
"Flower"	80	80
"Rose"	60	80
"Daisy"	120	140
"Tulip"	280	165
"Tree"	80	80
"Apple Tree"	60	80
"Pine Tree"	120	135
"Palm Tree"	250	170



3. Particle Swarm Optimization

PSO represents potential solutions for maximizing an objective function as particle positions existing within a multidimensional space. Over a number of iterations, increasingly suitable solutions are found as particles explore this space, their paths influenced by the thus far best-found solutions (Kennedy & Eberhart, 1995).



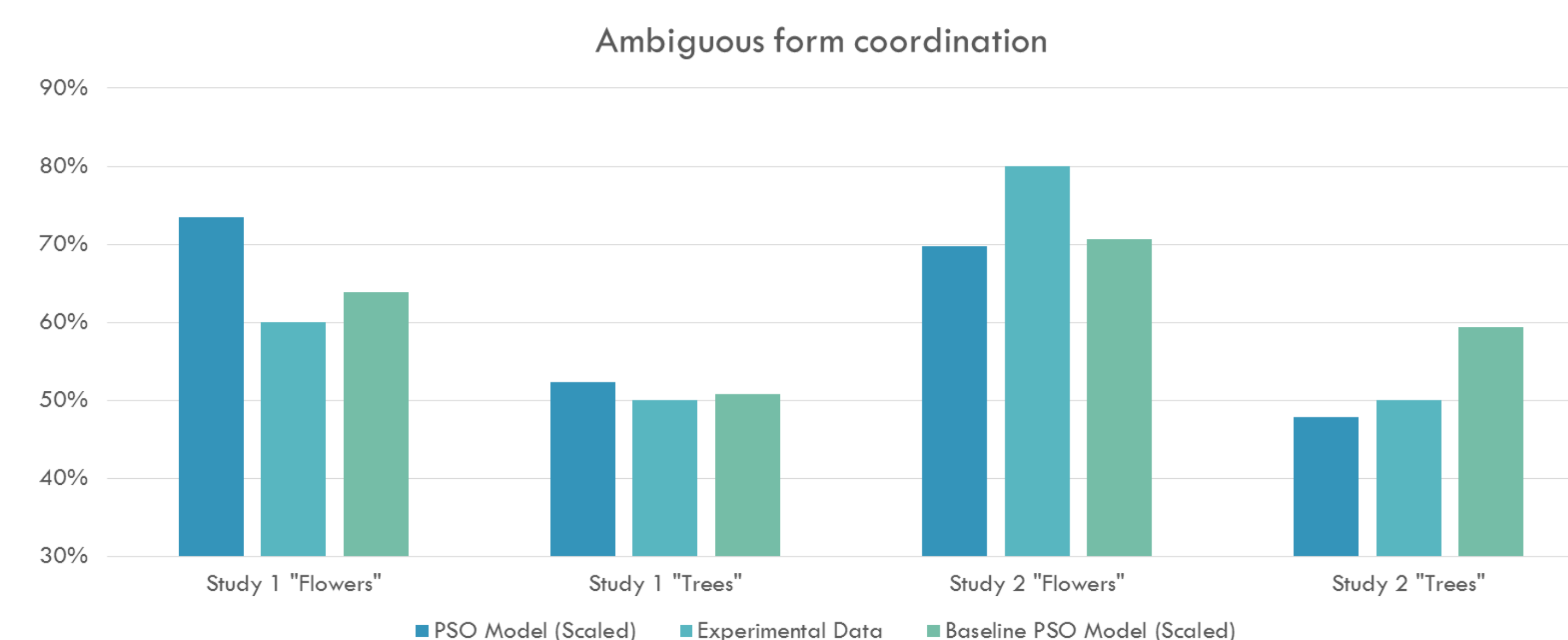
Noto et al. (2013). Agent-based Social Simulation Model for Analyzing Human Behaviours using Particle Swarm Optimization.

4. Applying PSO to Rohde et al. 2012

- Agents' strategies modeled as sets of probabilities
- Each dimension of search space represents preference of an agent to use ambiguous referring expression instead of given unambiguous referring expression
- Pairs of interlocutors modelled as 2-particle swarms
- Fitness of a referential strategy is evaluated with regards to costs and rewards defined by language game, in conjunction with likelihood of successful communication dictated by partner's referential strategy

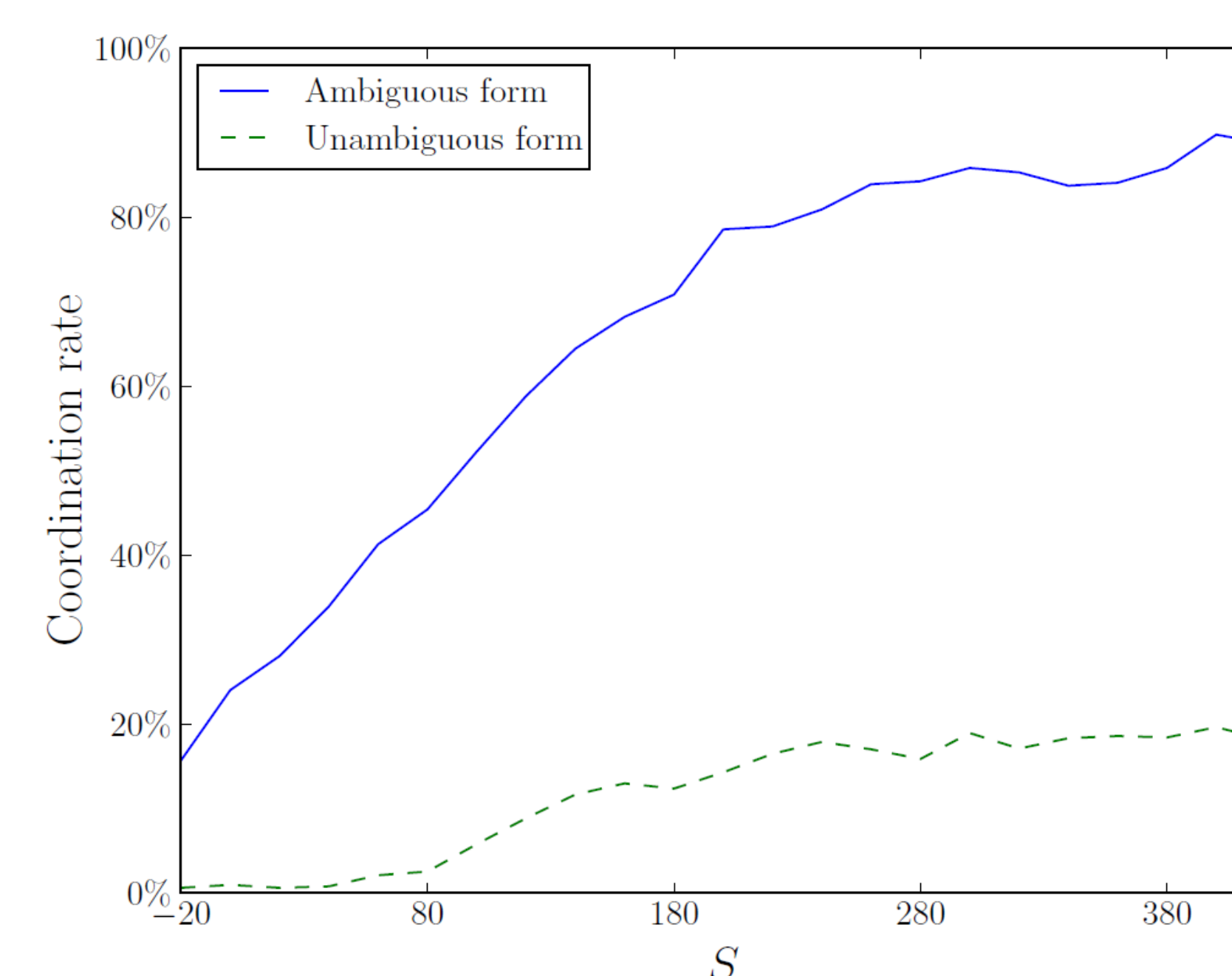
6. Results – replicating previous findings

Our PSO-based model, parameterized using optimized values, is able to successfully capture the relative effects of varying form costs on referential coordination rate observed by Rohde et al.



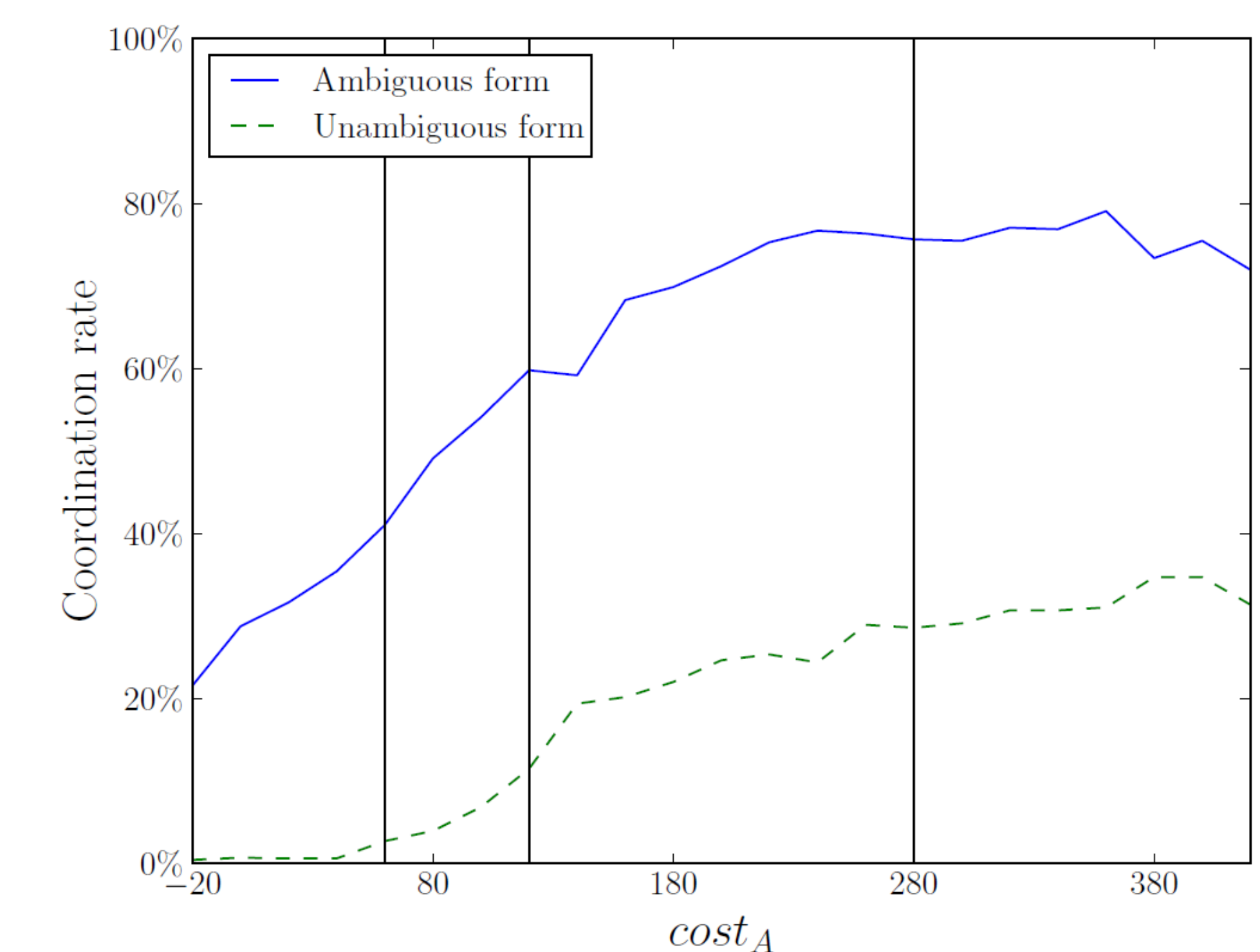
Additionally, agents in our model capture the overinformativity behavior noted in Brennan and Clark, in which human participants continued the use of forms on which they had been entrained, even when a change in the discourse context permitted the use of less costly forms.

7. Results – predictions varying reward



In keeping with findings from Rohde et al., our PSO model predicts higher rates of coordination when agents are more greatly rewarded for successful communication, which is speculated to promote exploration of the space.

8. Results – predictions varying ambiguous form cost



Study 1 "Flower" context with ambiguous form cost varied; lines indicate costs for unambiguous forms. We suggest the positive trend here reflects higher ambiguous form cost more readily indicating which unambiguous forms it should supplant and ergo facilitating dyadic coordination.

9. Conclusions

- Our PSO-based model captures and extrapolates beyond experimentally observed behavior, enabling exploration of the influence of form costs on referential coordination and production
- Our use of PSO suggests that referential coordination can be explained in terms of a generalized optimization process – a finding in keeping with more egocentric models of communication (Horton & Keysar, 1996)
- Our model suggests a lower bound for how complex agents must be in order to respond to variations in form costs in a similar manner to humans

10. References

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