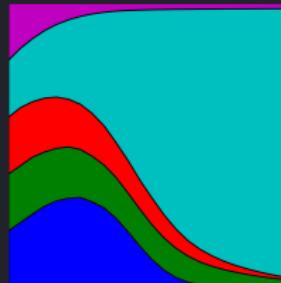


# Understanding responses to environments for the Prisoner's Dilemma

Max Planck Institute for Evolutionary Biology

@NikoletaGlyn





<http://rebloggy.com/post/animals-bat-black-and-white-eyes-creepy-horror-gore-halloween-animal-bats-vampir/101865318472>

$$S_p = \begin{pmatrix} 3 & 0 \\ 5 & 1 \end{pmatrix} \quad S_q = \begin{pmatrix} 3 & 5 \\ 0 & 1 \end{pmatrix}$$



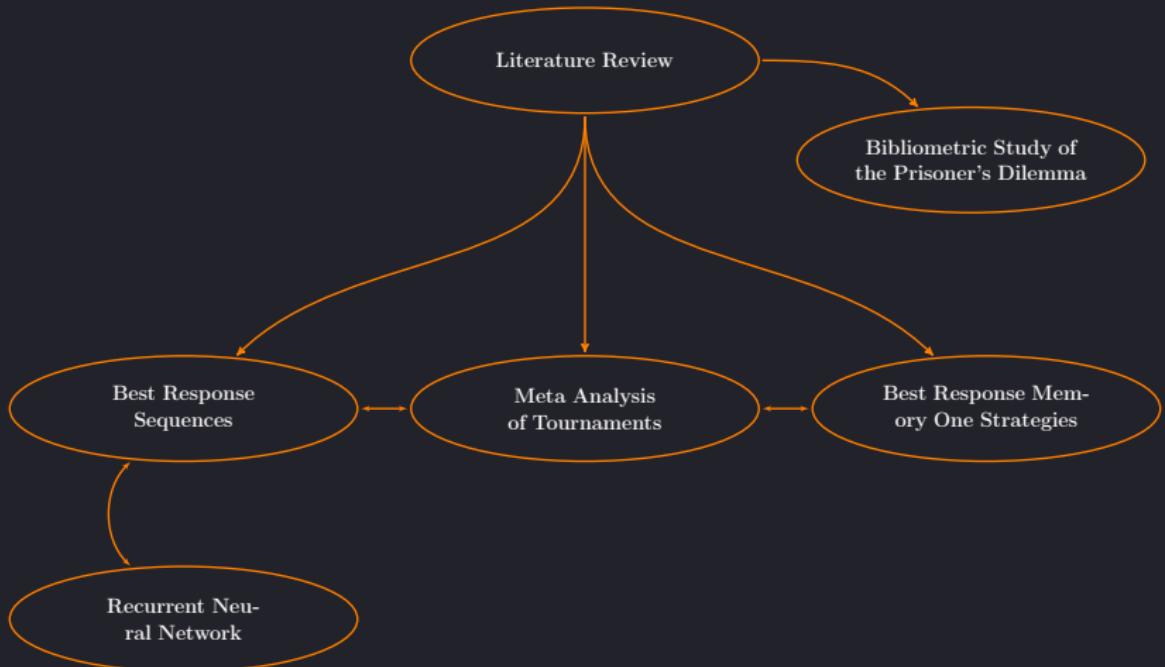


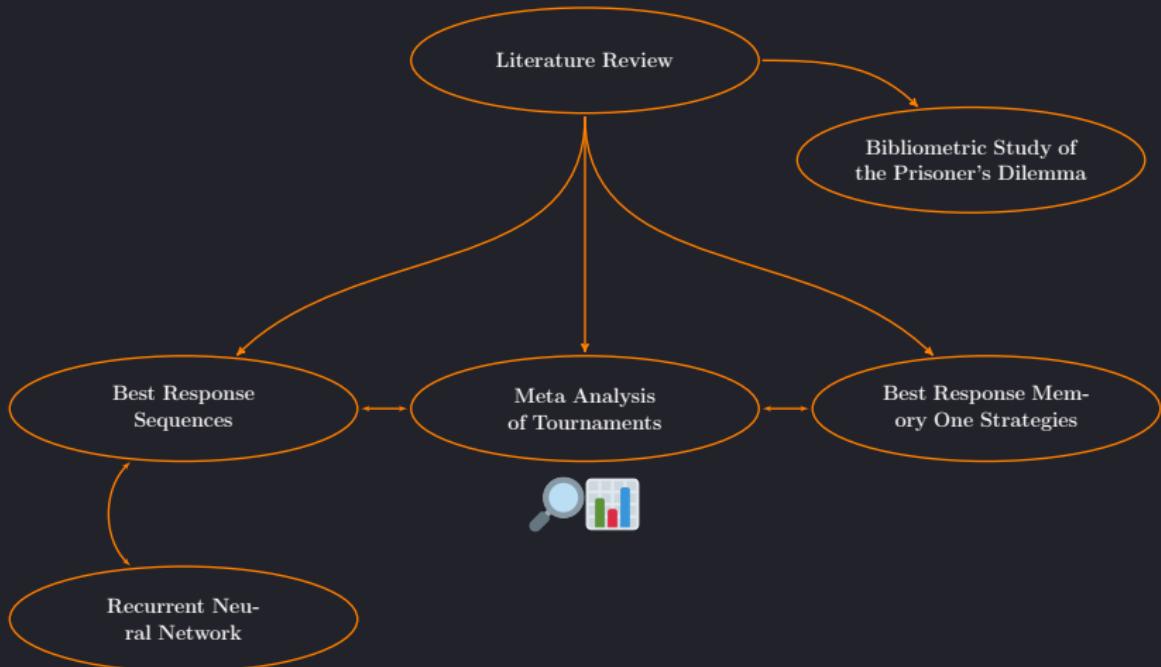


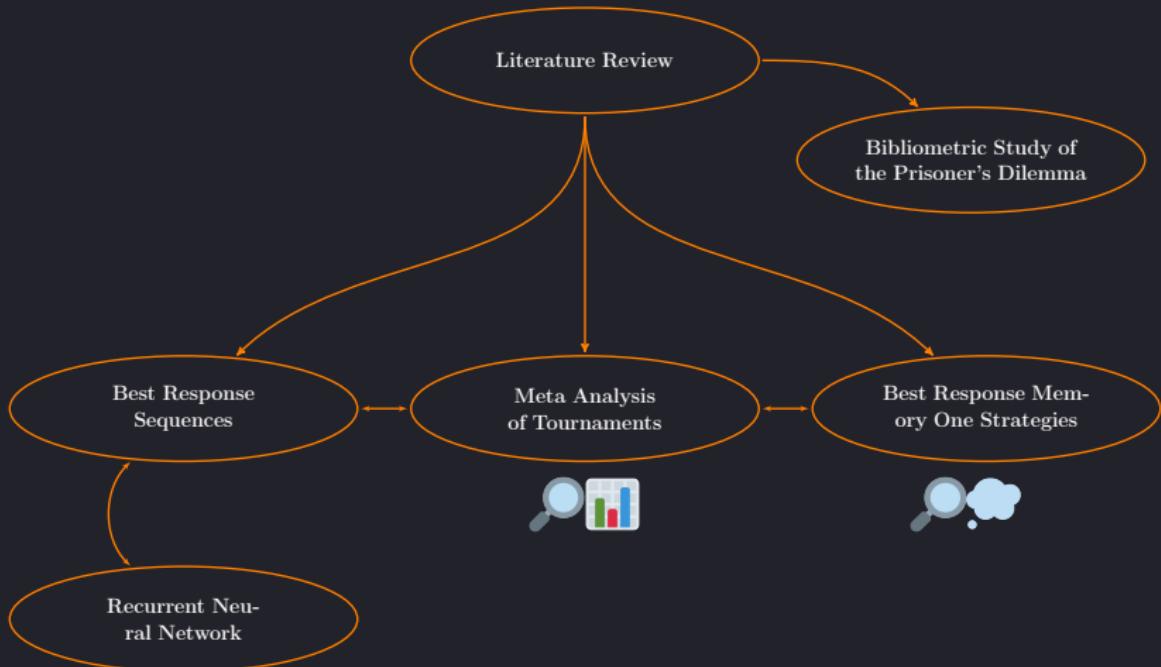


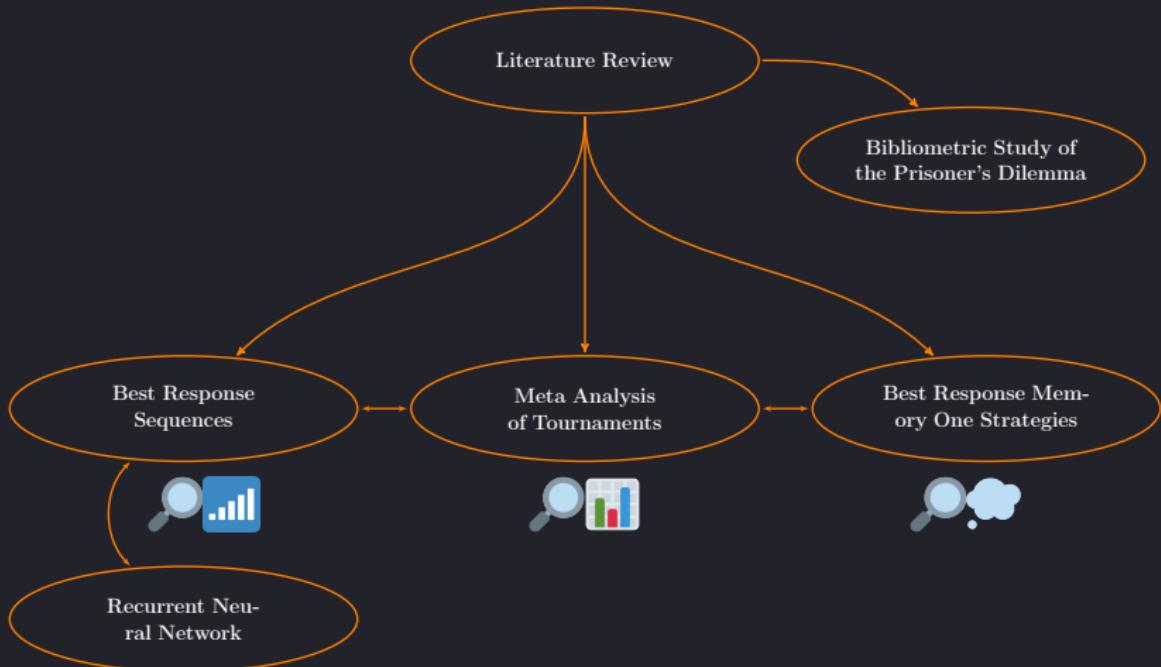
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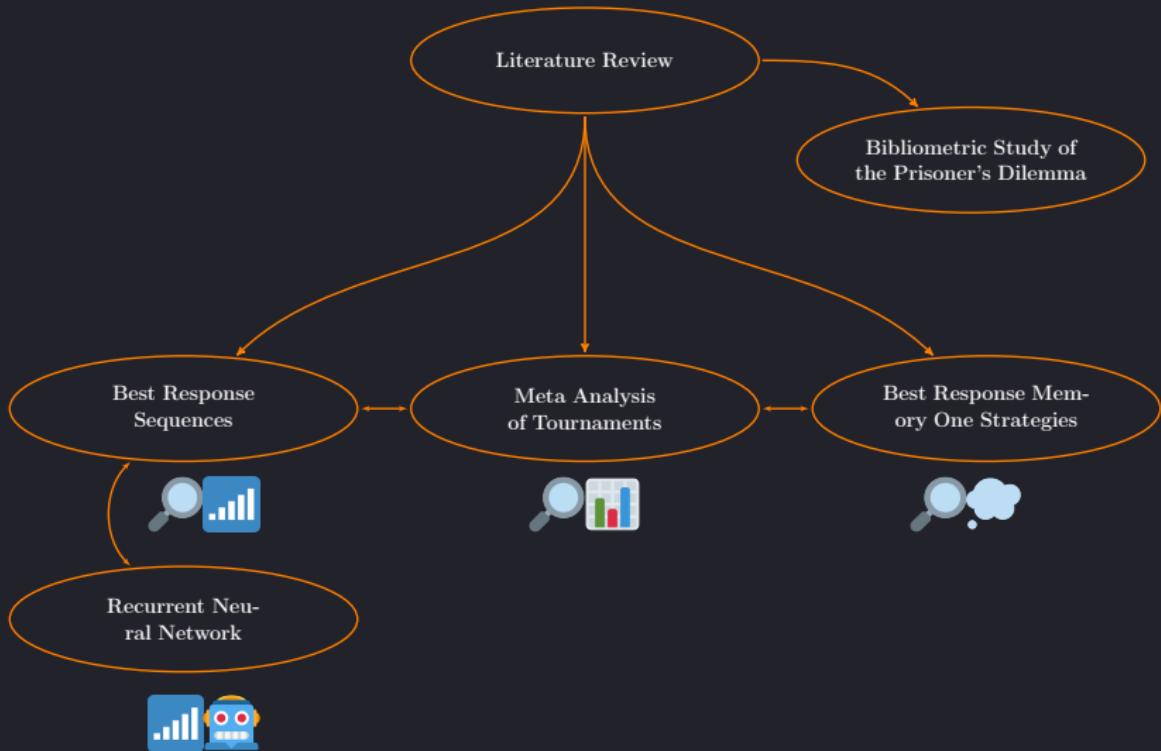


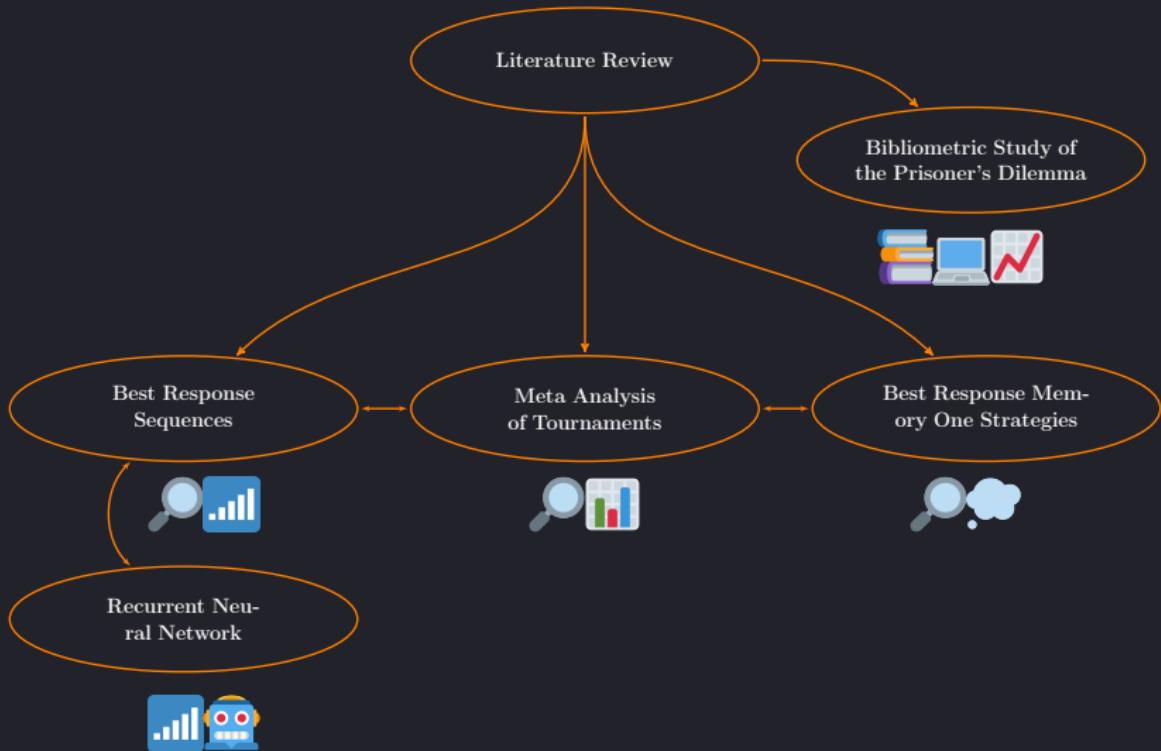








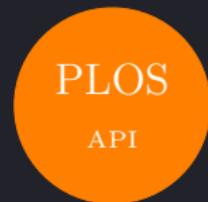




# Bibliometric Study of the Prisoner's Dilemma

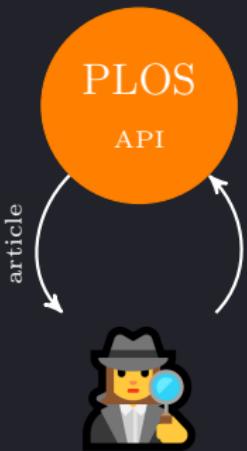


PLOS  
API





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q=title:"Game"+AND+abstract:  
"Game"&rows=1
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{'id': '10.1371/journal.pone.0058546',  
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 'eissn': '19326203',  
 'publication date': '20130313T00:00:00Z',  
 'article type': 'Research Article',  
 'author display': ['Adam C. Oei', 'Michael D. Patterson'],  
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PLOS

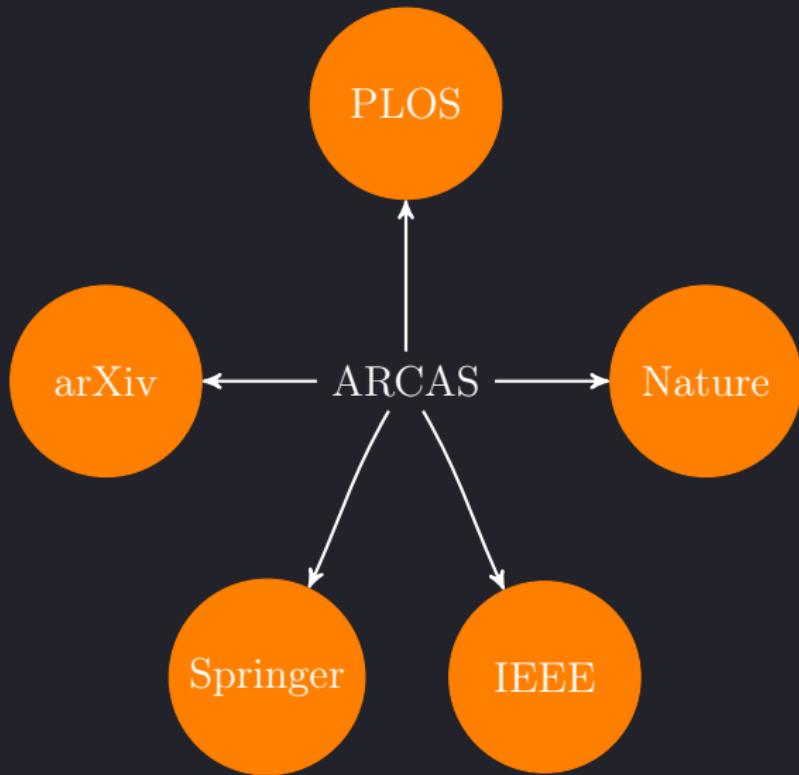
arXiv



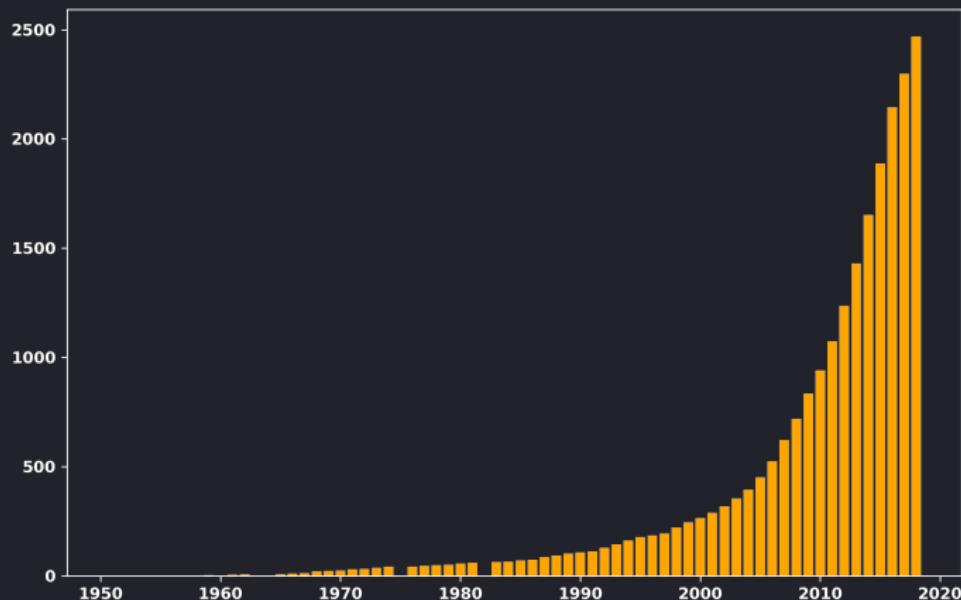
Nature

Springer

IEEE



title="prisoner's dilemma" OR abstract="prisoner's dilemma"







Natural Language Process  $\longrightarrow \mathbb{R}^n$





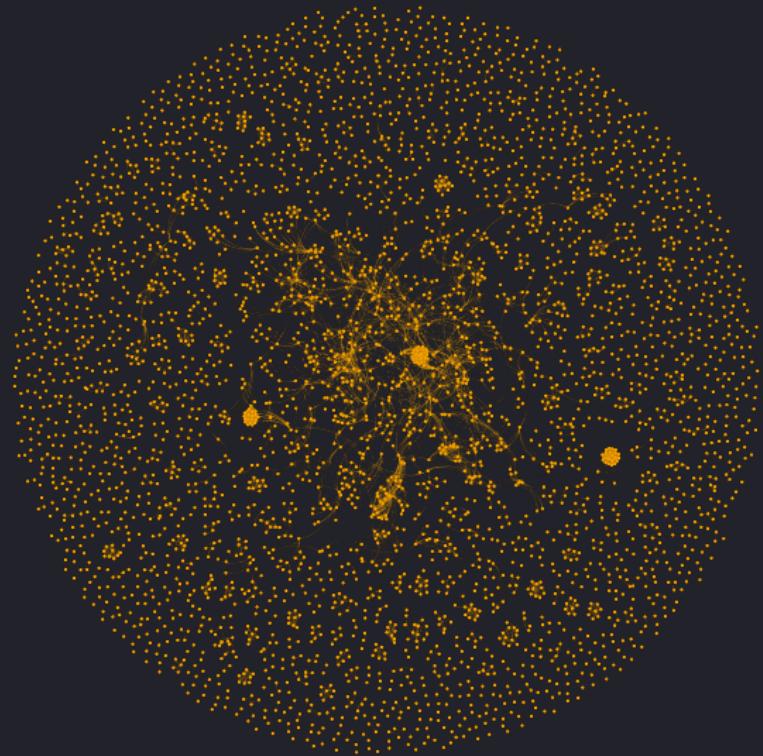
cooperation,  
network,  
population,  
evolutionary

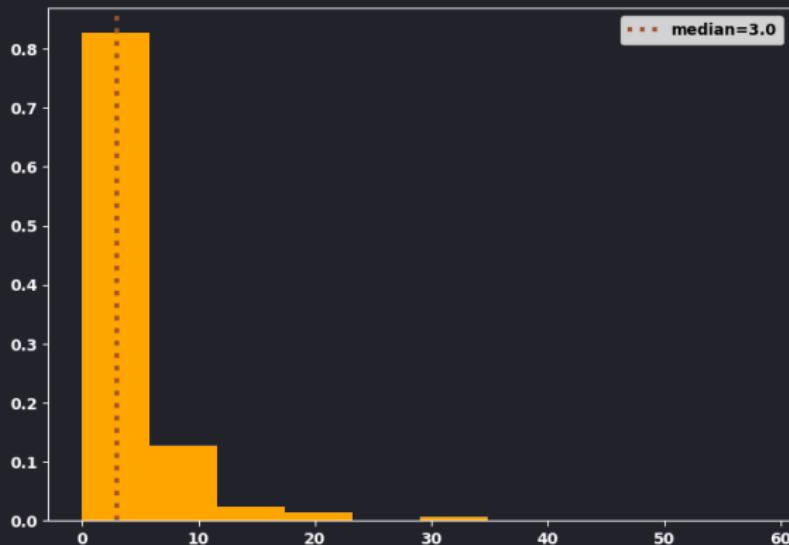
individual, group,  
good, high

social, behavior,  
study, experiment

model, theory,  
system, problem

game, strategy,  
player, agent





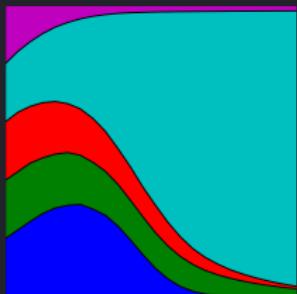
“A bibliometric study of research topics, collaboration and influence in the field of the Iterated Prisoner’s Dilemma”

Nikoleta E. Glynatsi, Vincent A. Knight

<https://arxiv.org/abs/1911.06128>

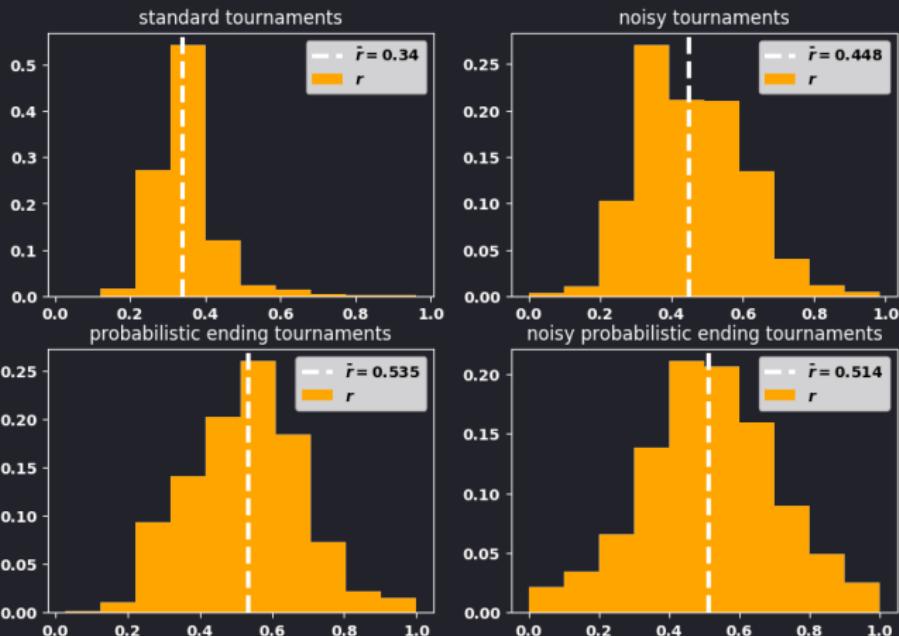
# Meta Analysis of Tournaments



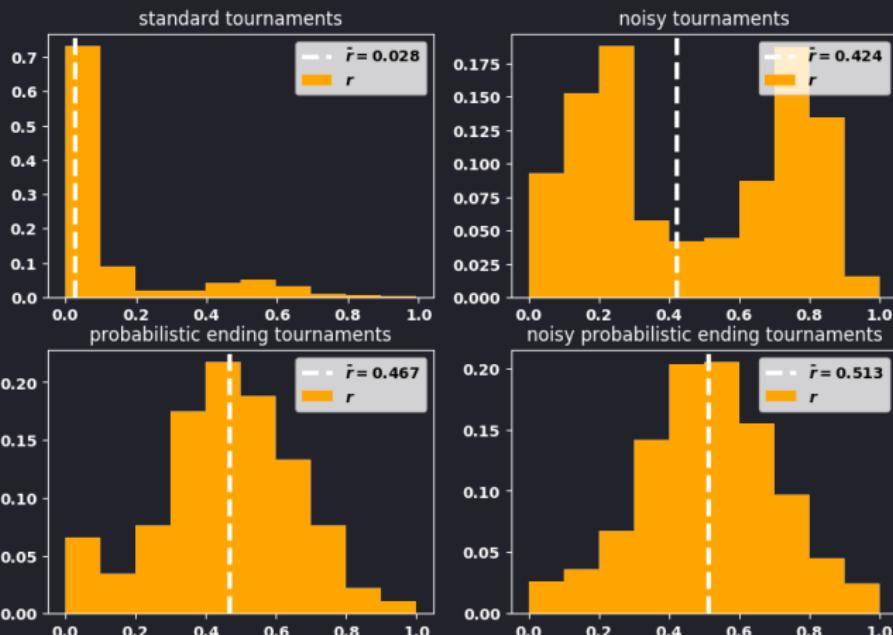


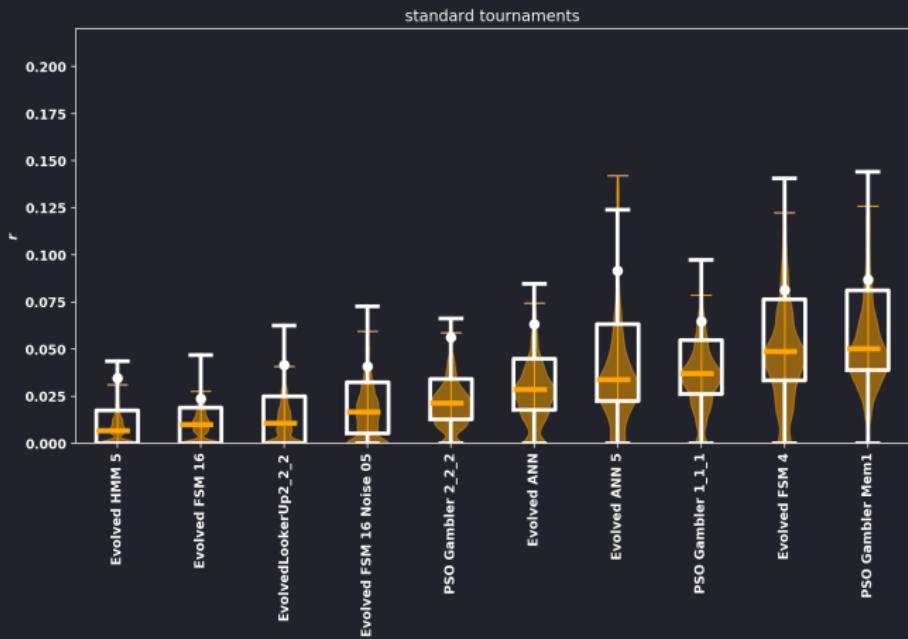
**195** strategies in **45686** tournaments

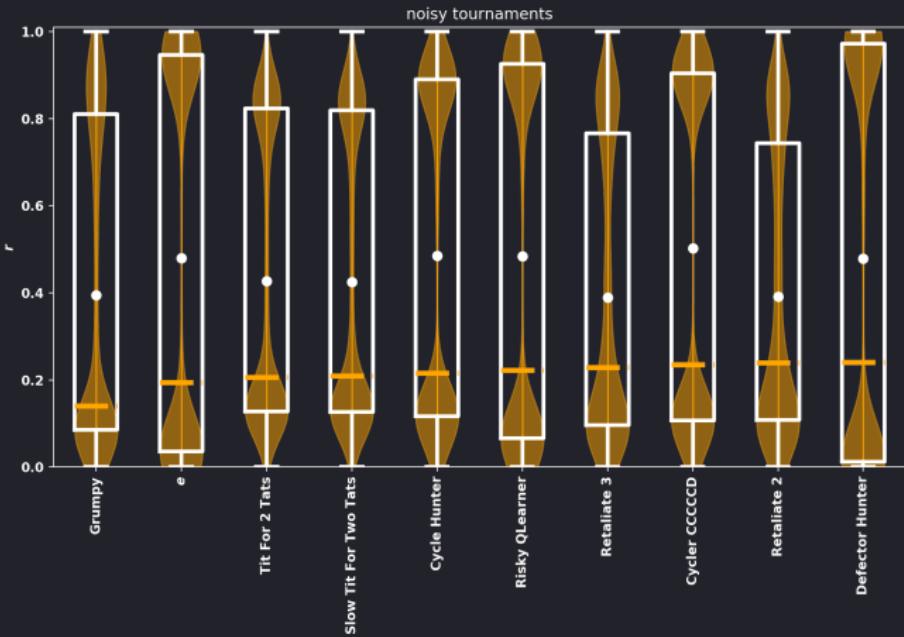
# Tit For Tat Performance

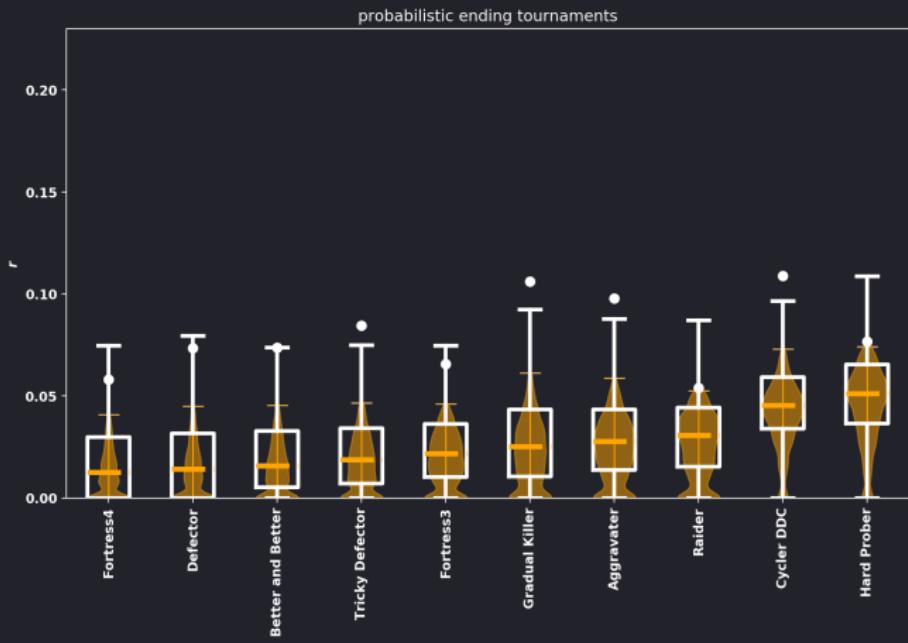


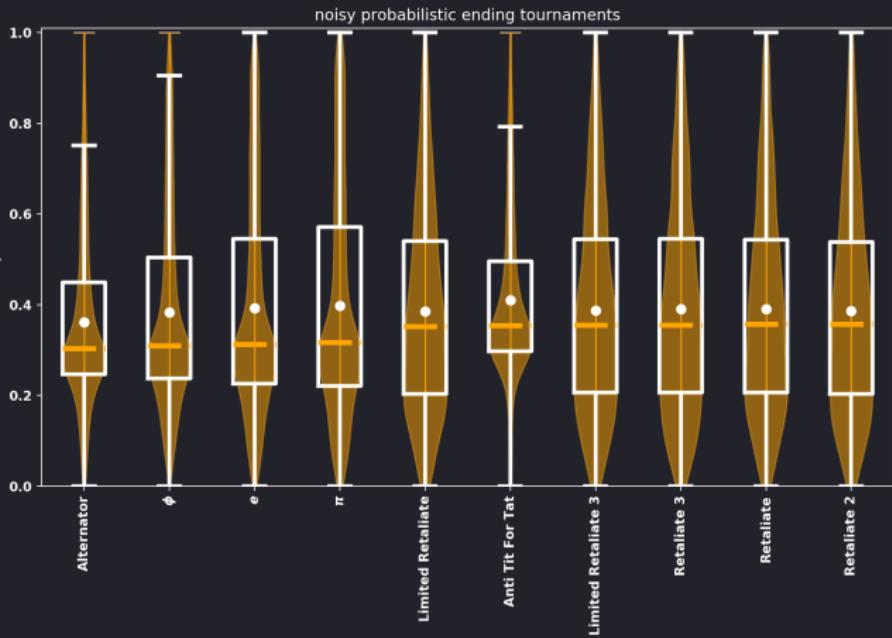
# Evolved FSM 16 Performance





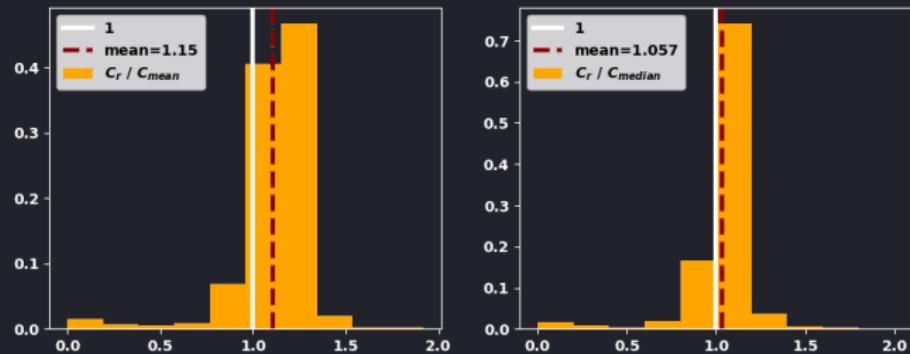






# Evolved FSM 16





“A meta analysis of tournaments and an evaluation of performance in the Iterated Prisoner’s Dilemma”

Nikoleta E. Glynatsi, Vincent A. Knight

arXiv:2001.05911

DOI:10.5281/zenodo.3516652

# Best Response Memory One Strategies





*CC*



*CD*



*DC*



*DD*

*CC*

*CD*

*DC*

*DD*

$$p = (p_1, p_2, p_3, p_4)$$

*CC*

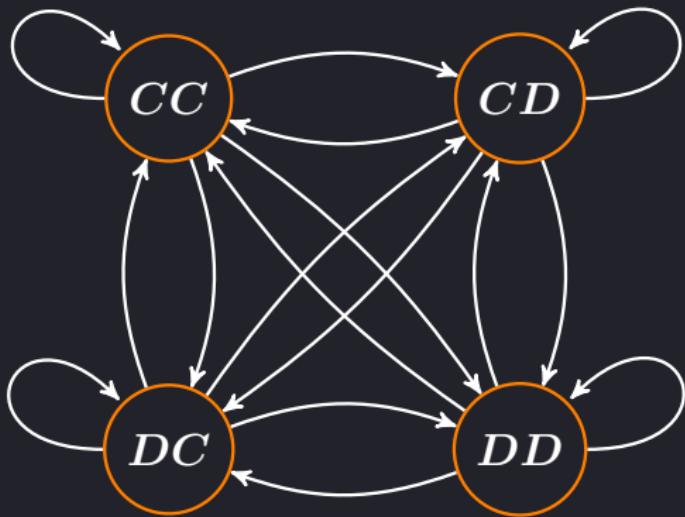
*CD*

*DC*

*DD*

$$p = (p_1, p_2, p_3, p_4)$$

$$q = (q_1, q_2, q_3, q_4)$$



$$p = (p_1, p_2, p_3, p_4)$$

$$q = (q_1, q_2, q_3, q_4)$$

$$u_q(p) = v \cdot (R,S,T,P)$$

$$u_q(p) = v \cdot (R, S, T, P)$$



$$u_q(p) = \frac{\frac{1}{2}pQp^T + cp + a}{\frac{1}{2}p\bar{Q}p^T + \bar{c}p + \bar{a}}$$

$$u_q(p) = v \cdot (R, S, T, P)$$



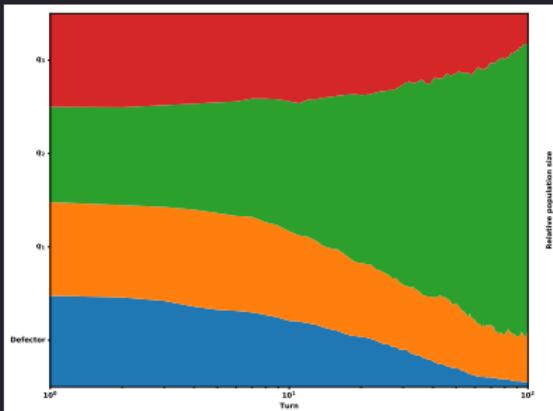
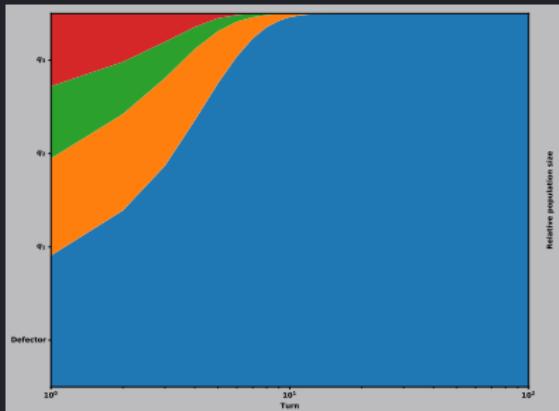
$$u_q(p) = \frac{\frac{1}{2}pQp^T + cp + a}{\frac{1}{2}p\bar{Q}p^T + \bar{c}p + \bar{a}}$$



$$\frac{1}{N} \sum_{i=1}^N u_q^{(i)}(p)$$

$$\sum_{i=1}^N (c^{(i)T}\bar{a}^{(i)} - \bar{c}^{(i)T}a^{(i)}) \leq 0$$

$$\sum_{i=1}^N (c^{(i)T} \bar{a}^{(i)} - \bar{c}^{(i)T} a^{(i)}) \leq 0$$

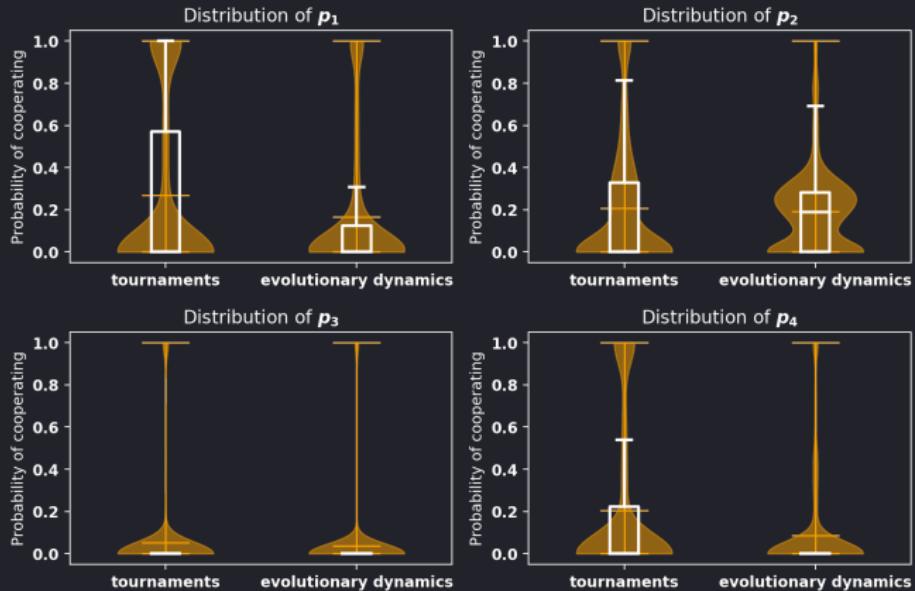


$$\sum_{i=1}^N u_q^{(i)}(p)$$

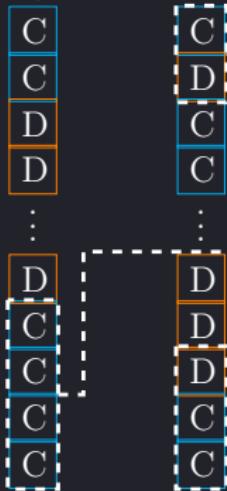
$$\sum_{i=1}^N u_q^{(i)}(p) \xrightarrow{\hspace{1cm}} \max_p : \sum_{i=1}^N u_q^{(i)}(p)$$

$$\sum_{i=1}^N u_q^{(i)}(p) \xrightarrow{\hspace{1cm}} \max_p : \sum_{i=1}^N u_q^{(i)}(p)$$

$$\sum_{i=1}^N u_q^{(i)}(p) + u_p(p) \xrightarrow{\hspace{1cm}} \max_p : \sum_{i=1}^N u_q^{(i)}(p) + u_p(p)$$

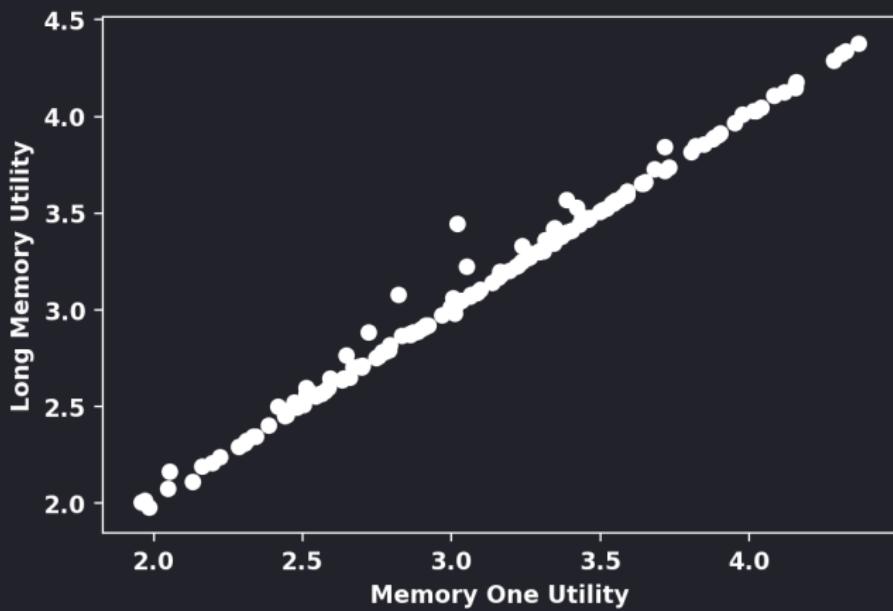


Player      Opponent



CD  
CCCC  
DCC

$(p_c, p_d)$



# “Stability of defection, optimisation of strategies and the limits of memory in the Prisoner’s Dilemma”

Nikoleta E. Glynatsi, Vincent A. Knight

arXiv:1911.12112

# Best Response Sequences



	1	2	3	4	5	$U$
Tit For Tat	$C$	$D$	$D$	$D$	$D$	0.8
Defector	$D$	$D$	$D$	$D$	$D$	1.8

1      2      3      4      5       $U$

Tit For Tat

Best response

1      2      3      4      5       $U$

Tit For Tat

Best response

	1	2	3	4	5	$U$
Tit For Tat	$C$	$C$	$C$	$C$	$C$	2.5
Best response	$C$	$C$	$C$	$C$	$D$	3.3





## Heuristics



	Heuristics	$R^{205}$
	Tit For Tat →	→ [C, C, C, C, ...]
	Alternator →	→ [D, D, D, D, ...]
	AntiTitForTat →	→ [D, D, D, D, ...]
	Random →	→ [D, D, D, D, ...]
	Cooperator →	→ [D, D, D, D, ...]
	Defector →	→ [D, D, D, D, ...]
197	SuspiciousTitForTat →	→ [C, C, C, C, ...]
	WinShiftLoseStay →	→ [C, D, D, D, ...]
	⋮	
	Evolved FSM 16 →	→ [D, C, D, D, ...]

197

**Heuristics** $R^{205}$ 

<b>Tit For Tat</b>	→	→ [C, C, C, C, ...]
<b>Alternator</b>	→	→ [D, D, D, D, ...]
<b>AntiTitForTat</b>	→	→ [D, D, D, D, ...]
<b>Random<sup>seed1</sup></b>	→	→ [D, D, D, D, ...]
<b>Random<sup>seed2</sup></b>	→	→ [D, D, D, D, ...]
<b>Random<sup>seed3</sup></b>	→	→ [D, D, D, D, ...]
<b>Cooperator</b>	→	→ [D, D, D, D, ...]
<b>Defector</b>	→	→ [D, D, D, D, ...]
<b>SuspiciousTitForTat</b>	→	→ [C, C, C, C, ...]
<b>WinShiftLoseStay</b>	→	→ [C, D, D, D, ...]
⋮		
<b>Evolved FSM 16</b>	→	→ [D, C, D, D, ...]

755  
197

## Heuristics

$R^{205}$

**Tit For Tat** →

→ [C, C, C, C, ...]

**Alternator** →

→ [D, D, D, D, ...]

**AntiTitForTat** →

→ [D, D, D, D, ...]

**Random<sup>seed1</sup>** →

→ [D, D, D, D, ...]

**Random<sup>seed2</sup>** →

→ [D, D, D, D, ...]

**Random<sup>seed3</sup>** →

→ [D, D, D, D, ...]

**Cooperator** →

→ [D, D, D, D, ...]

**Defector** →

→ [D, D, D, D, ...]

**SuspiciousTitForTat** →

→ [C, C, C, C, ...]

**WinShiftLoseStay** →

→ [C, D, D, D, ...]

⋮

**Evolved FSM 16** →

→ [D, C, D, D, ...]

# “Training Recurrent Neural Network strategies for Iterated Prisoner’s Dilemma”

DOI:10.5281/zenodo.3516652

# Recurrent Neural Network Player

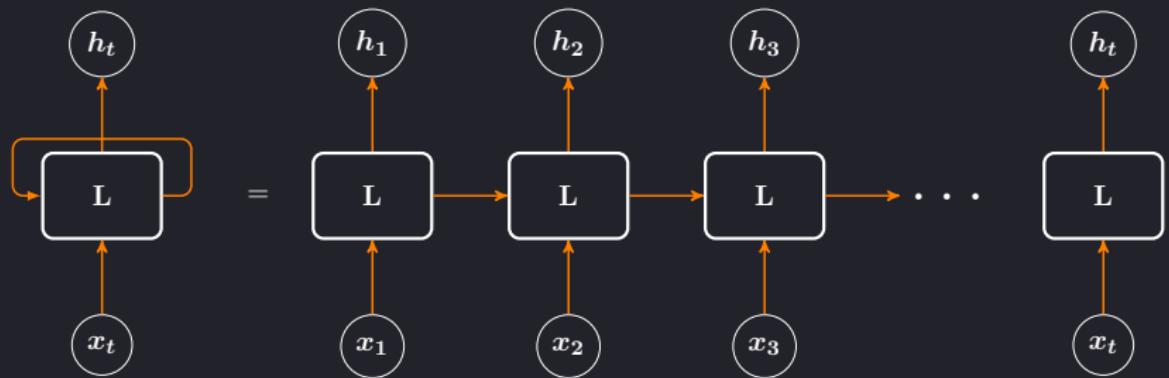


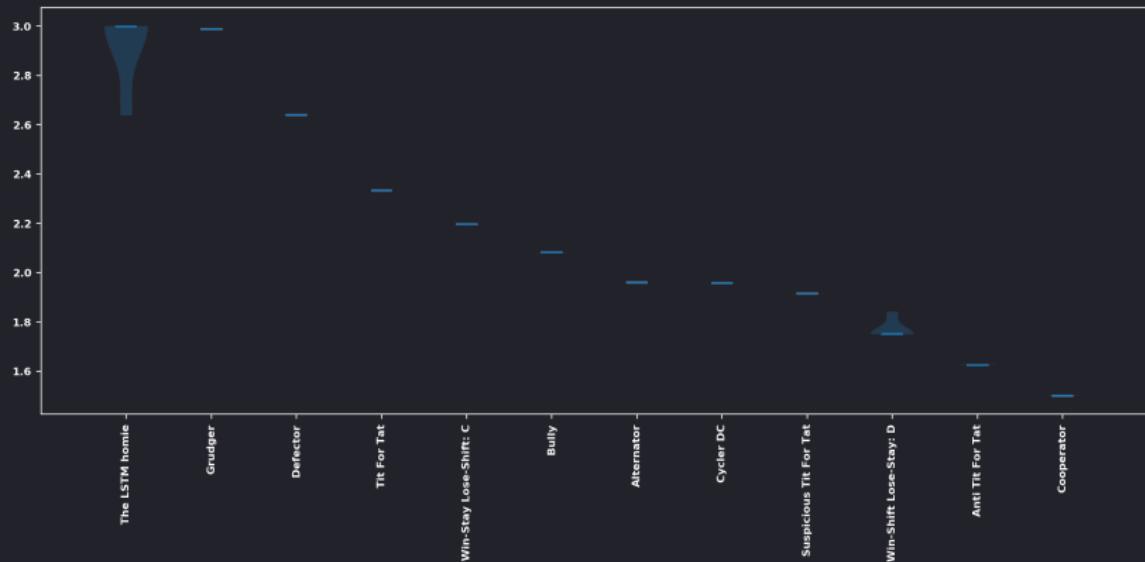




Reinforcement learning produces dominant strategies for the Iterated Prisoner's Dilemma: <https://doi.org/10.1371/journal.pone.0188046>







# 5 TOPICS & AUTHORS ARE COLLABORATIVE

IDENTIFY THE MEAN COOPERATOR  
& ADJUST TO THEM

TO BE ES YOU MUST BE FORGIVING

A LONGER MEMORY IS BENEFICIAL

**RECOGNITION MECHANISMS ARE  
BENEFICIAL**

Manager strategies		
Poacher strategies	Horn devalued	Horn intact
Selective		
Indiscriminate		





- nikoleta-v3.github.io
- ⌚ [github.com/ArcasProject/Arcas](https://github.com/ArcasProject/Arcas)
- ⌚ [github.com/Nikoleta-v3/bibliometric-study-of-the-prisoners-dilemma](https://github.com/Nikoleta-v3/bibliometric-study-of-the-prisoners-dilemma)
- ⌚ [github.com/Nikoleta-v3/meta-analysis-of-prisoners-dilemma-tournaments](https://github.com/Nikoleta-v3/meta-analysis-of-prisoners-dilemma-tournaments)
- ⌚ [github.com/Nikoleta-v3/Memory-size-in-the-prisoners-dilemma](https://github.com/Nikoleta-v3/Memory-size-in-the-prisoners-dilemma)
- arXiv:2001.05911
- arXiv:1911.12112
- arXiv:1911.06128