Navigating social dilemmas

Adaptations to infer fitness interdependence promote the evolution of cooperation

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From social dilemmas to ecologies of games

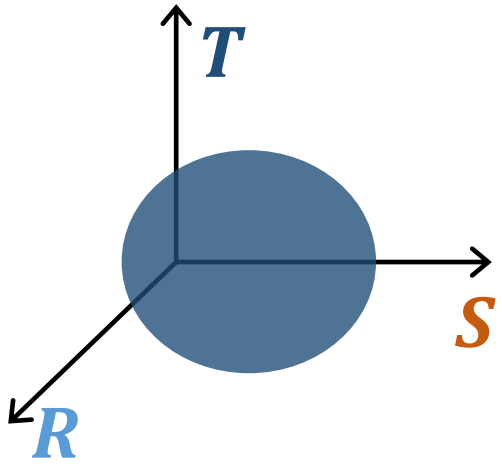
Standard game-theoretical approach:

- Consider a social dilemma
- Investigate stable strategies/evolutionary dynamics
- What factors promote cooperation?

	C	D
C	R	S
D	T	P

Human societies:

- Many different situations with varying levels of interdependence
- Heterogeneous ecologies/distributions of games
- How does this impact cooperation?

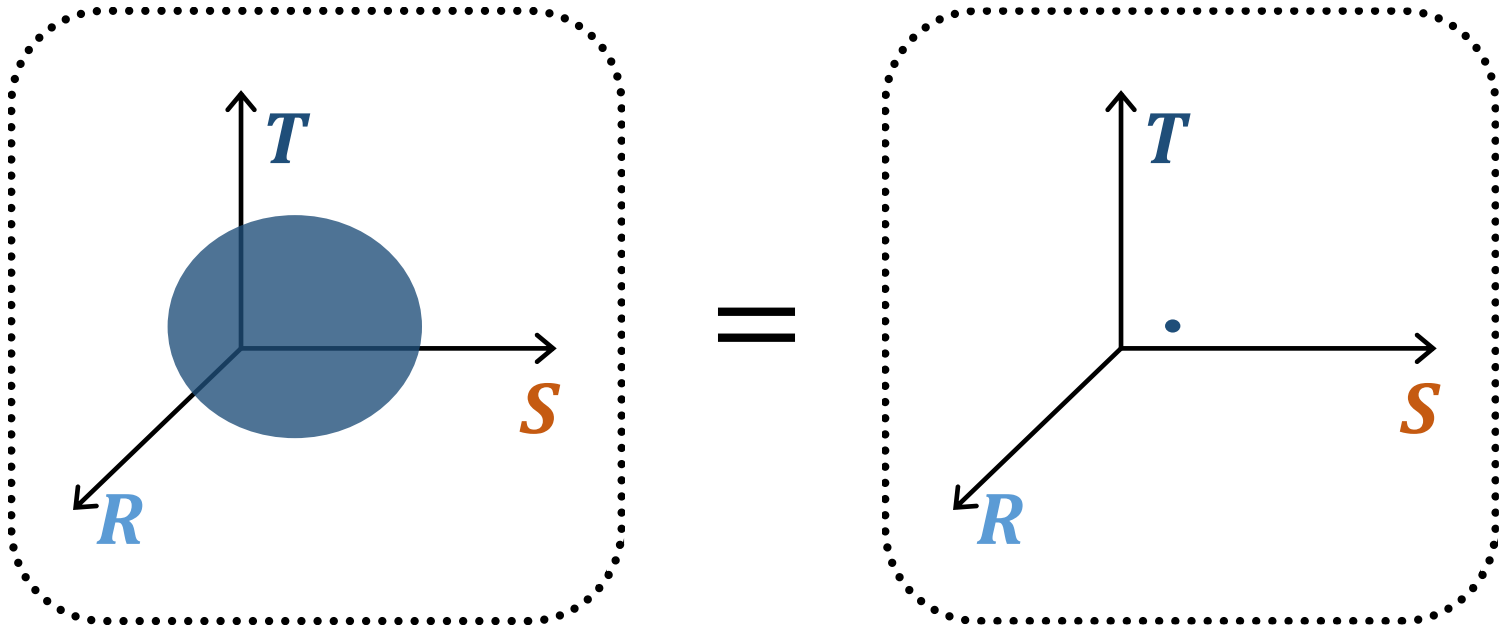


Heterogeneity and cooperation

No impact on cooperation IF:

- Unstructured populations
- Behavior does not depend on the features of interactions

(Amaral et al., J Phys A, 2015)



Interdependence theory

(Kelley and Thibaut, 1978; Kelley et al., 2003; Balliet, Tybur, and Van Lange, 2017)

Humans infer interdependence to decide when and with whom to cooperate.

Initiate cooperation
Anger in response to defection
Punish cheaters
Condition behavior on trust
Monitor for cheaters

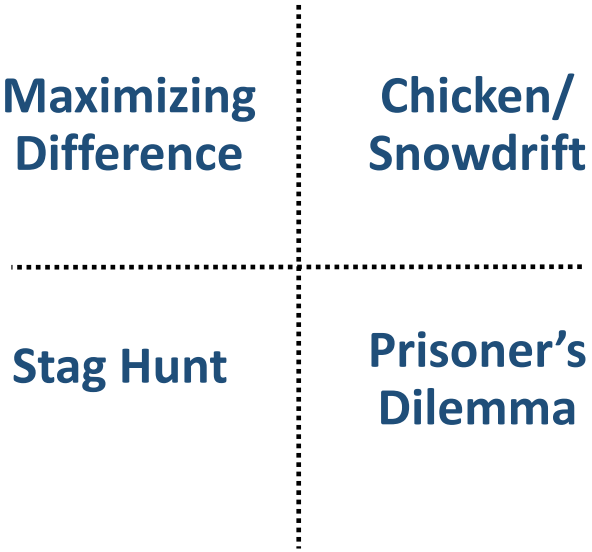
Variation in Interdependence → Inference → Adaptive behavior

→ Degree of conflict/correspondence of interests (Columbus et al., 2021; Balliet and Lindrstrom, 2023; Spadaro et al., 2022)

“Archetypal” games

(Rapoport, 1966; Halevy et al., 2012; Bruns and Kimmich, 2021)

Humans use archetypal social dilemmas to frame and classify different situations” (Halevy et al., 2012):



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Adaptations to infer fitness interdependence promote the evolution of cooperation

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Methods:

Evolutionary game theory on space of games (instead of single game)

Strategies contingent on game features

Theoretical contribution:

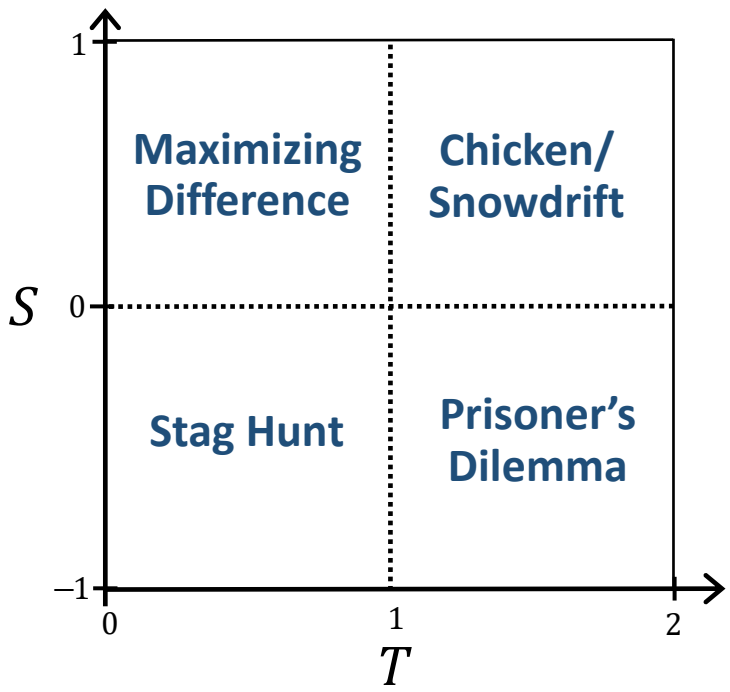
Bridge evolutionary game theory and interdependence theory:

- When do adaptations to infer interdependence evolve?
- What is their effect on cooperation?

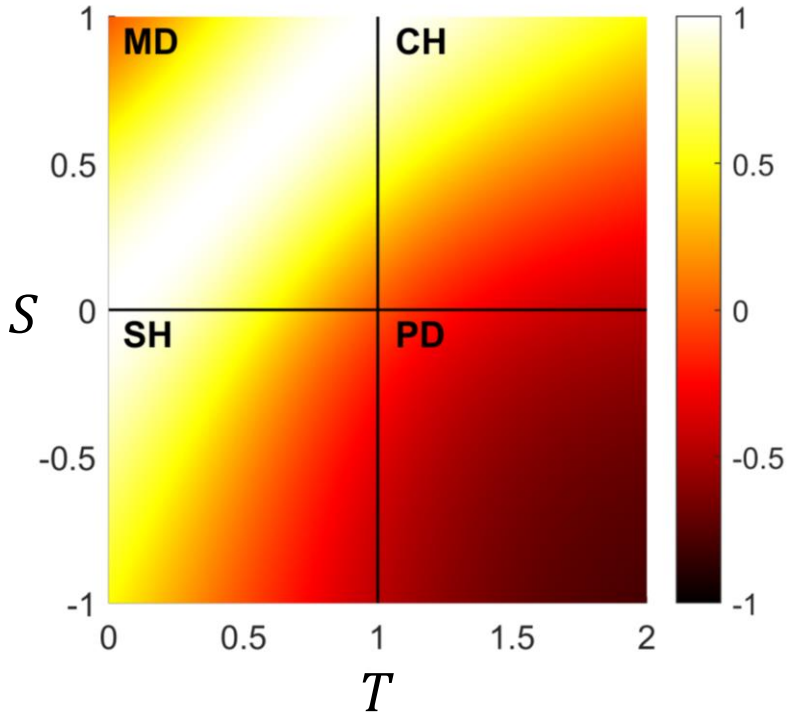
How to model an “ecology of games”?

	C	D
C	R	S
D	T	P

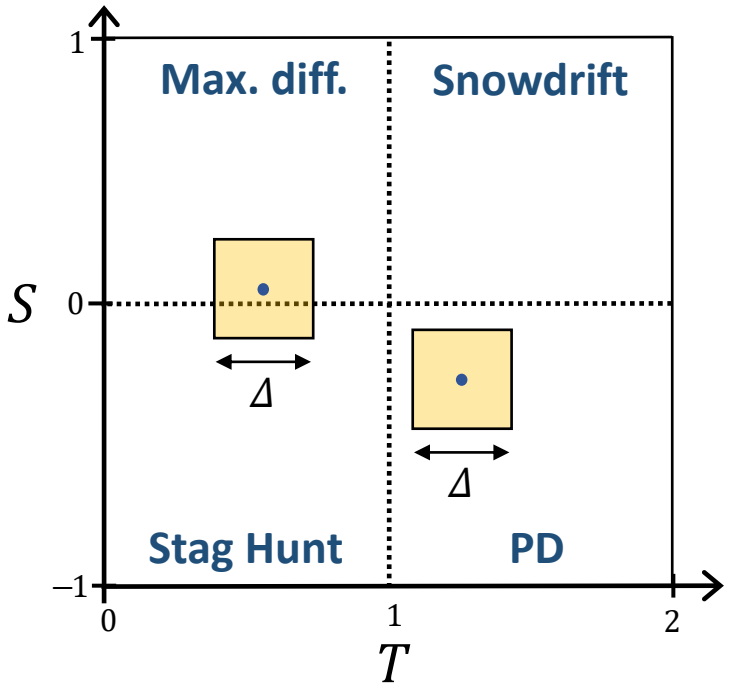
	C	D
C	1	S
D	T	0



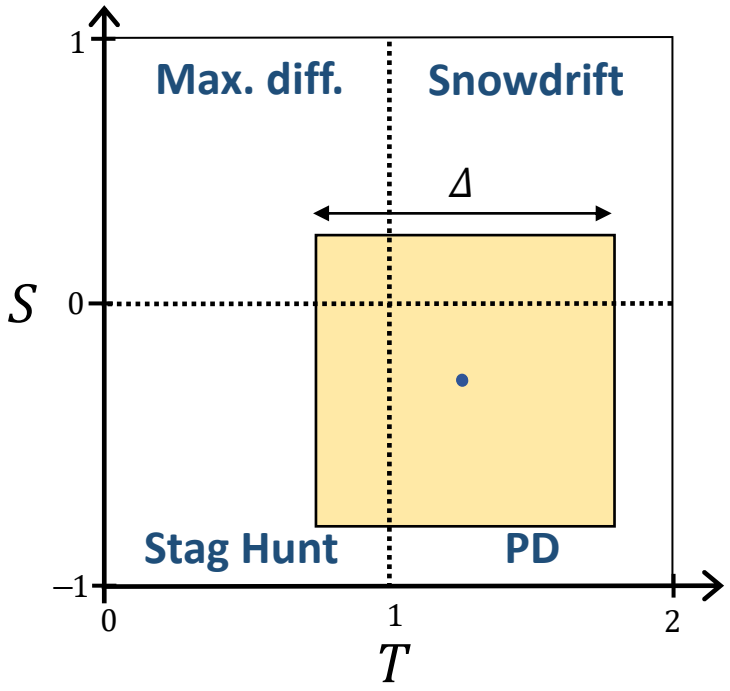
Correspondence of Interests



How to model an “ecology of games”?

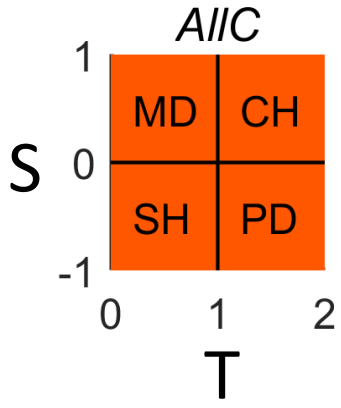


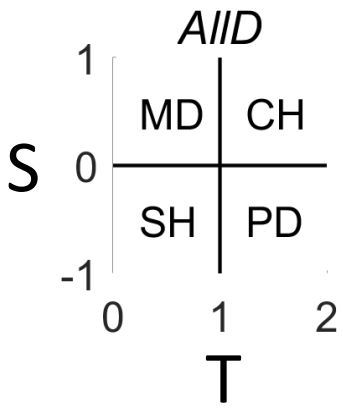
Low heterogeneity (Δ)



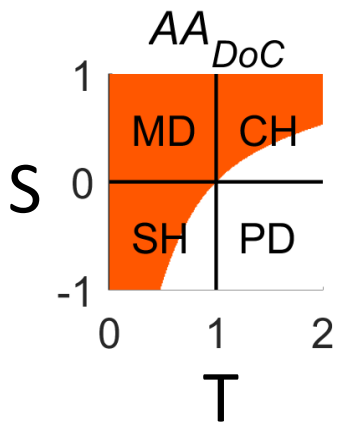
High heterogeneity (Δ)

Fixed-behavior vs adaptive agents

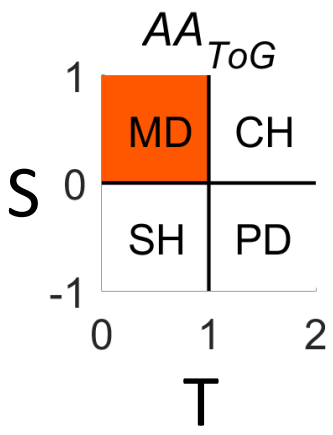




No inference



Degree of Correspondence Inference (costly)



Type of game Inference (costly)

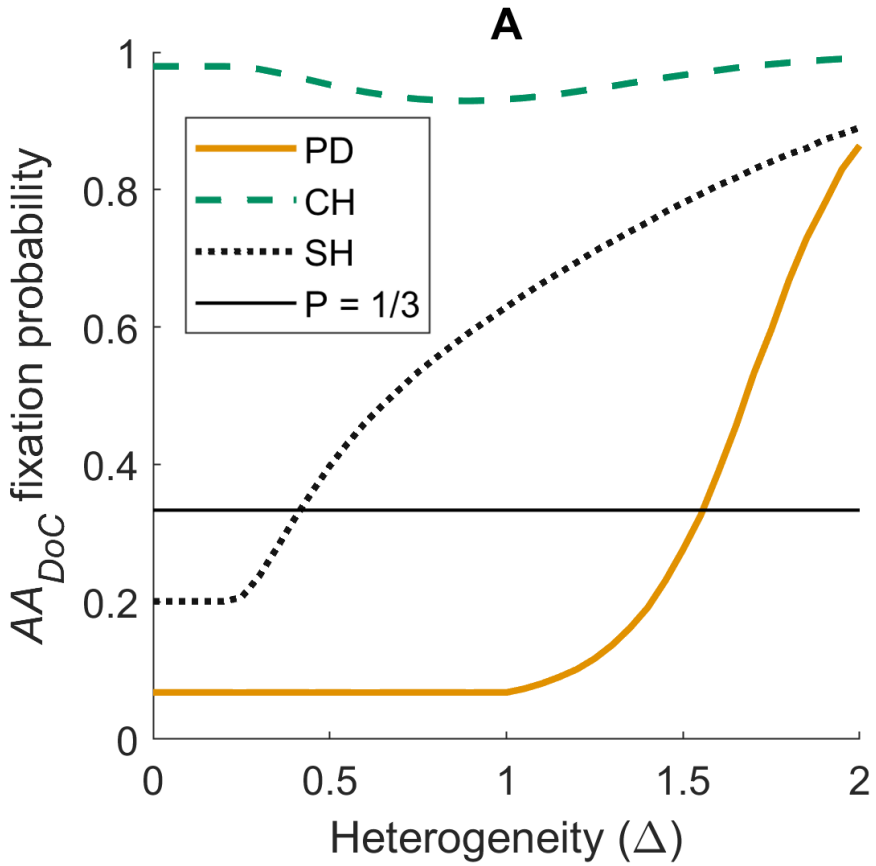
AllC + AllD + Adaptive →

1) Fixation Probability
2) ESS
3) Cooperation

When is inference advantageous?

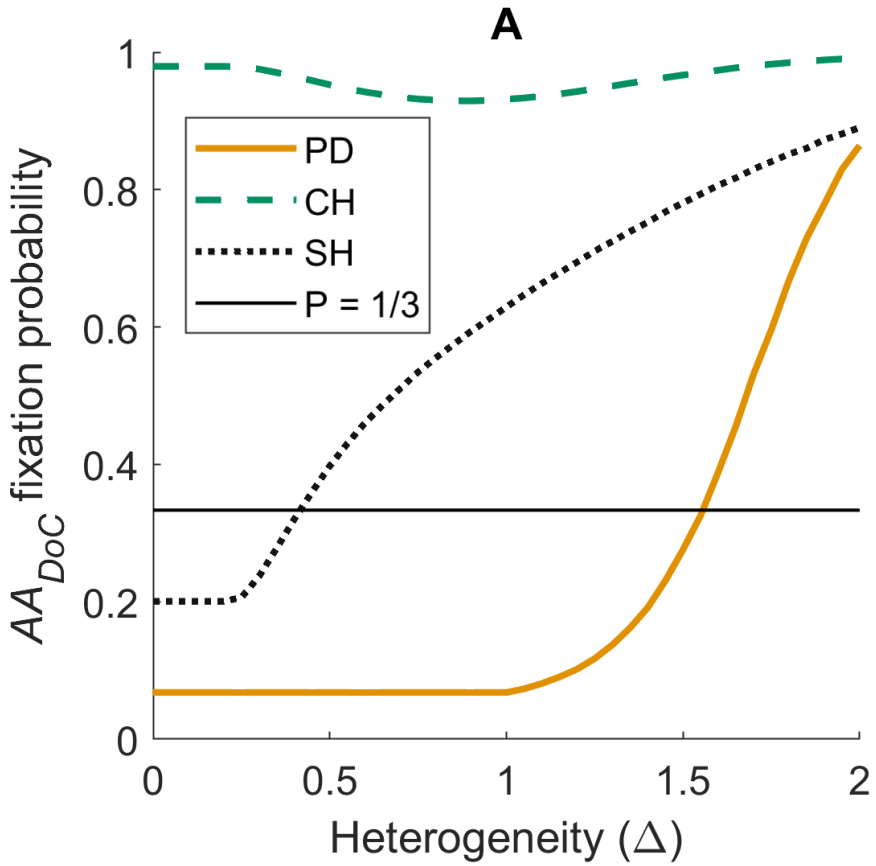
When does inference promote cooperation?

Inference: degree of correspondence

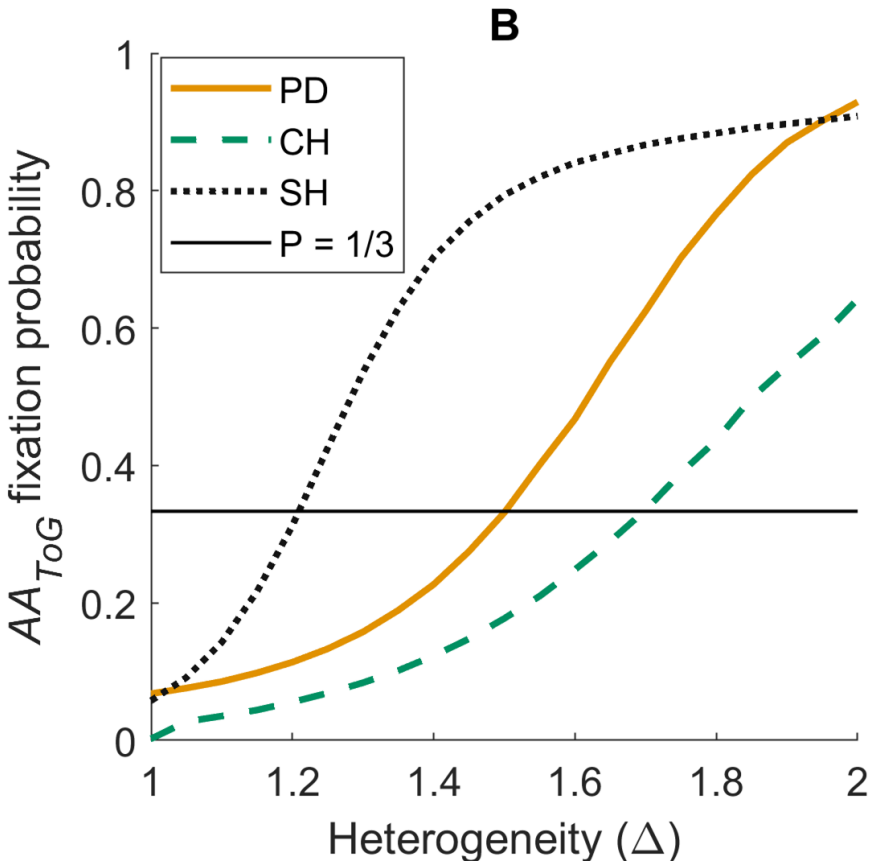


Heterogeneity promotes adaptations to infer interdependence.

Inference: degree of correspondence



Inference: type of game



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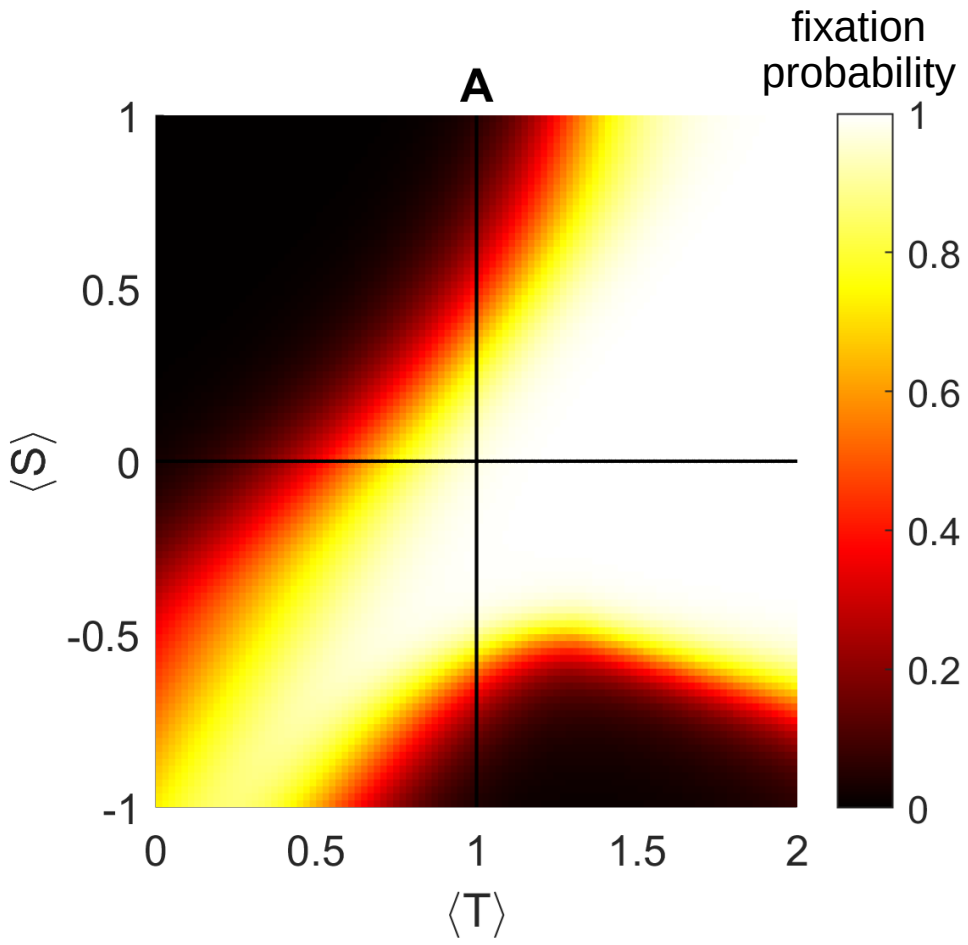
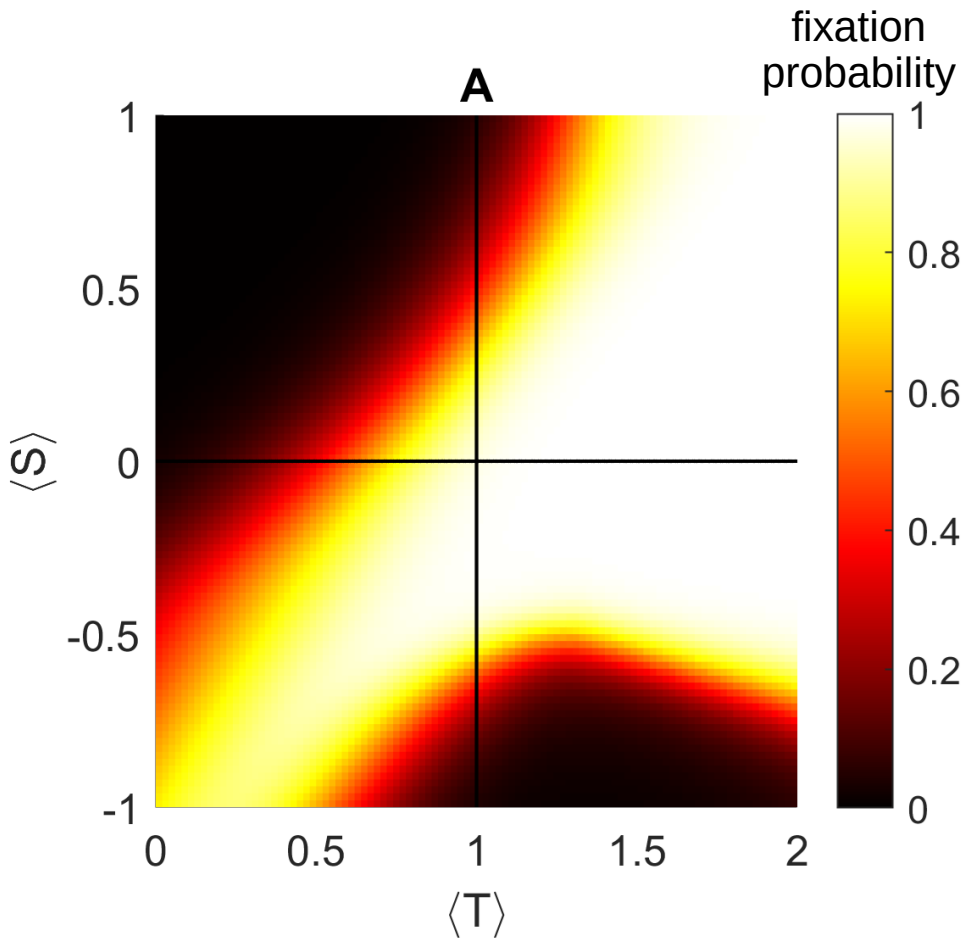
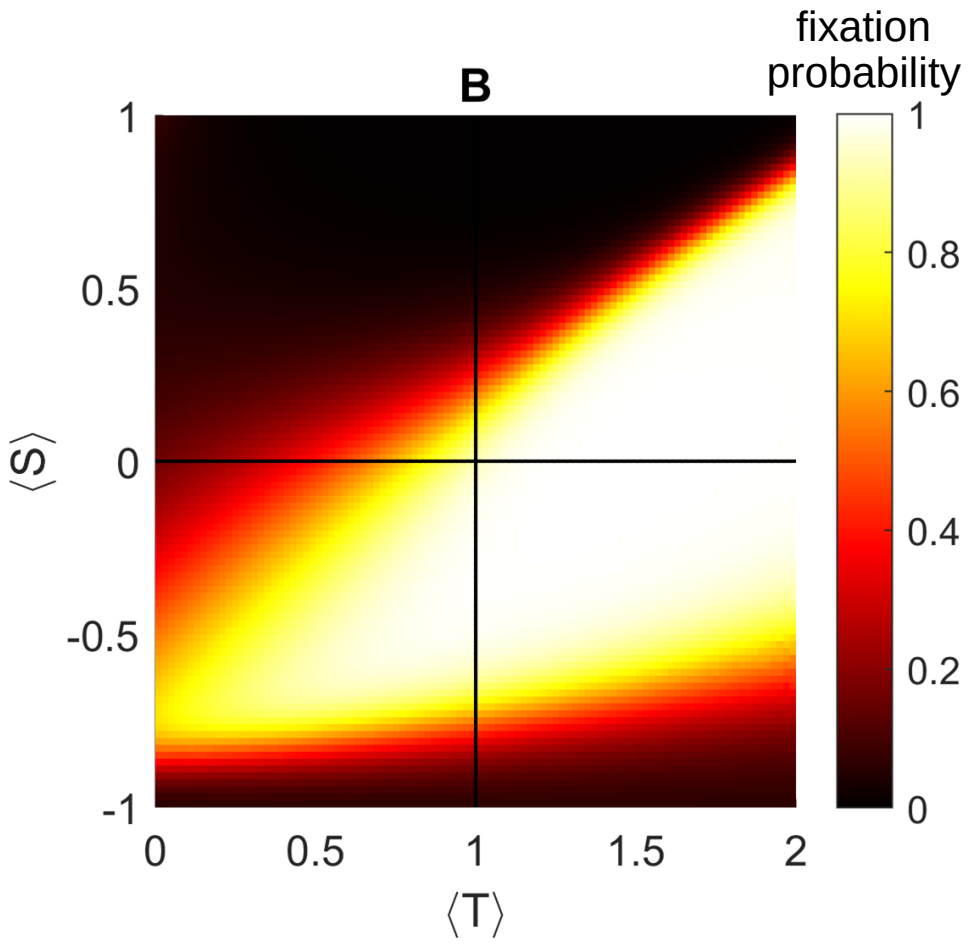


Benign or high-conflict ecologies do not favor adaptive agents.

Inference: degree of correspondence



Inference: type of game



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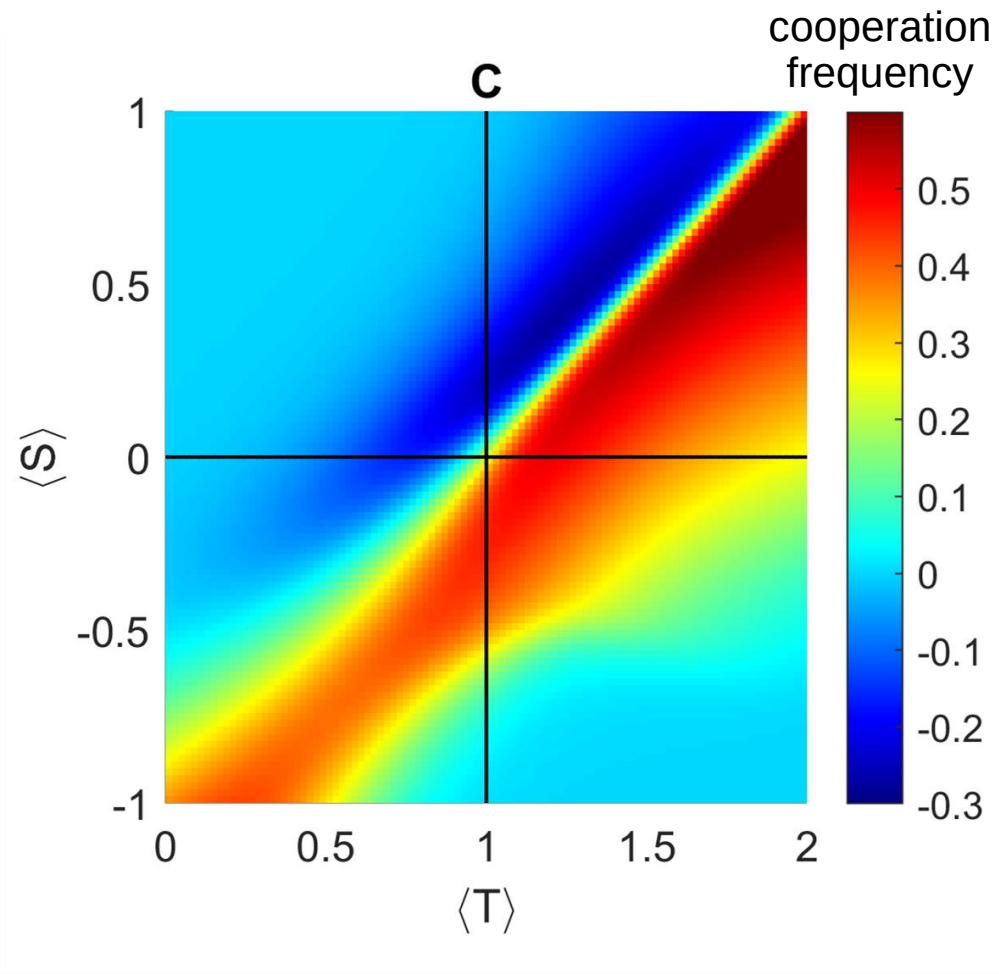
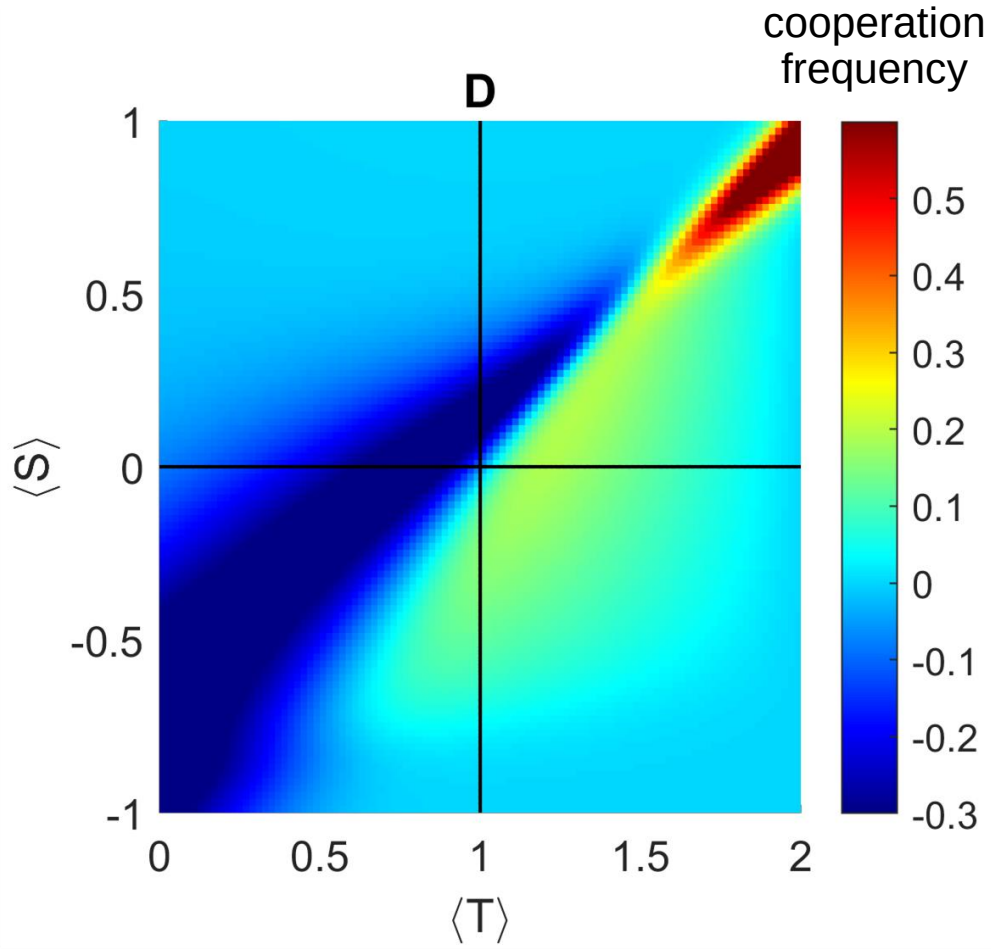


Degree of correspondence inference (mostly) enhances cooperation.

Type of game inference has a mixed impact on cooperation.

Inference: type of game



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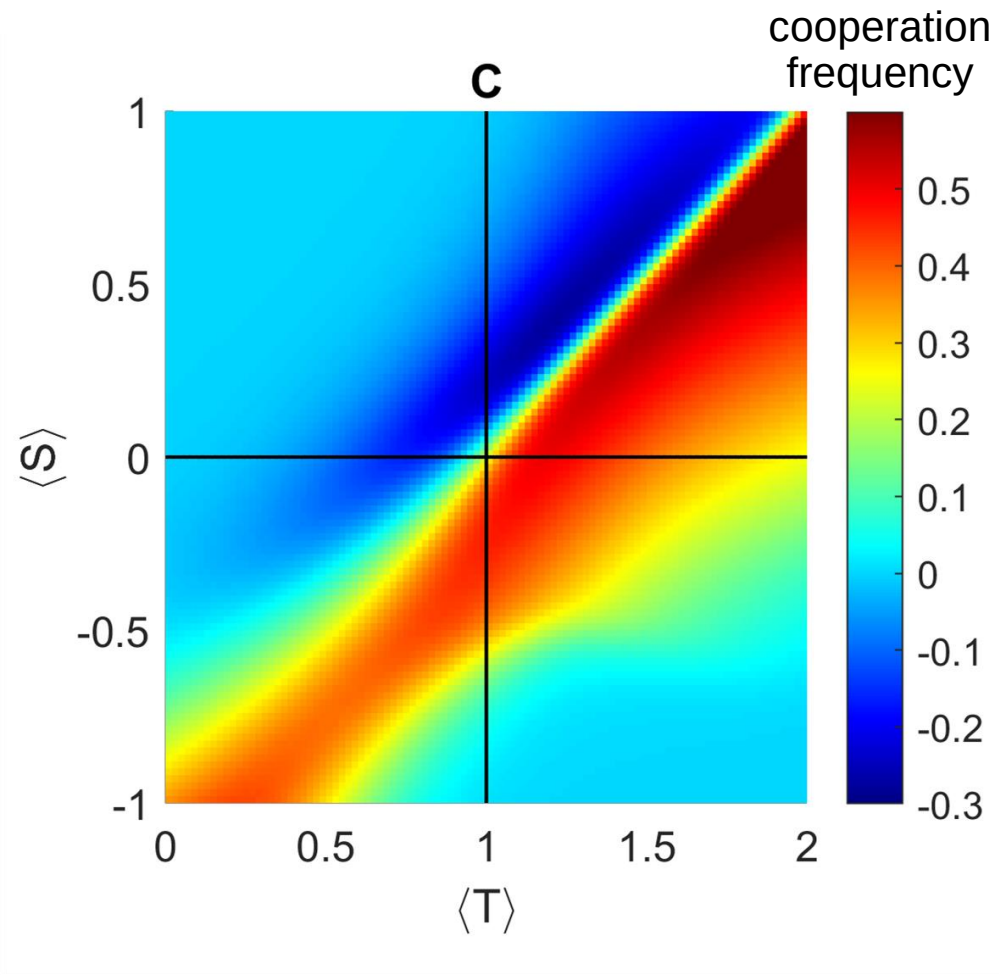

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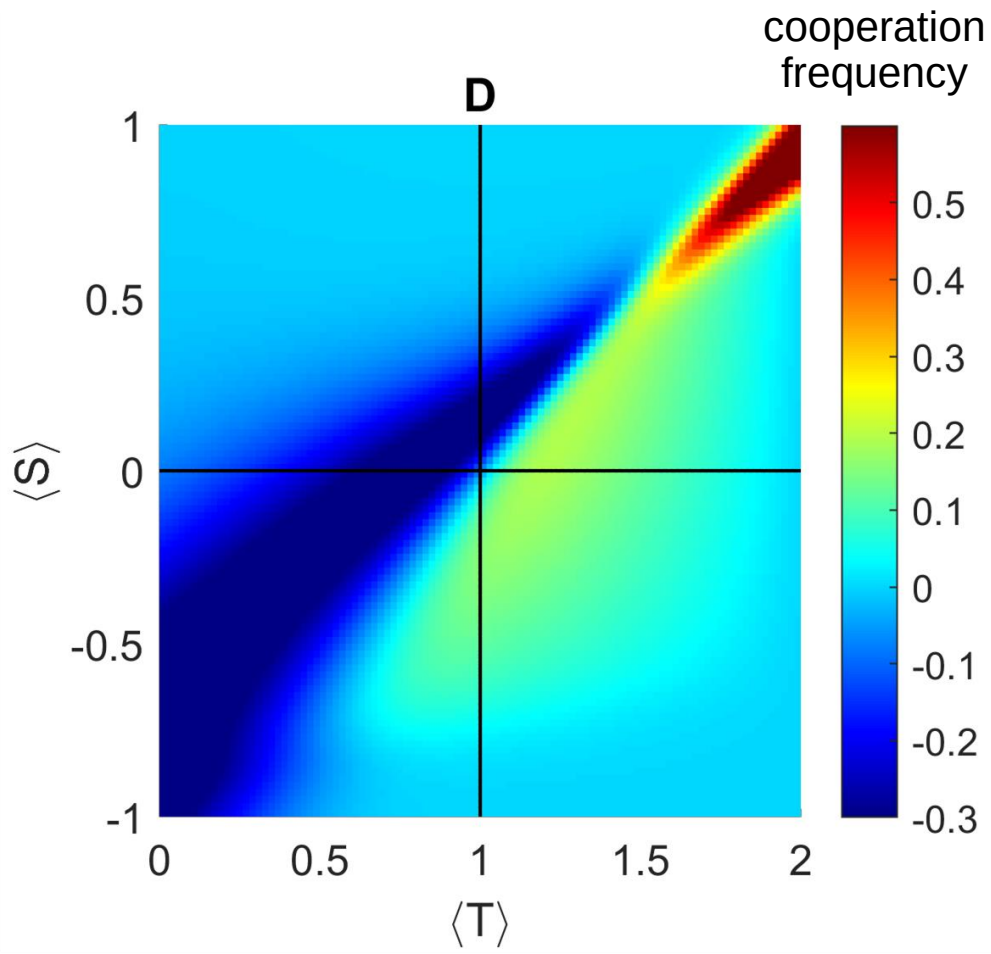

THANK YOU

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Universiteit van Amsterdam

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AMSTERDAM COOPERATION LAB

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Quantifying interdependence

		Player 2	
		C	D
Player 1	C	R	S
	D	T	P

Actor control: $A = \frac{1}{2}(R + S - T - P)$

Partner control: $P = \frac{1}{2}(R - S + T - P)$

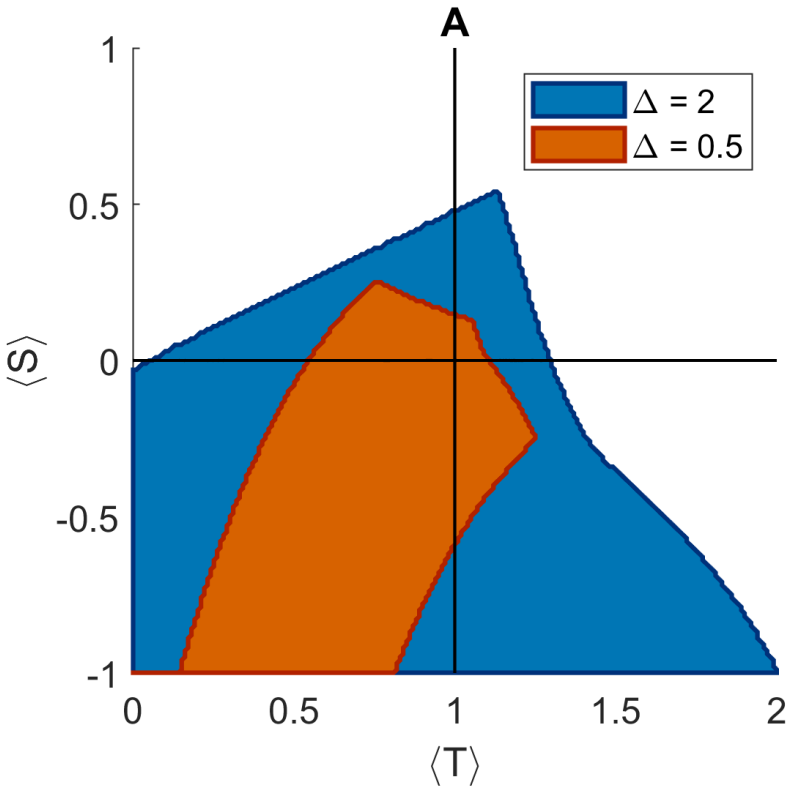
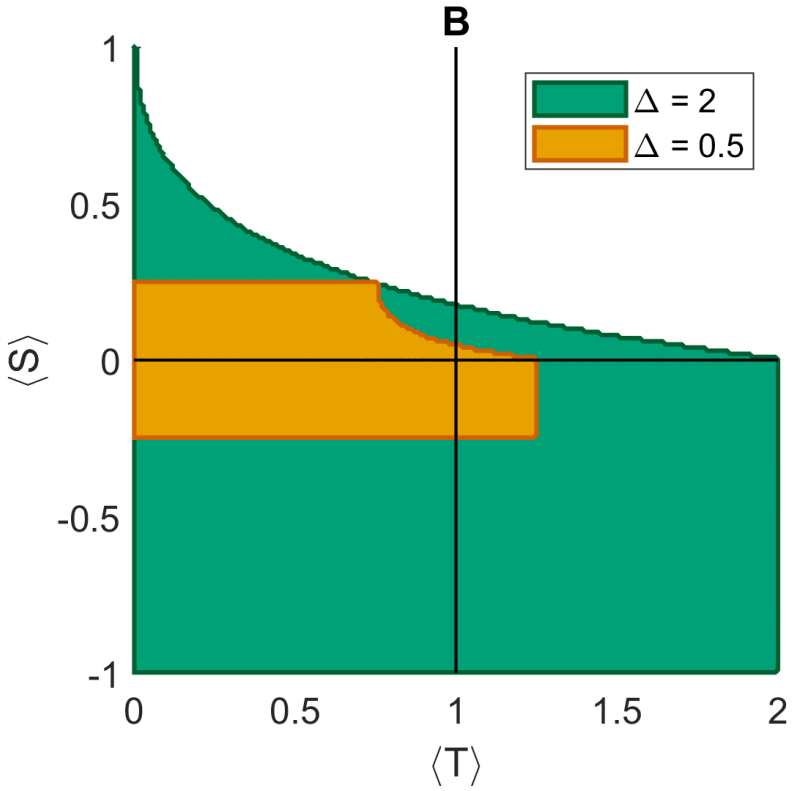
Joint control: $J = \frac{1}{2}(R - S - T + P)$

Mutual dependence	$\frac{P^2 + J^2}{A^2 + P^2 + J^2}$	[0, 1]
Correspondence of interest	$\frac{2AP - J^2}{A^2 + P^2 + J^2}$	[-1, 1]
Asymmetric dependence	$M_2 - M_1$	[-1, 1]

(Balliet, Tybur, and van Lange, PSPR 2017)

Evolutionary stability increases with heterogeneity

Inference: degree of correspondence



Inference: type of game