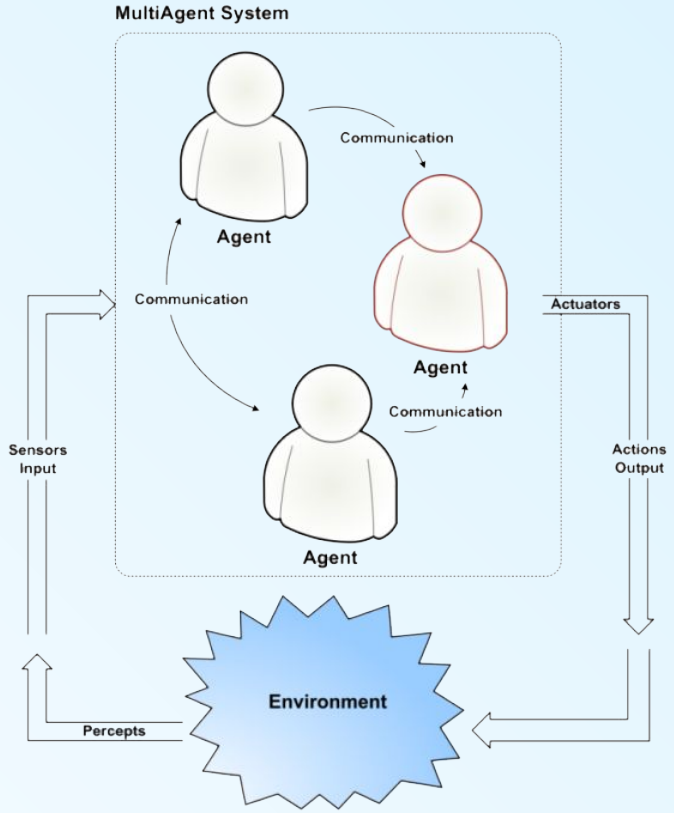
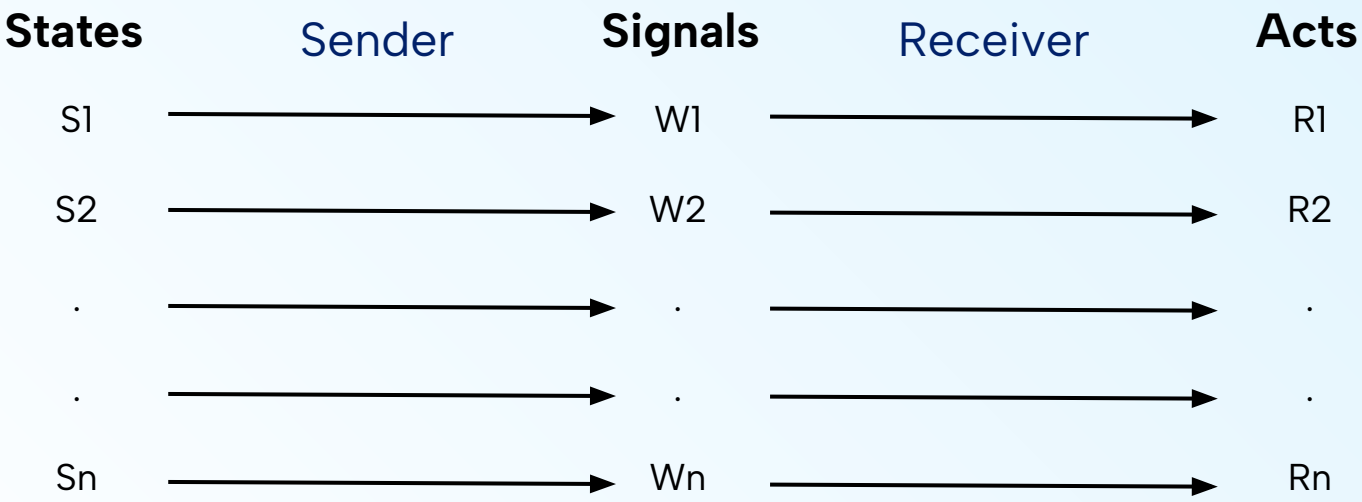
Emergence of Communication in Coordination Games with Signaling Strategies

Zahra Moradi and Anil Yaman

- AI communication has been researched in various fields including language game theory, evolutionary linguistics and cognitive science.
- A specific research area: Lewis's signaling game
- Individuals communicate to achieve a shared interest in a particular goal.
- One individual is the sender of a message, and the other is the receiver.
- The sender aims to communicate information about the goal to the receiver, who then acts accordingly.



Signaling game



Research Question:

”To what extent do agents agree about the semantic of the emergent language in coordination games and how can this agreement be improved?”

Scenario 1

-Baseline

-Fixed sender

-Sender chooses role randomly

-Learned communication

Scenario 2

-Fixed sender

-Learned communication

-Sender learns role values

-Sender explores environment

Scenario 3

-Random sender

-Learned communication

-Sender learns role values

-Sender explores environment

Scenario 4

-Pairs of sender & receiver

-Learned communication

-Sender learns role values

-Sender explores environment

Scenario 5

-Pairs of sender & receiver

-Learned communication

-Sender learns role values

-Sender explore environment

-Sender Observes receiver

Scenario 1, 2 signals:

Sender (signal generation probability = 0.1)

Symbol	State of Sender	Confidence
Wn	sender's role	conf_lvl I

Receiver

Symbol	Action of Receiver	Confidence
Wn	random guess	conf_lvl I

Scenario 3,4,5 signals:

Sender (signal generation probability = 0.1)

Symbol	State of Sender	Action of Receiver	Confidence
Wn	sender's role	random guess	conf_lvl

Receiver

Symbol	State of Sender	Action of Receiver	Confidence
Wn	random guess	random guess	conf_lvl

Games

(a) Game 1

Sender	Receiver	
	A	B
A	(5,5)	(0,0)
B	(0,0)	(5,5)

(b) Game 2

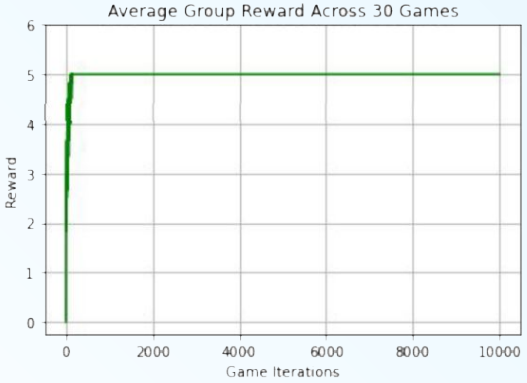
Sender	Receiver	
	A	B
A	(0,0)	(5,5)
B	(5,5)	(0,0)

(c) Game 3

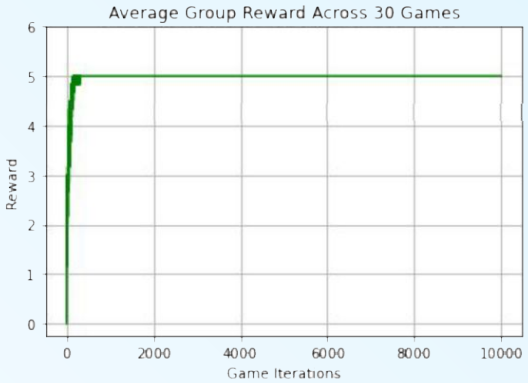
Sender	Receiver	
	A	B
A	(0,0)	(0,0)
B	(5,5)	(0,0)

Scenario 1

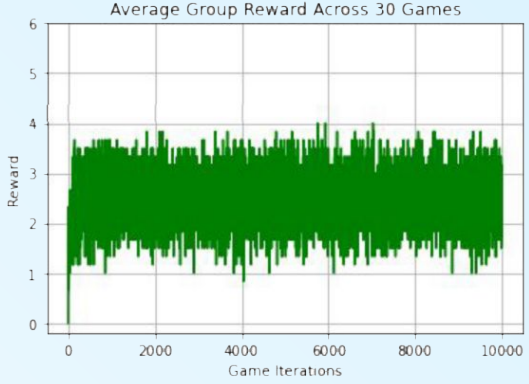
Game 1



Game 2

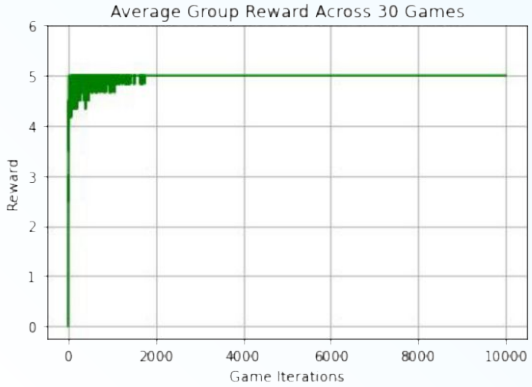


Game 3

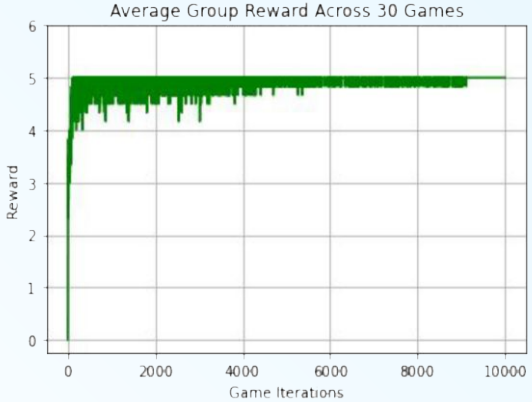


Scenario 2

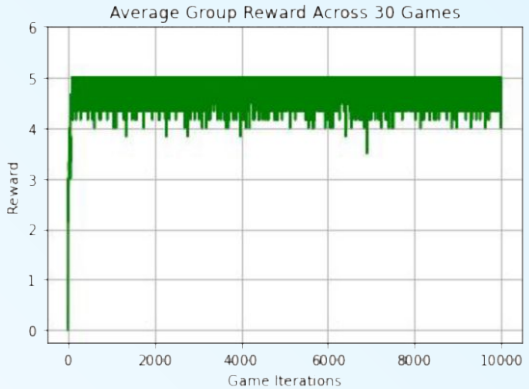
Game 1



Game 2

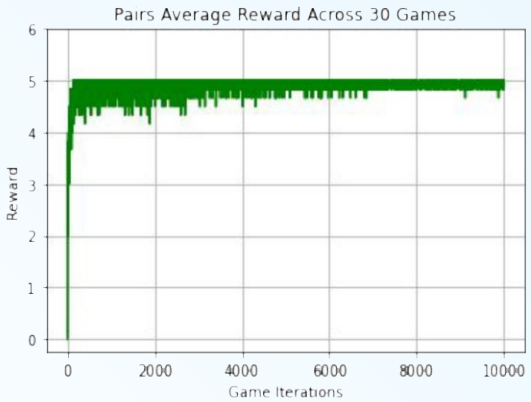


Game 3

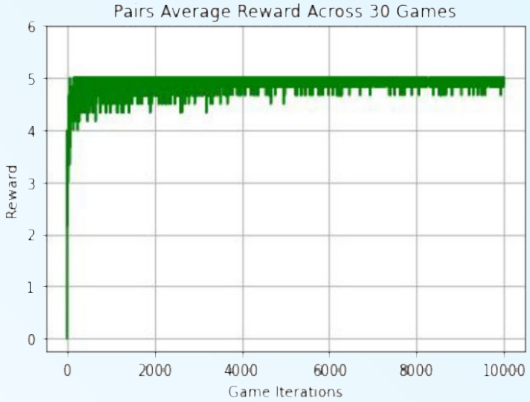


Scenario 4

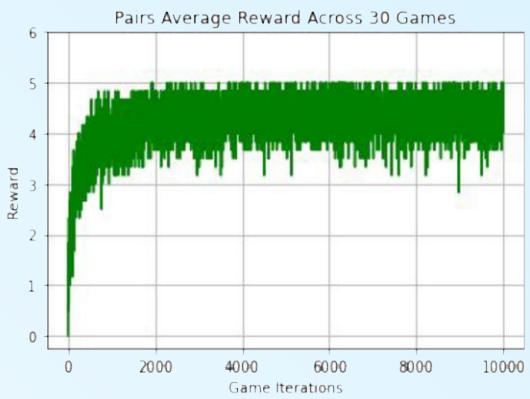
Game 1



Game 2

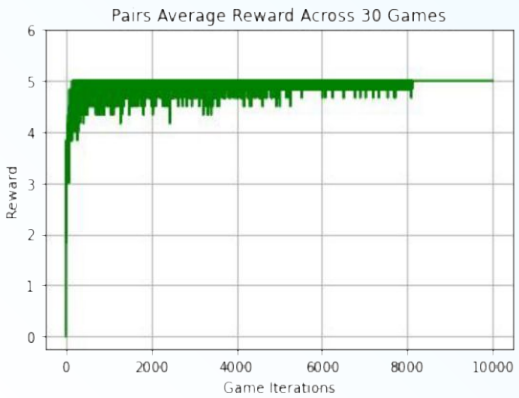


Game 3

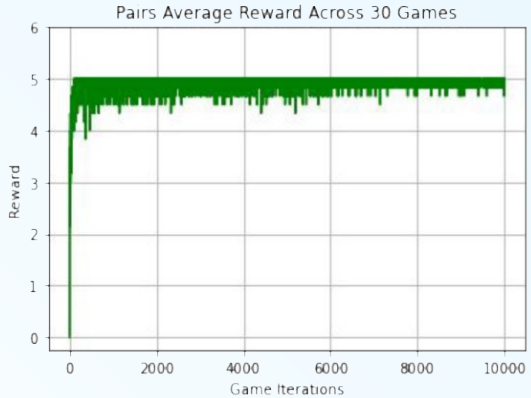


Scenario 5

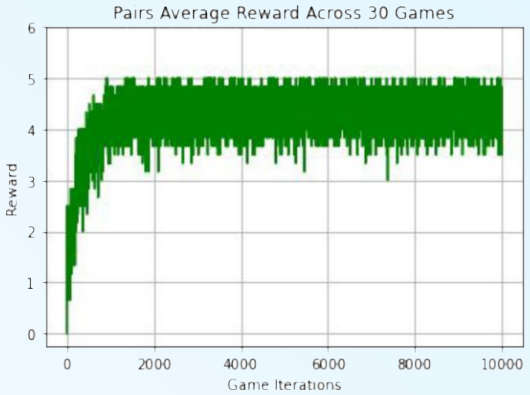
Game 1



Game 2



Game 3



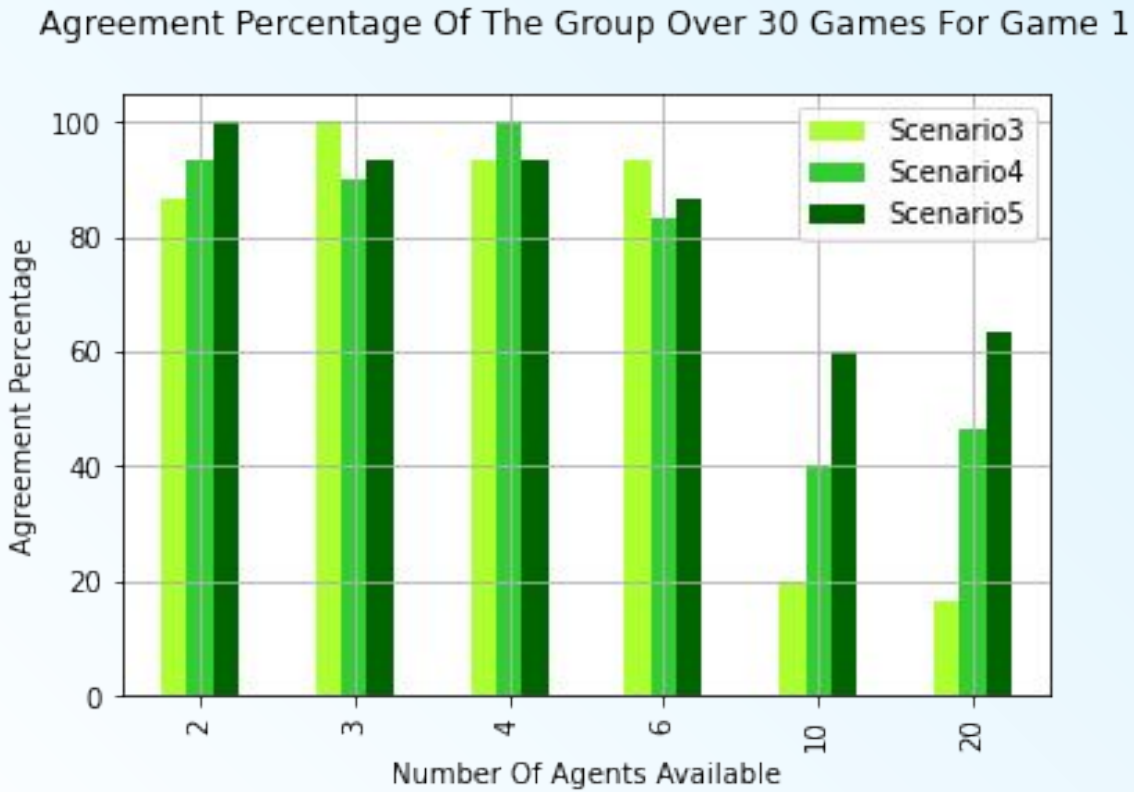
Signal Results and Agreement Percentages

		Games		
		Game 1	Game 2	Game 3
Scenario 1	Sender Signals	[['w2', 0, 0.99], ['w3', 1, 1]]	[['w0', 0, 0.99], ['w1', 1, 1]]	[['w10', 0, 1]]
	Receiver Signals	[['w2', 0, 0.99], ['w3', 1, 1]]	[['w0', 1, 0.99], ['w1', 0, 1]]	[['w10', 0, 1]]
	Agreement percentage	100%	100%	53.3%
Scenario 2	Sender Signals	[['w0', 0, 0.99], ['w4', 1, 1]]	[['w6', 1, 0.99], ['w9', 0, 1]]	[['w0', 0, 1]]
	Receiver Signals	[['w0', 0, 0.99], ['w4', 1, 1]]	[['w6', 0, 0.99], ['w9', 1, 1]]	[['w0', 0, 1]]
	Agreement percentage	100%	100%	56.6%
Scenario 3	Sender Signals	[['w9', 0, 0, 1], ['w13', 1, 1, 0.96]]	[['w0', 0, 0, 1], ['w2', 1, 1, 0.65]]	[['w6', 0, 1, 1]]
	Receiver Signals	[['w9', 0, 0, 1], ['w13', 1, 1, 0.96]]	[['w0', 1, 1, 1], ['w2', 0, 0, 0.65]]	[['w6', 0, 1, 1]]
	Agreement percentage	86.6%	86.6%	100%
Scenario 4	Sender Signals	[['w1', 0, 0, 0.99], ['w0', 1, 1, 1]]	[['w2', 1,1, 0.88], ['w3', 0, 0, 1]]	[['w0', 0, 1, 1]]
	Receiver Signals	[['w1', 0, 0, 0.99], ['w0', 1, 1, 1]]	[['w2', 0, 0, 0.88], ['w3', 1, 1, 1]]	[['w0', 0, 1, 1]]
	Agreement percentage	93.3%	83.3%	100%
Scenario 5	Sender Signals	[['w12', 0, 0, 1], ['w15', 1, 1, 1]]	[['w3', 0, 0, 1], ['w8', 1, 1, 0.9]]	[['w13', 0, 1, 1]]
	Receiver Signals	[['w12', 0, 0, 1], ['w15', 1, 1, 1]]	[['w3', 1, 1, 0.99], ['w8', 0, 1, 1]]	[['w13', 0, 1, 1]]
	Agreement percentage	100%	96.6%	100%

Scenario comparison for 2 agents

	Average agreement percentage across all games
Scenario 1	84
Scenario 2	94
Scenario 3	91
Scenario 4	92.2
Scenario 5	98.8

Effect of different population sizes



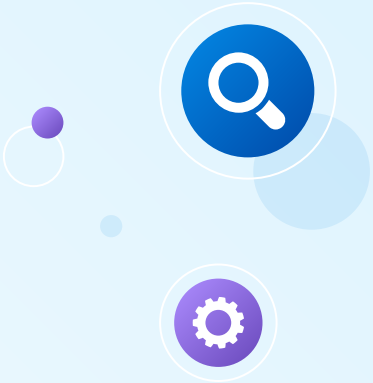
Research question: “To what extent do agents agree about the semantic of the emergent language in coordination games and how can this agreement be improved?”

- Notable agreement of almost 90%
- Learning the value of the roles
- Learning the confidence of signals

Sub research question: “What factors contribute to reducing the time required to achieve higher agreement?”

- Different population sizes
- Difference in reward distribution schema
- Enabling the sender to observe the receiver’s action.

Future Work



- Introducing more role
- Introducing more games
- Running longer experiment

Thank you for your time!