Exploiting Evolutionary Modeling to Prevail in Iterated Prisoner's Dilemma Tournaments

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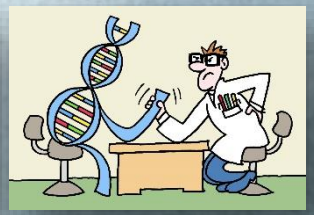
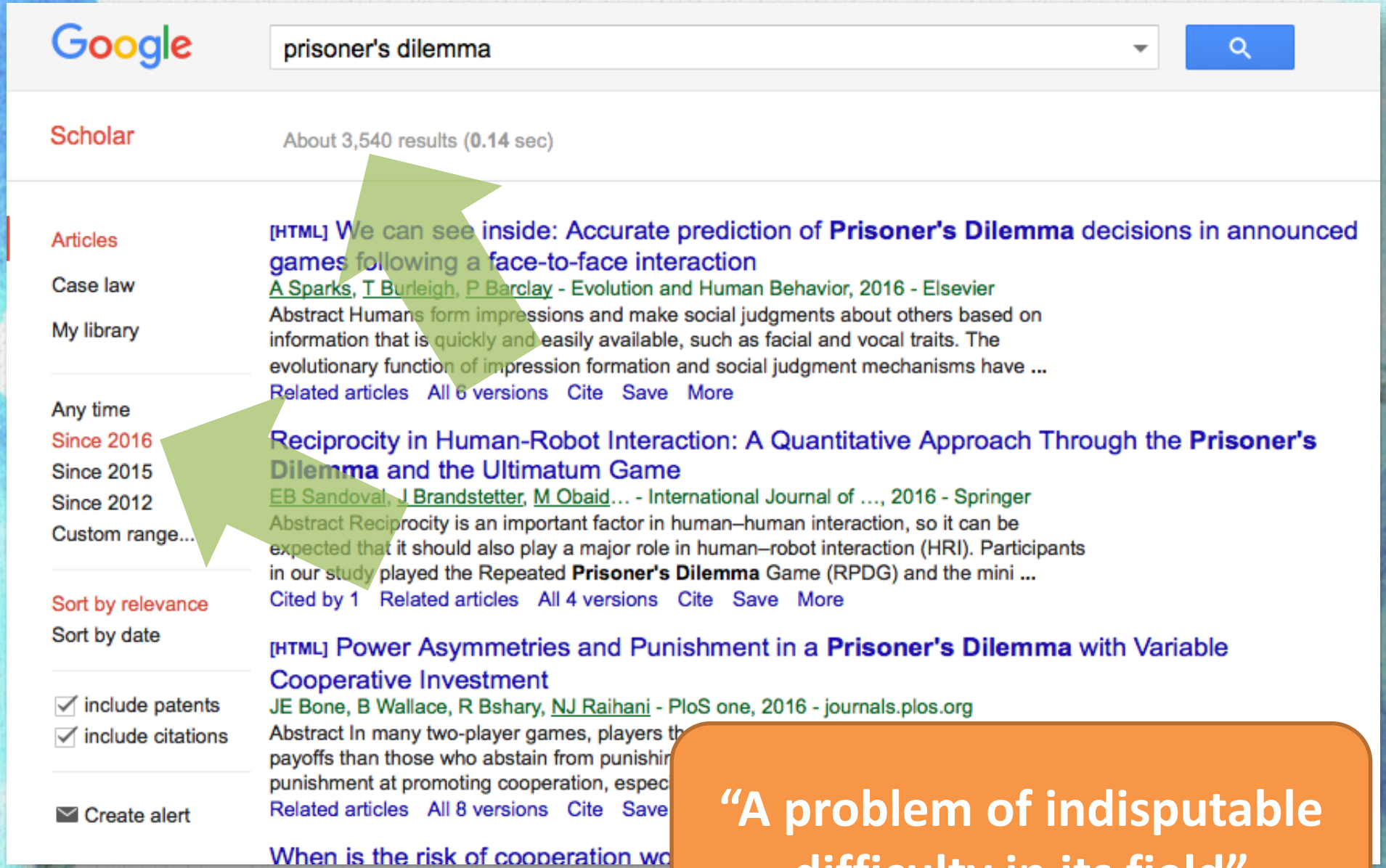
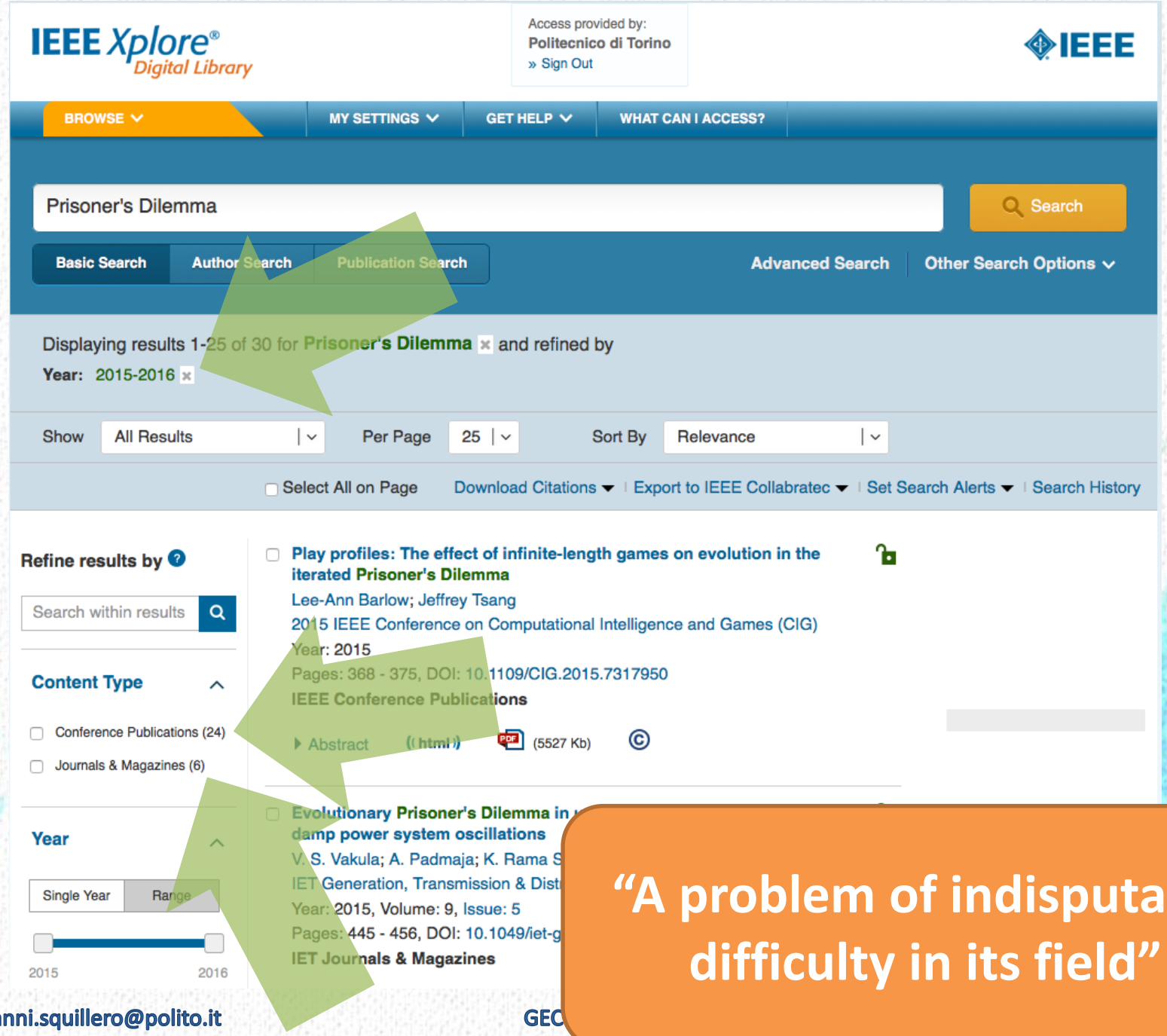


Iterated Prisoner's Dilemma

Player A \ Player B	Defection	Cooperation
Defection	(**P**: 1, **P**: 1)	(**T**: 5, **S**: 0)
Cooperation	(**S**: 0, **T**: 5)	(**R**: 3, **R**: 3)



"A problem of indisputable difficulty in its field"



"A problem of indisputable difficulty in its field"

Proposed Approach

TAGES

Proposed Approach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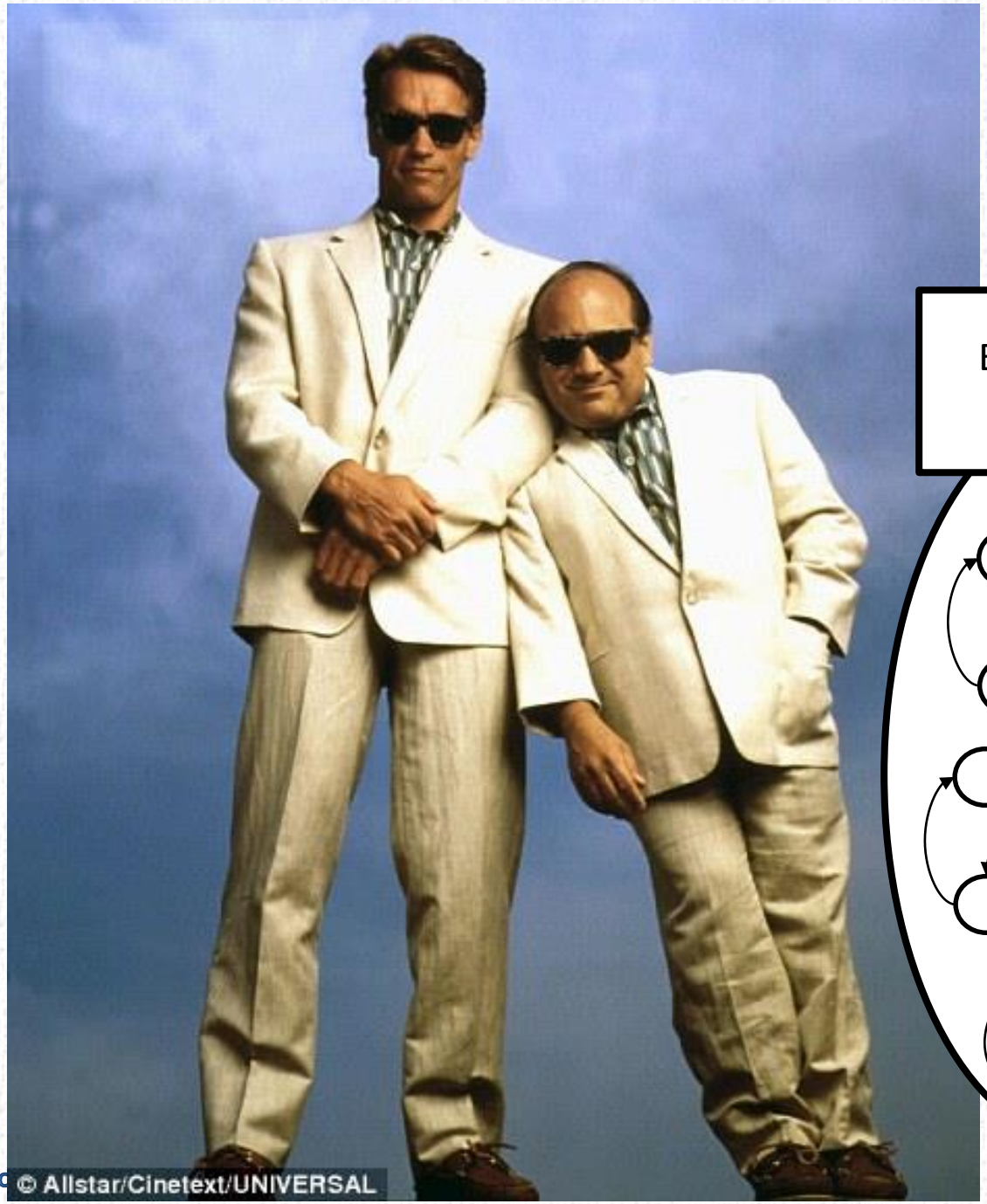
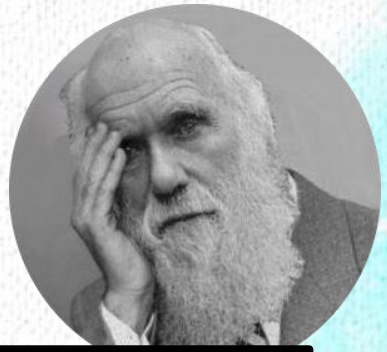
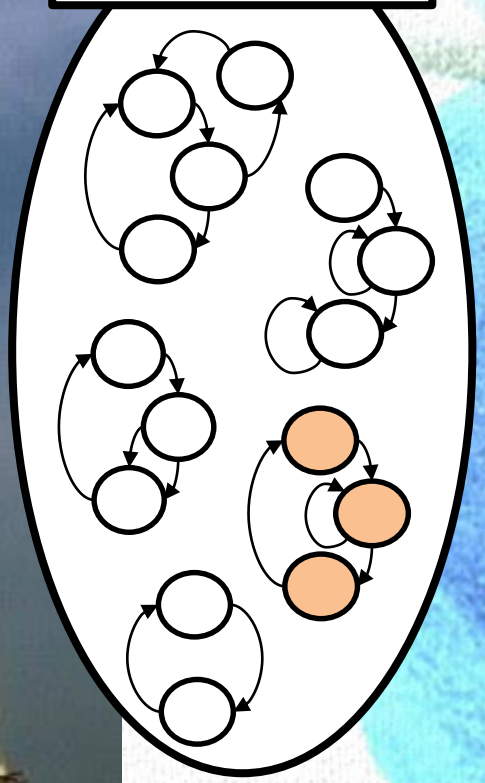
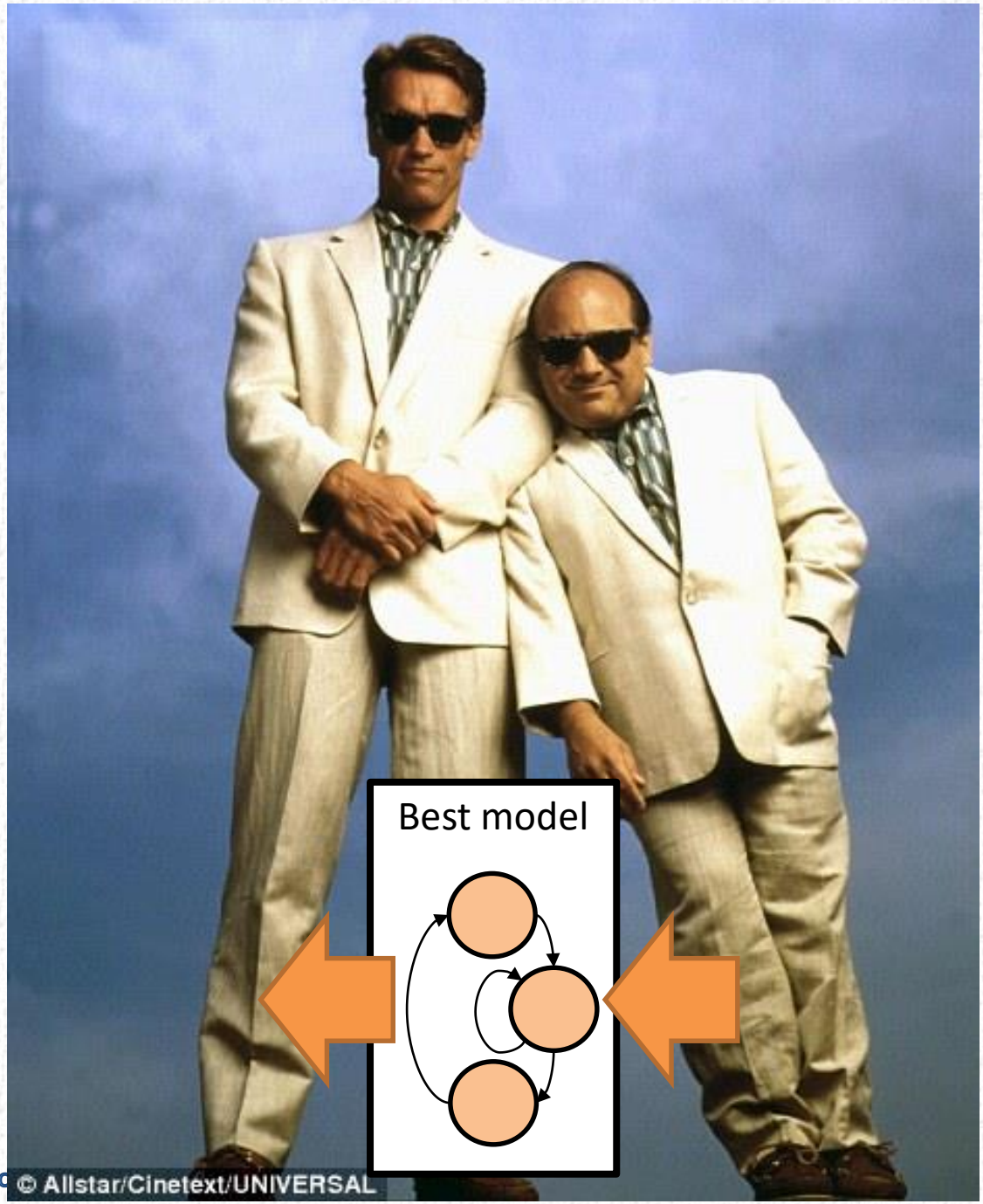




Evolutionary Algorithm




Best model
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Brute force approach
(try all possibilities)

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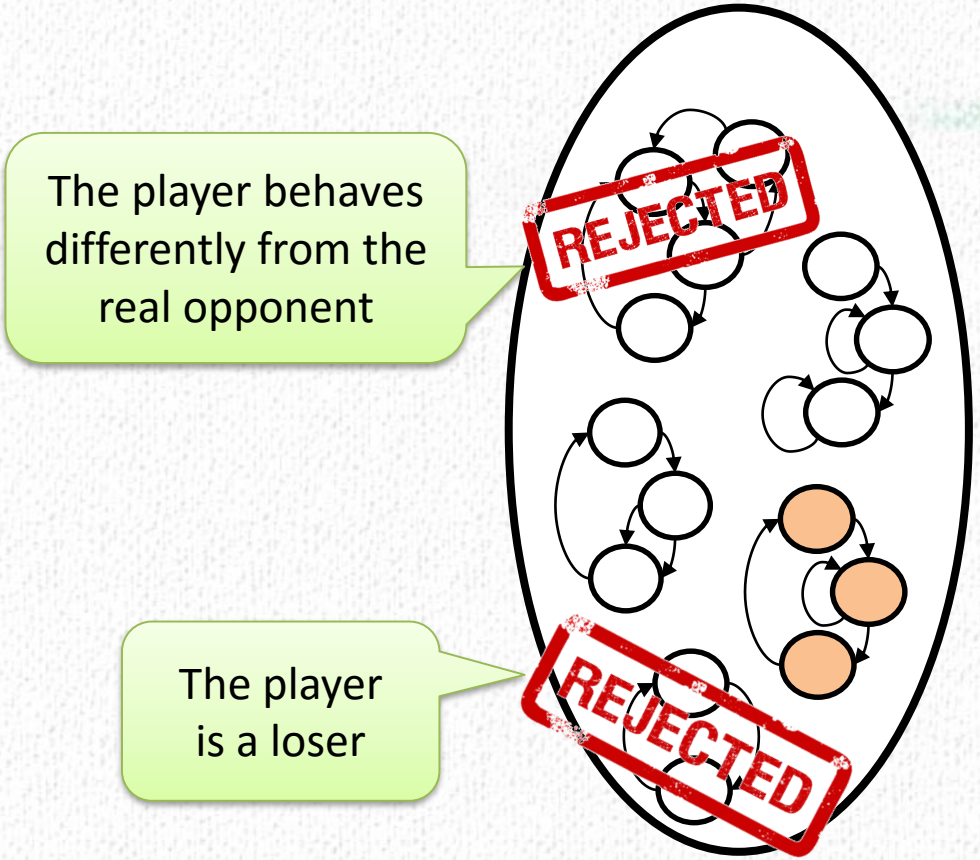
Etruscan Mythology

- Laran (2011)
  - First prototype based on FSM
- Turan (2014)
  - First prototype based on ND-FSM
- Tages (2016)

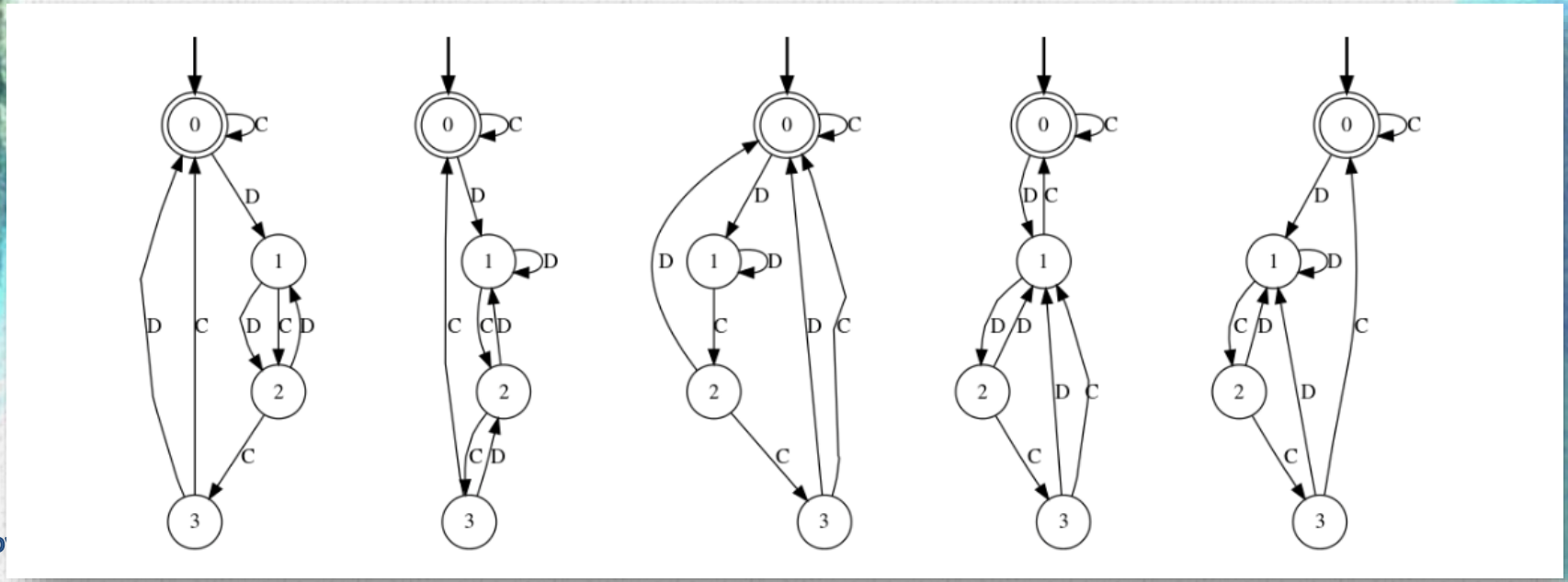
Etruscan Mythology

- **Turan:** Only strong players can be good models



Etruscan Mythology

- **Turan:** Only strong players can be good models
- **Laran:** Models don't need to be exact to be useful



Etruscan Mythology

- **Turan:** Only strong players can be good models
- **Laran:** Models don’t need to be exact to be useful
- **Laran:** Lose a match, win the tournament

Opponent name	Tages		Opponent		Model	
	$\overline{P}$	P_σ	$\overline{P}$	P_σ	$\overline{E}$	E_σ
2TFT	2.89	0.04	2.98	0.02	0.97	0.01
ATFT	3.10	0.29	2.34	0.23	0.88	0.07
CTFT	3.00	0.00	2.77	0.18	0.99	0.00
GTFT $\epsilon = 0.05$	2.94	0.04	2.92	0.07	0.97	0.02
GTFT $\epsilon = 0.1$	2.89	0.20	2.83	0.27	0.92	0.14
GTFT $\epsilon = 0.33$	2.89	0.11	2.41	0.55	0.70	0.33
HTF2T	3.77	0.06	1.61	0.03	0.97	0.00
HTFT2	2.88	0.04	2.97	0.02	0.97	0.01
HTFT3	2.84	0.07	3.00	0.03	0.96	0.01
NP	2.48	0.13	2.85	0.12	0.82	0.13
NPM	2.94	0.05	2.94	0.06	0.97	0.03
OTFT	1.89	1.04	2.29	0.65	0.96	0.02
RP $\epsilon = 0.01$	2.91	0.07	2.94	0.07	0.97	0.01
RP $\epsilon = 0.1$	2.44	0.12	2.63	0.19	0.67	0.18
RTFT	4.92	0.04	0.04	0.03	0.98	0.00
STFT	2.94	0.03	2.96	0.03	0.99	0.00
TF2T	3.88	0.04	1.56	0.02	0.97	0.00
TFT	2.96	0.01	2.96	0.01	0.98	0.00

Strategy	Tages		Opponent		Model	
	$\overline{P}$	P_σ	$\overline{P}$	P_σ	$\overline{E}$	E_σ
ADP	0.97	0.03	1.49	0.12	0.98	0.00
APAV	1.89	0.78	2.41	0.50	0.79	0.20
ATFT	3.26	0.21	2.28	0.31	0.92	0.05
CTFT	3.00	0.00	2.83	0.13	0.99	0.00
FBF	3.00	0.00	2.83	0.11	0.99	0.00
GRD	2.82	0.14	2.96	0.06	0.93	0.04
HM	2.72	1.18	1.85	0.47	0.97	0.04
OTFT	1.85	1.07	2.24	0.70	0.96	0.02
PAV	4.97	0.02	0.04	0.02	0.99	0.00
SG	2.91	0.04	2.97	0.02	0.97	0.01
SM	3.59	0.20	1.80	0.16	0.95	0.03

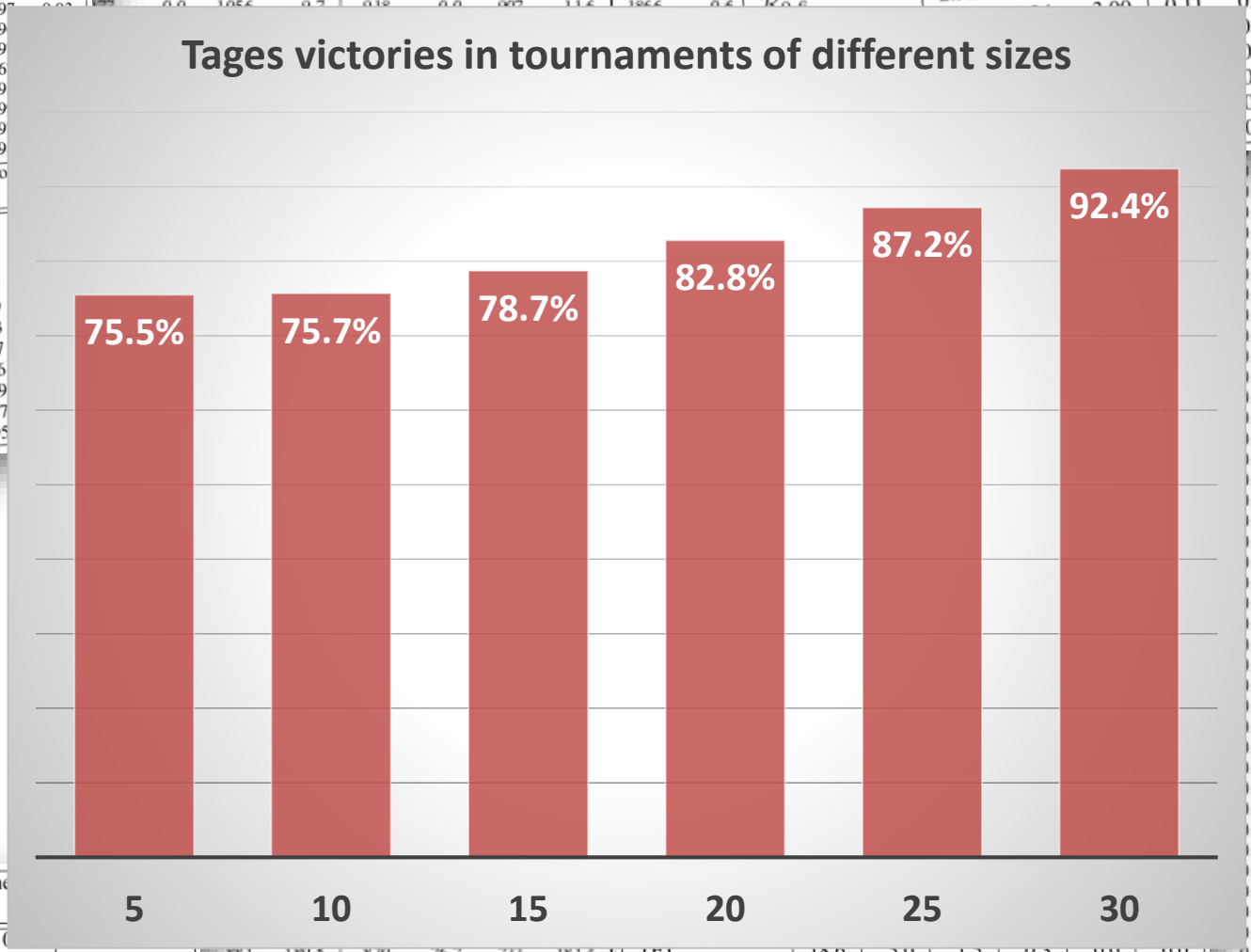
Parameters		Tages		Opponent		Model	
$\mathcal{G}$	μ	$\overline{P}$	P_σ	$\overline{P}$	P_σ	$\overline{E}$	E_σ
300	100	1.41	0.12	1.37	0.11	0.23	0.08
30	100	1.30	0.14	1.32	0.12	0.08	0.06
300	10	1.49	0.15	1.38	0.15	0.12	0.05
30	10	1.62	0.11	2.06	0.13	0.32	0.09

Opponent name	Payoff			Model	
	$\overline{P}$	P_σ	P_{opt}	$\overline{E}$	E_σ
CD	2.91	0.04	3.00	0.99	0.00
CCD	3.57	0.02	3.67	0.97	0.01
DDC	2.19	0.02	2.33	0.97	0.01
$\mathcal{R}_{1.0}$ (AC)	4.98	0.01	5.00	1.00	0.00
$\mathcal{R}_{0.9}$	4.54	0.18	4.60	0.46	0.22
$\mathcal{R}_{0.8}$	3.97	0.26	4.20	0.33	0.18
$\mathcal{R}_{0.7}$	3.43	0.44	3.80	0.12	0.06
$\mathcal{R}_{0.6}$	2.92	0.14	3.40	0.14	0.08
$\mathcal{R}_{0.5}$ (RND)	2.68	0.24	3.00	0.11	0.10
$\mathcal{R}_{0.4}$	2.14	0.17	2.60	0.16	0.04
$\mathcal{R}_{0.3}$	1.83	0.12	2.20	0.14	0.08
$\mathcal{R}_{0.2}$	1.51	0.11	1.80	0.25	0.06
$\mathcal{R}_{0.1}$	1.01	0.15	1.40	0.56	0.05
$\mathcal{R}_{0.0}$ (AD)	0.86	0.03	1.00	1.00	0.00

Player						
2TFT						
AC	28.1	10.4	2.8	0.5	0.0	0.0
AD	19.3	1.1	0.0	0.0	0.0	0.0
ADP	33.0	17.1	7.7	2.4	0.3	0.0
APAV	19.5	5.0	1.2	0.1	0.0	0.0
ATFT	29.4	10.3	3.5	0.7	0.1	0.0
CTFT	20.3	6.7	2.2	0.6	0.1	0.0
EXT2	1.6	0.0	0.0	0.0	0.0	0.0
FBF	19.7	6.7	2.2	0.6	0.1	0.0
FRT3	12.1	1.5	0.1	0.0	0.0	0.0
FRT4	15.1	2.2	0.2	0.0	0.0	0.0
GRD	26.5	14.3	6.8	2.4	0.5	0.0
GRM	19.5	7.7	1.6	0.1	0.0	0.0
GTFT $\epsilon = 0.05$	32.5	25.4	18.9	12.4	6.4	2.6
GTFT $\epsilon = 0.1$	36.3	33.1	29.4	23.1	16.7	10.5
GTFT $\epsilon = 0.33$	40.0	36.0	31.4	25.0	18.1	10.8
HM	2.0	0.0	0.0	0.0	0.0	0.0
HTF2T	26.4	9.2	2.4	0.4	0.0	0.0
HTFT2	13.2	1.3	0.1	0.0	0.0	0.0
HTFT3	17.9	3.1	0.5	0.0	0.0	0.0
NP	2.7	0.0	0.0	0.0	0.0	0.0
OTFT	36.2	30.3	27.3	22.9	15.6	6.9
PAV	29.4	11.5	3.6	0.7	0.1	0.0
PRO	1.1	0.0	0.0	0.0	0.0	0.0
RND	6.1	0.1	0.0	0.0	0.0	0.0
RP $\epsilon = 0.01$	6.5	0.2	0.0	0.0	0.0	0.0
RP $\epsilon = 0.1$	5.1	0.1	0.0	0.0	0.0	0.0
RTFT	11.0	1.2	0.0	0.0	0.0	0.0
SG	25.2	12.7	6.3	2.7	0.8	0.1
SM	36.5	20.9	11.8	5.6	1.8	0.3
STF2T	31.3	12.0	3.5	0.8	0.1	0.0
STFT	3.0	0.1	0.0	0.0	0.0	0.0
Tages	**75.5**	**75.7**	**78.7**	**82.8**	**87.2**	**92.4**
TFT	18.6	5.0	1.5	0.3	0.0	0.0
ZDE	2.1	0.0	0.0	0.0	0.0	0.0
ZDF	2.8	0.0	0.0	0.0	0.0	0.0
ZDG	22.4	8.9	2.9	0.6	0.1	0.0

average over 100,000 random tournaments for each tournament size

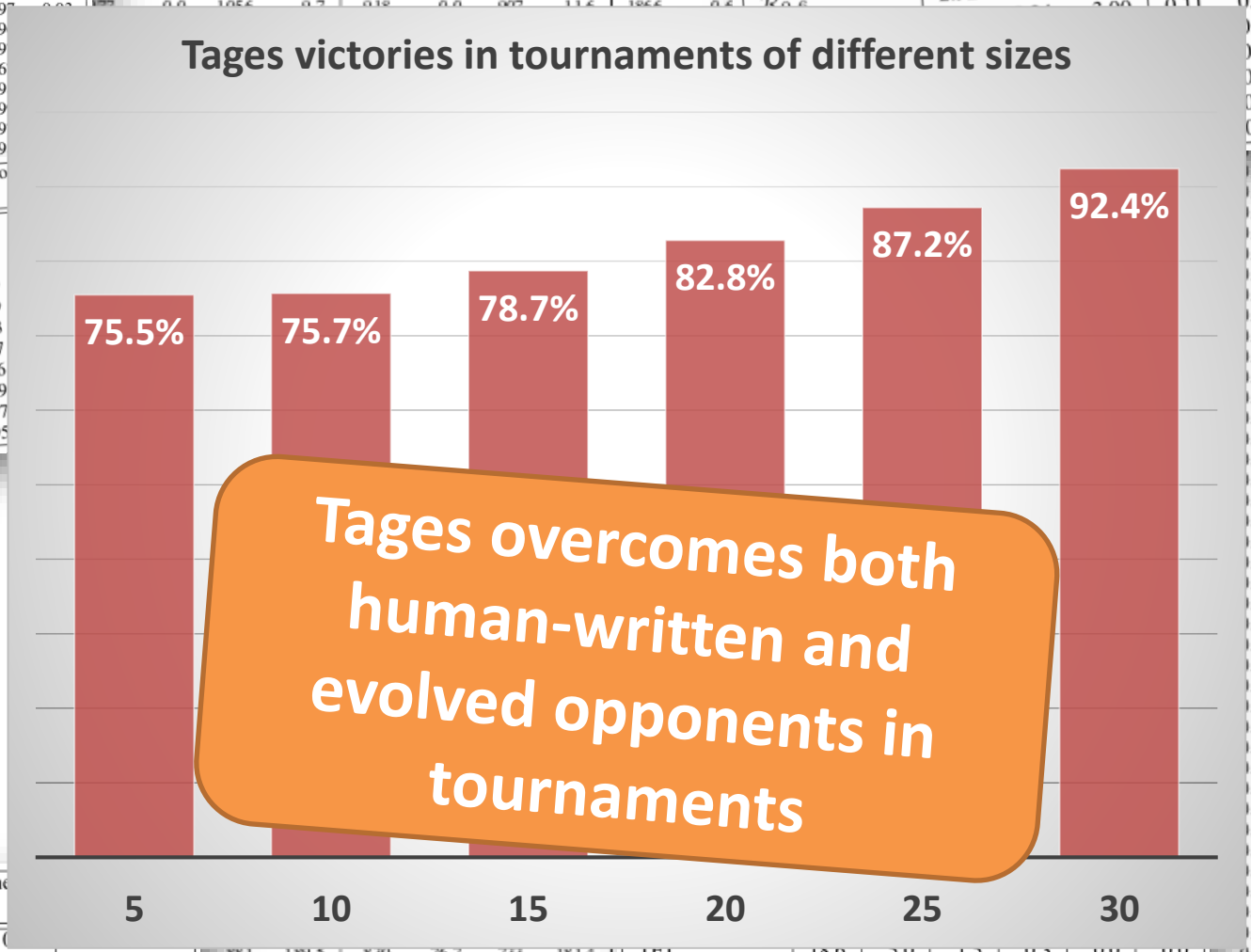
40 opponents (all the usual suspects + others)



Why we deserve the prize?

average over 100,000 random tournaments for each tournament size

40 opponents (all the usual suspects + others)



Tages overcomes both human-written and evolved opponents in tournaments

Why we deserve the prize?

average over 100,000 random tournaments for each tournament size

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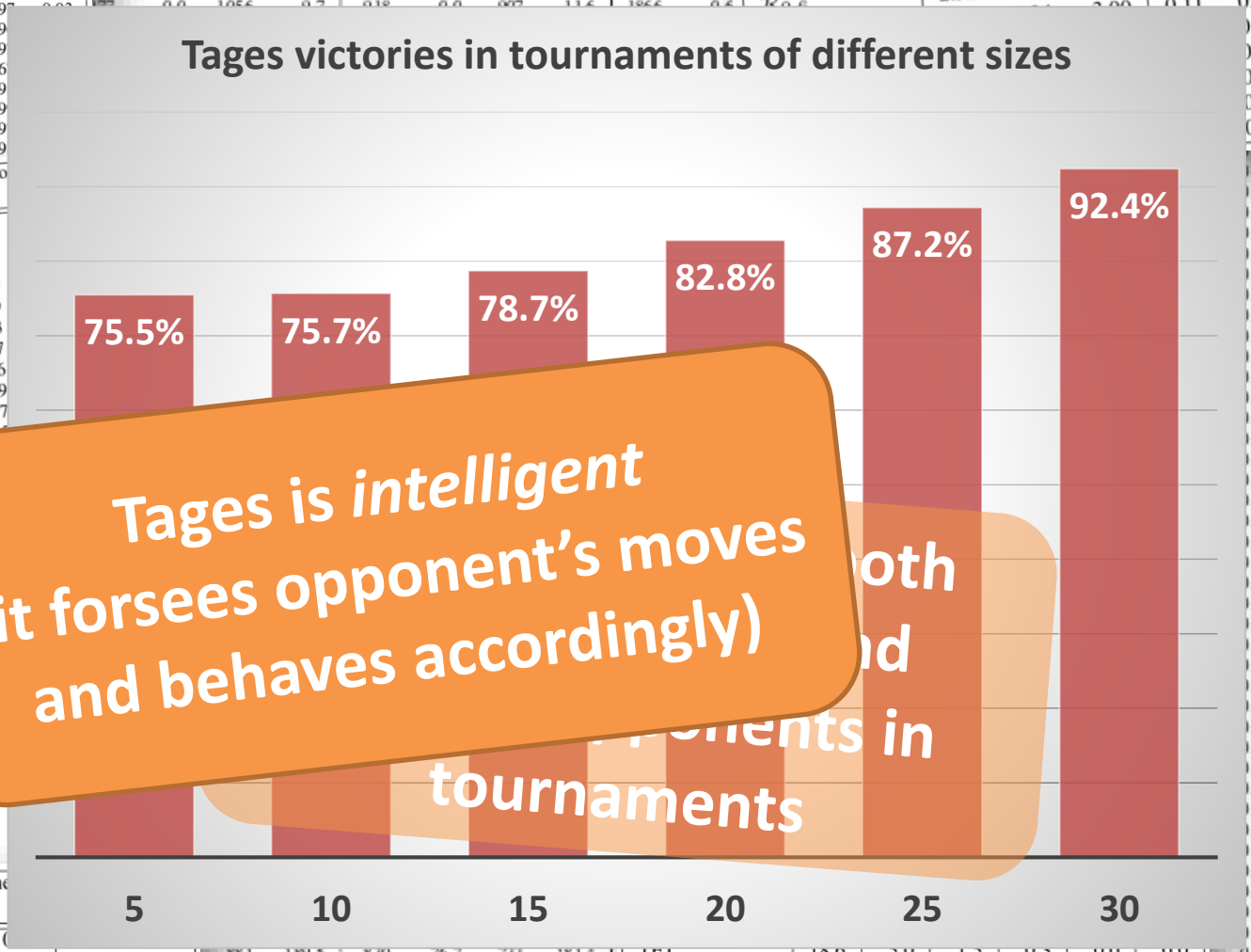

Tages is *intelligent*
(it forsees opponent's moves and behaves accordingly)

…oth …d …ponents in tournaments

Thanks

- HPC@POLITO (computational resources)
- Andrea Mussano (Laran)

- Denny De Vito (presentation)
- Arnold Schwarzenegger (presentation)