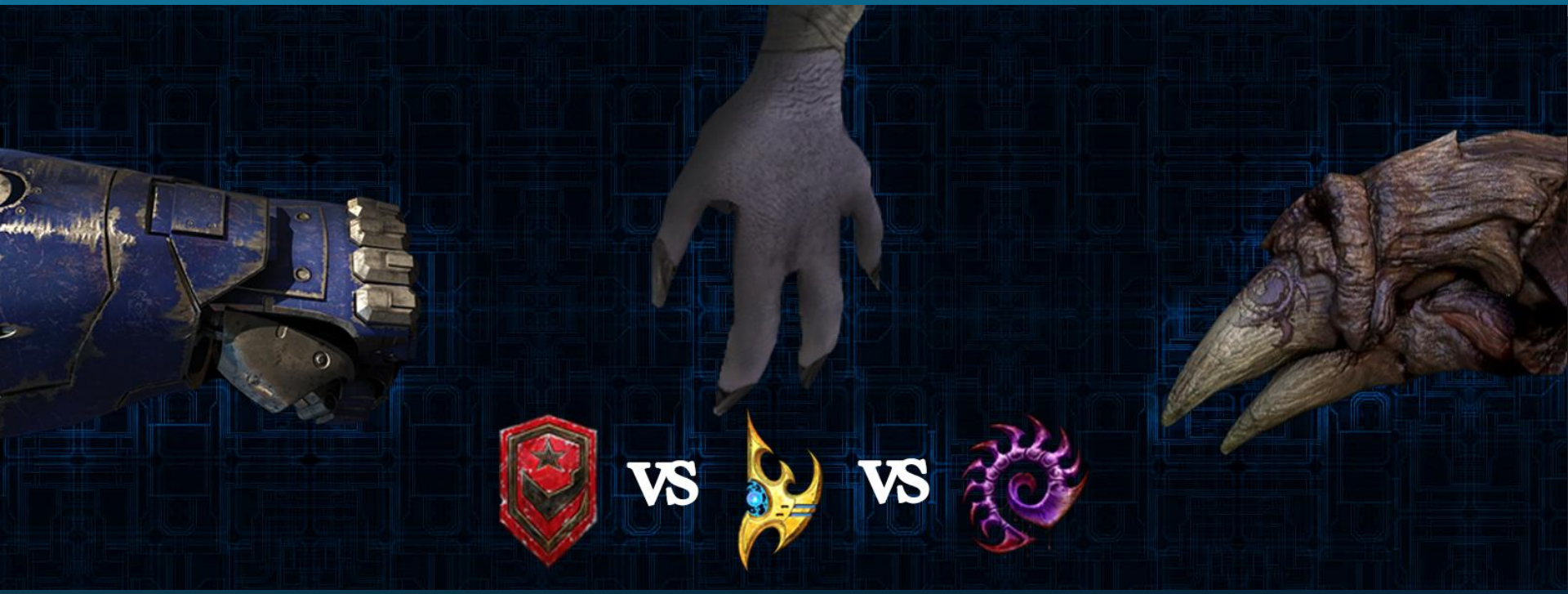
Rock, Paper, StarCraft: Strategy Selection in Real-Time Strategy Games



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Playing complex games

Wouldn't it be nice if we could play a complex game just like a simple one?

Complex game

Simple game

Playing complex games

Can you do that?

John Nash

The Strategy Selection Metagame

- Yes, we can!
  - With the strategy selection metagame.

- Strategy:
  - A mapping from states to actions
  - A black-box policy to play the game

The Strategy Selection Metagame

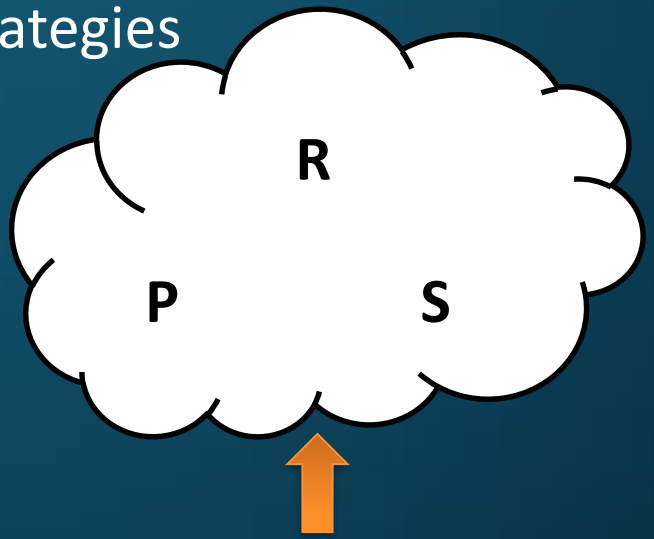
Strategies

Game

1) Identify strategies in a game

The Strategy Selection Metagame

Strategies

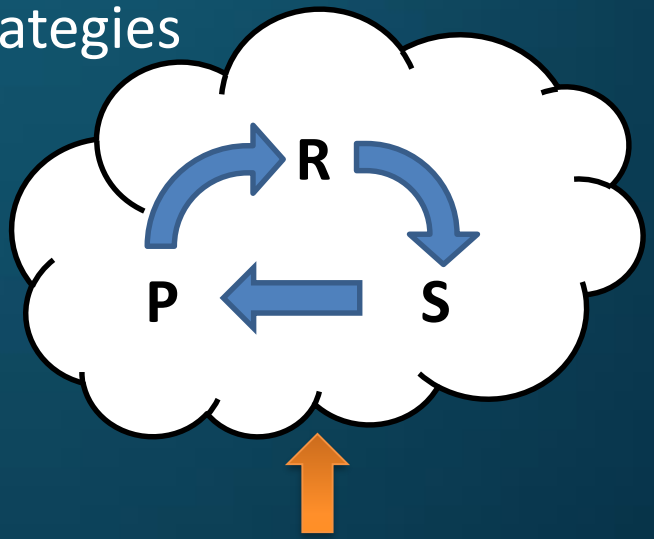


Game

1) Identify strategies in a game

The Strategy Selection Metagame

Strategies



Metagame

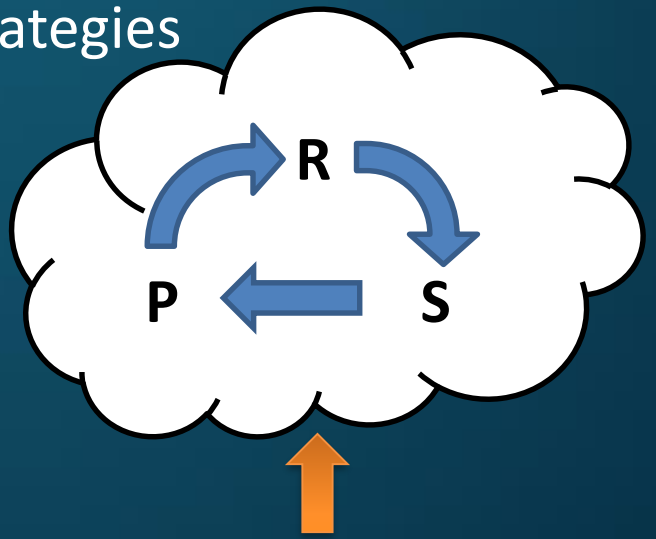
	R	P	S
R	0	-1	1
P	1	0	-1
S	-1	1	0

Game

2) Identify how strategies interact

The Strategy Selection Metagame

Strategies



Metagame

	R	P	S
R	0	-1	1
P	1	0	-1
S	-1	1	0

Game

Strategy	Probability
R	33.33%
P	33.33%
S	33.33%
Expected payoff: 0	

Nash Equilibrium

3) Solve the metagame

The Strategy Selection Metagame

I like the metagame!

John Nash

3) Solve the metagame

Metagame in StarCraft

- Complex RTS game
- Vibrant developer community
- Lots of available bots

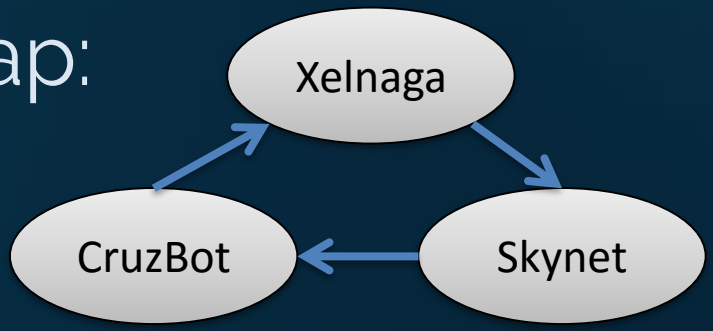
Metagame in StarCraft

1. Identify strategies:
   - AIIDE 2015 Protoss bots
   - Full game-playing agentes
   - They map states to actions

Bot	Xelnaga	CruzBot	NUSBot	Aiur	Skynet
Xelnaga	-				
CruzBot		-			
NUSBot			-		
Aiur				-	
Skynet					-

Metagame in StarCraft

2. Identify how strategies interact:
- 100 rounds in Fortress map:



Bot	Xelnaga	CruzBot	NUSBot	Aiur	Skynet
Xelnaga	-	**26%**	86%	73%	73%
CruzBot	74%	-	80%	67%	**16%**
NUSBot	**14%**	**20%**	-	74%	97%
Aiur	**27%**	**33%**	**26%**	-	79%
Skynet	**27%**	84%	**3%**	**21%**	-

Metagame in StarCraft

3. Solve the metagame:

Strategy	Probability
Xelnaga	41.97%
CruzBot	28.40%
NUSBot	0%
Aiur	0%
Skynet	29.63%
Expected payoff:	**50% victories**

Nash Equilibrium

Metagame in StarCraft

I would even play StarCraft now!

John Nash

Metagame in StarCraft

- Let's play the metagame!

Metagame in StarCraft

- Isn't solving it enough?
  - You can do better against sub-optimal opponents
- Computer Rock, Paper, Scissors[1]:
  - Nash Equilibrium placed only 27th out of 55 competitors

[1] Billlings. 2001. RoShamBo programming competition. https://webdocs.cs.ualberta.ca/~darse/rsbpc.html

Playing the Metagame

- Strategy selection methods:
  - Frequentist
  - Reply-last
  - Nash
  - ε-Nash
  - α-greedy
  - Single choice

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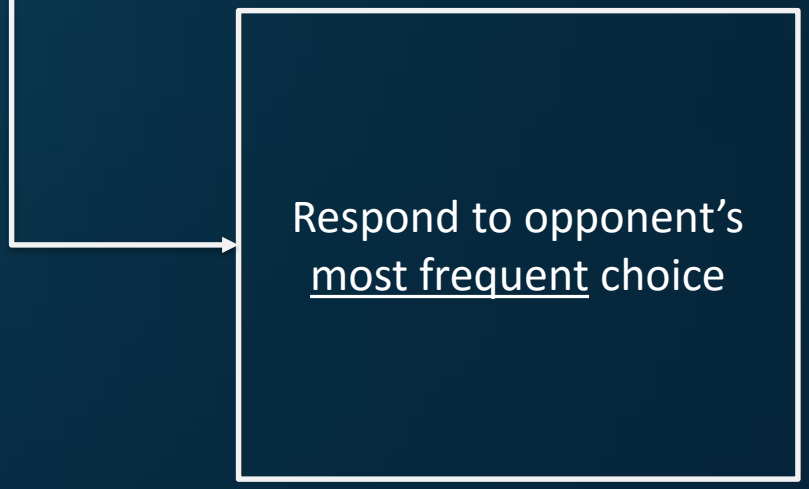

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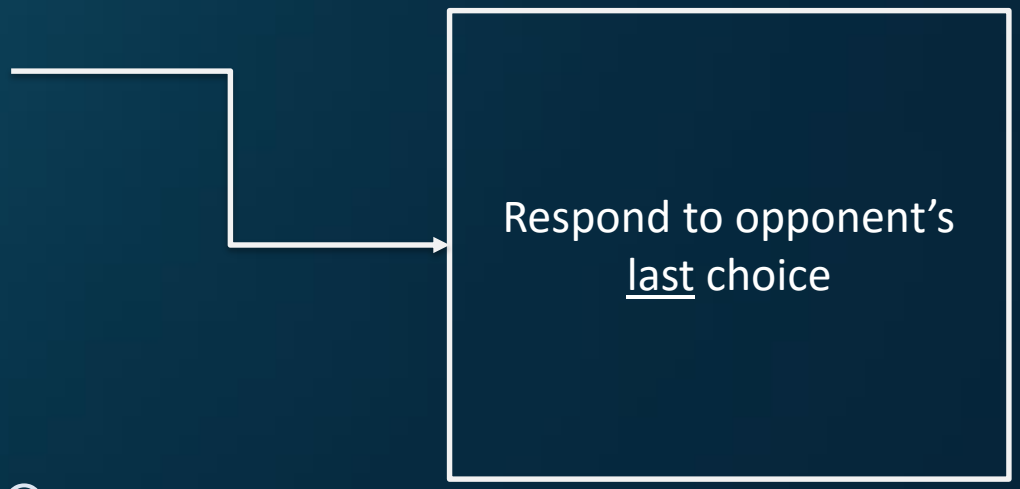

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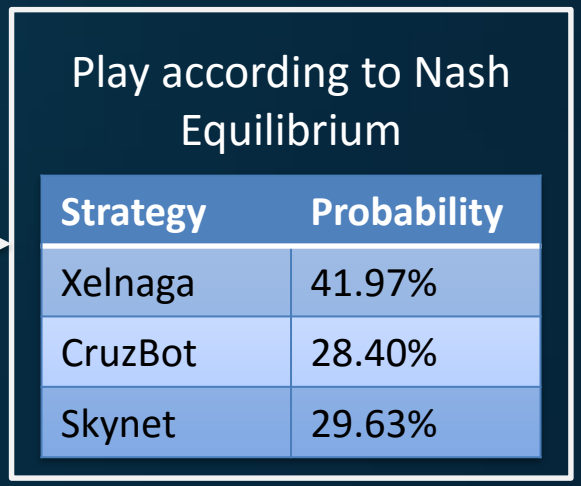

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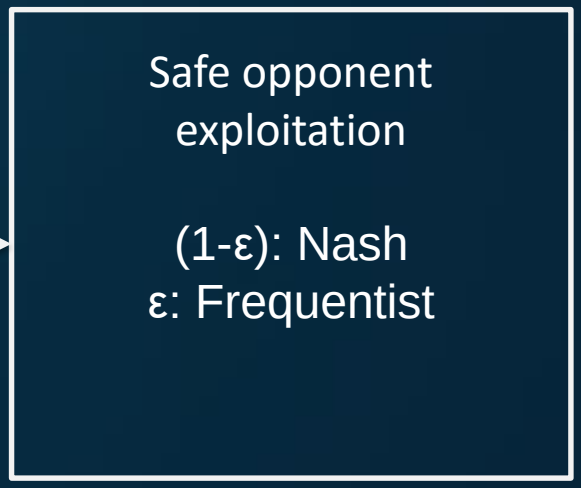

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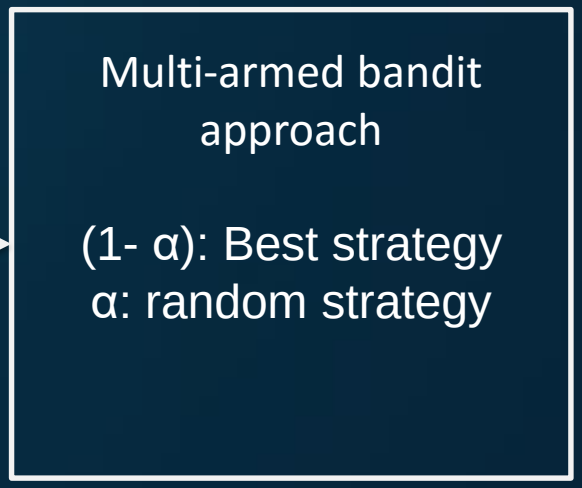

Playing the Metagame

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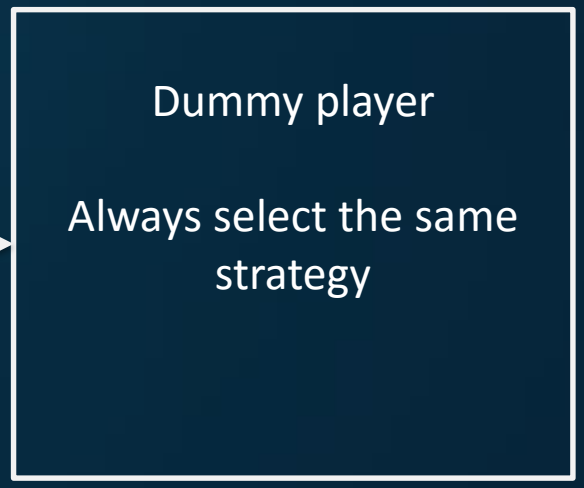
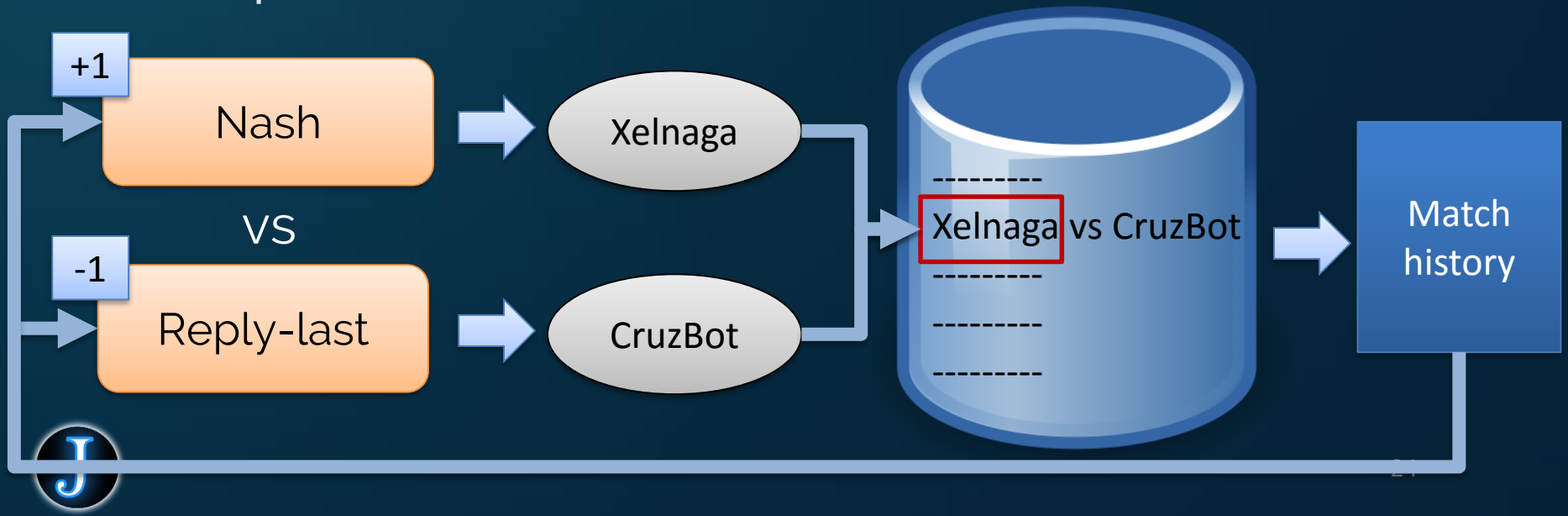


Experiments

- Strategy selection tournament
  - Strategy selection methods face each other
  - Each match: methods choose a bot
  - Result: queried from a pool of matches
  - Repeat



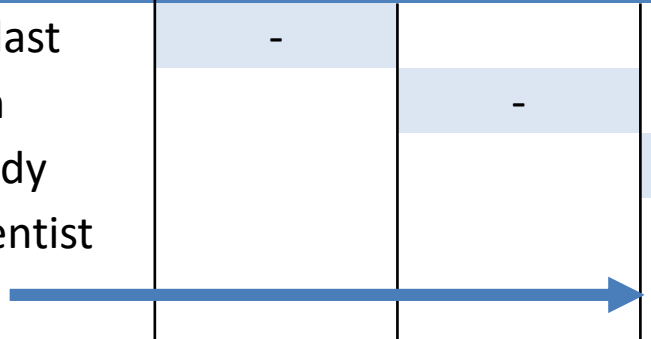
Experiments

- Setup
  - 1000-match round-robin tournament
  - 30 repetitions

Experiments

- Results

	Reply-last	ε-Nash	α-greedy	Frequentist	Nash	Single choice
Reply-last	-					
ε-Nash		-				
α-greedy			-			
Frequentist				-		
Nash					-	
Single choice						-



Experiments

- Results
  - Reply-last is good against 'repeaters'

	Reply-last	ε-Nash	α-greedy	Frequentist	Nash	Single choice
Reply-last	-	50.2%	62.5%	63%	48.1%	80.8%
ε-Nash	49.8%	-	49.8%	53.6%	51.3%	69.1%
α-greedy	37.5%	50.2%	-	52.5%	51.3%	73.5%
Frequentist	37%	46.4%	47.5%	-	52.5%	80.8%
Nash	51.9%	48.7%	48.7%	47.5%	-	55.5%
Single choice	19.2%	30.9%	26.5%	19.2%	44.5%	-

Experiments

- Results
  - Reply-last is good against ‘repeaters’
  - Nash is safe

	Reply-last	ε-Nash	α-greedy	Frequentist	Nash	Single choice
Reply-last	-	50.2%	62.5%	63%	48.1%	80.8%
ε-Nash	49.8%	-	49.8%	53.6%	51.3%	69.1%
α-greedy	37.5%	50.2%	-	52.5%	51.3%	73.5%
Frequentist	37%	46.4%	47.5%	-	52.5%	80.8%
Nash	51.9%	48.7%	48.7%	47.5%	-	55.5%
Single choice	19.2%	30.9%	26.5%	19.2%	44.5%	-

Experiments

- Results
  - Reply-last is good against 'repeaters'
  - Nash is safe
  - ε-Nash performs safe exploitation

	Reply-last	ε-Nash	α-greedy	Frequentist	Nash	Single choice
Reply-last	-	50.2%	62.5%	63%	48.1%	80.8%
ε-Nash	49.8%	-	49.8%	53.6%	51.3%	69.1%
α-greedy	37.5%	50.2%	-	52.5%	51.3%	73.5%
Frequentist	37%	46.4%	47.5%	-	52.5%	80.8%
Nash	51.9%	48.7%	48.7%	47.5%	-	55.5%
Single choice	19.2%	30.9%	26.5%	19.2%	44.5%	-

Conclusion

- Contributions:
  - Simplified representation of complex games
  - Discussion of game theory concepts
  - Spin-off: look out for MegaBot!
- Limitation:
  - Works with a predefined set of strategies

"To Nash Equilibrium… and beyond!"

The end

- Resources:
  - Strategy selection tournament engine

    https://github.com/h3ct0r/StarcraftNash
  - MegaBot

    https://github.com/andertavares/MegaBot

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Questions?