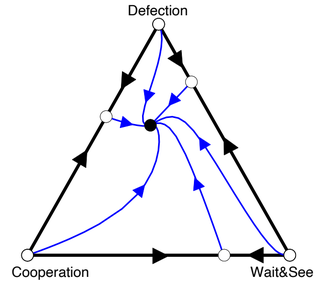
An overview

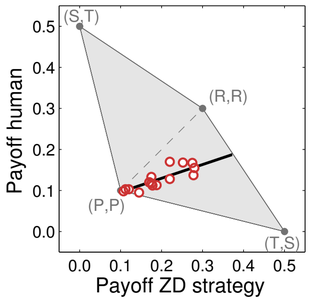
Yesterday's class (March 11, 2025)

- An introduction to evolutionary game theory
  (Replicator dynamics, games in finite populations)



Today's classes (March 12, 2025)

- Evolution of cooperation & direct reciprocity
- Social norms & indirect reciprocity



Tomorrow's class (March 13, 2025)

- Some current research: Reciprocity in complex environments

Evolution of cooperation: A Review

Remark 3.1. Evolution of cooperation

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- However, people sometimes engage in interactions with others they hardly know. In that case, they often rely on reputations. One idea: people cooperate because of social norms.

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Editorial

Under Review

Most scientists regarded the new streamlined peer-review process as "twice an improvement."

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  ⇒We can explore the evolution of norms with evolutionary game theory.

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  ⇒We can explore the evolution of norms with evolutionary game theory.
- Are there stable social norms that prevent people from defecting in the prisoner's dilemma?

Evolution of Indirect reciprocity: Image Scoring

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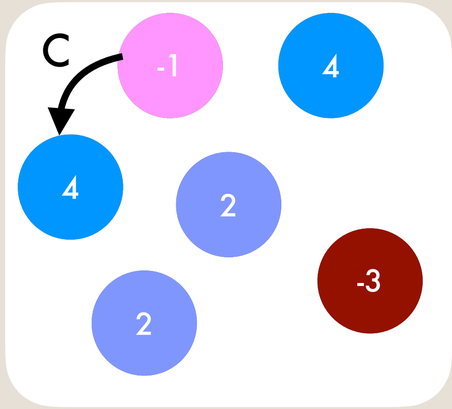

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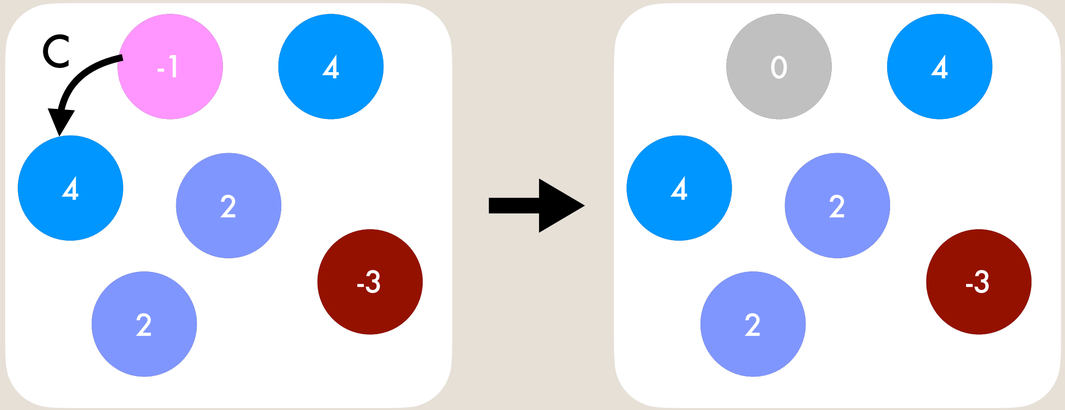

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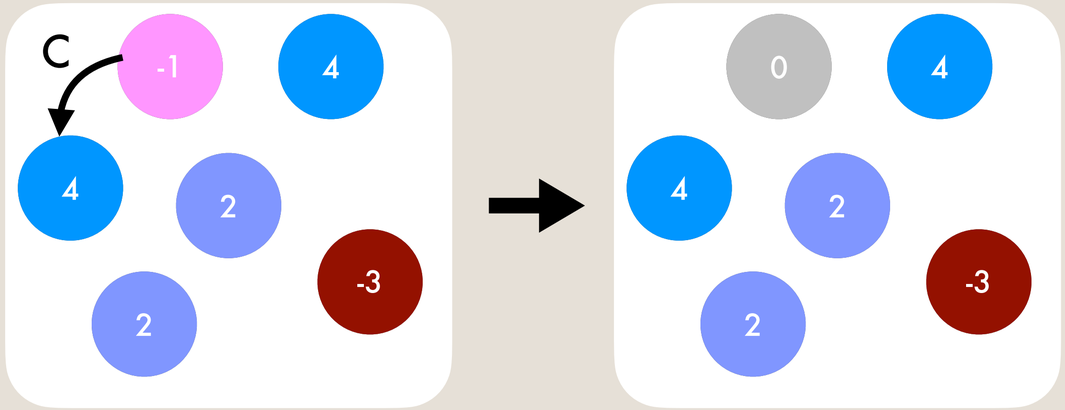

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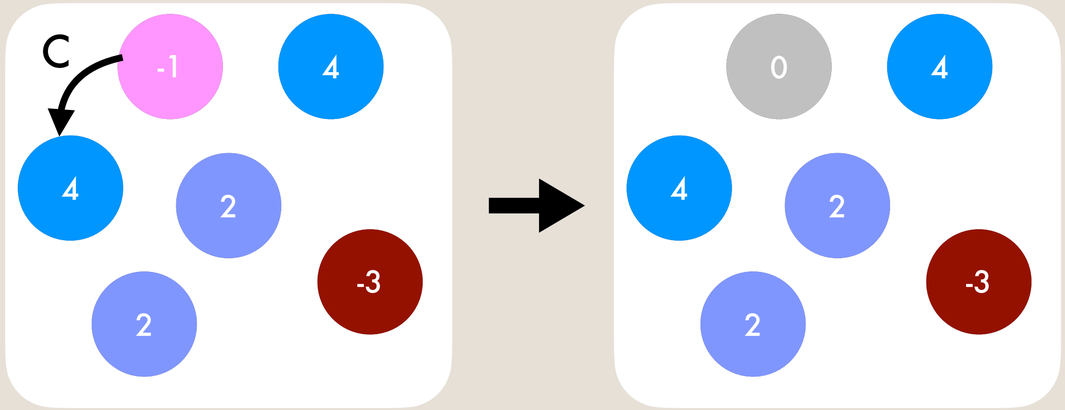

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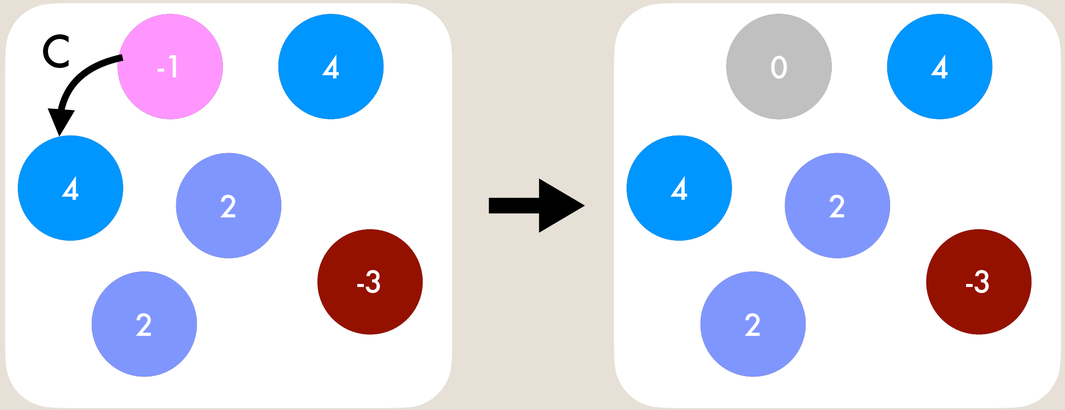

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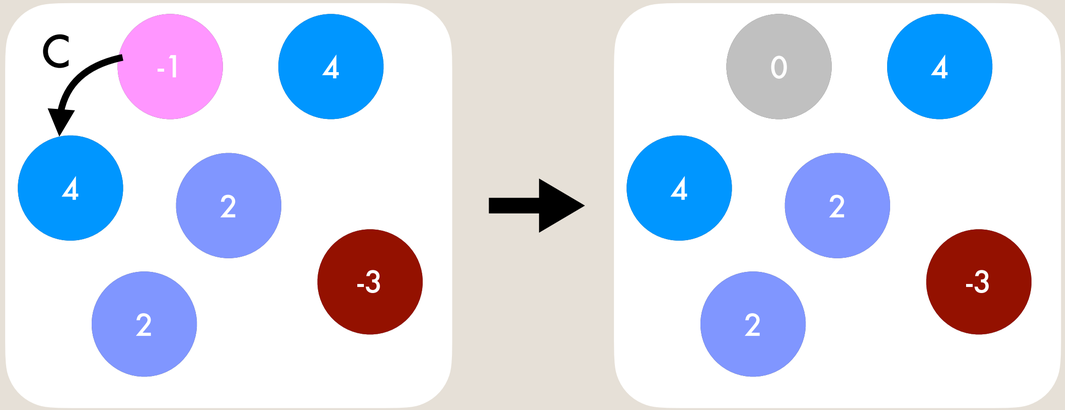

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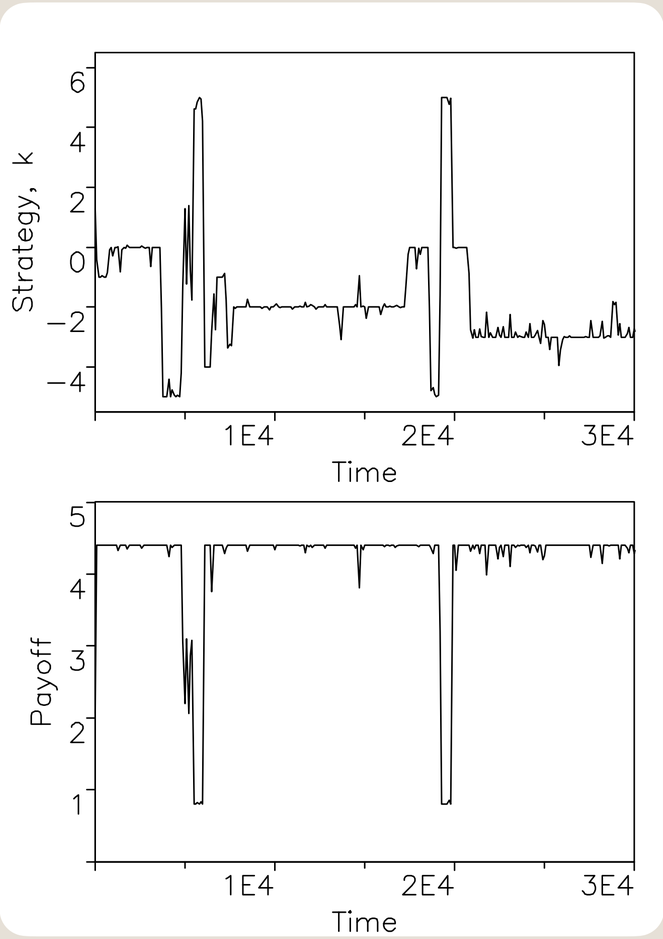

Evolution of Indirect reciprocity: Image Scoring, revisited

Remark 3.4. Instability of Image Scoring

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Evolution of cooperation through indirect reciprocity

Olof Leimar[1*] and Peter Hammerstein[2]

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- Major insight: To maintain cooperation, a population's reputation system should differentiate between *justified* and *unjustified defections*.
  That is, when assessing someone's action, one should not only take into account *what that person did*, but also to *whom*.

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How should we define goodness?—reputation dynamics in indirect reciprocity

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- The second component is called the action rule. It determines how donors make their decision whether or not to cooperate with a given recipient

$$\beta = (\beta_{gg}, \beta_{gb}, \beta_{bg}, \beta_{bb}) \in \{0,1\}^4$$

Evolution of Indirect reciprocity: Image Scoring, revisited

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- In principle, this gives rise to $2^{12} = 4{,}096$ possible social norms to consider.

Evolution of indirect reciprocity: Ohtsuki & Iwasa (2004)

How should we define goodness?—reputation dynamics in indirect reciprocity

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Remark 3.6. Examples of third-order norms

- Unconditional cooperators (ALLD)

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- Unconditional cooperators (ALLC)

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Remark 3.7. Searching for stable cooperative social norms

Question: Among all these pairs (α, β), can we identify all social norms with the following two properties:

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$$(\alpha_{gCg}, \alpha_{gCb}, \alpha_{bCg}, \alpha_{bCb}, \alpha_{gDg}, \alpha_{gDb}, \alpha_{bDg}, \alpha_{bDb}) = (1,1,1,1,1,1,1,1)$$
$$(\beta_{gg}, \beta_{gb}, \beta_{bg}, \beta_{bb}) = (1,1,1,1)$$

- Simple Scoring (SCO)

$$(\alpha_{gCg}, \alpha_{gCb}, \alpha_{bCg}, \alpha_{bCb}, \alpha_{gDg}, \alpha_{gDb}, \alpha_{bDg}, \alpha_{bDb}) = (1,1,1,1,0,0,0,0)$$
$$(\beta_{gg}, \beta_{gb}, \beta_{bg}, \beta_{bb}) = (1,0,1,0)$$

Remark 3.7. Searching for stable cooperative social norms

Question: Among all these pairs (α, β), can we identify all social norms with the following two properties:

- If the whole population adopts it, then everybody always cooperates in the long run

Evolution of indirect reciprocity: Ohtsuki & Iwasa (2004)

How should we define goodness?—reputation dynamics in indirect reciprocity

Hisashi Ohtsuki*, Yoh Iwasa

Remark 3.6. Examples of third-order norms

- Unconditional cooperators (ALLD)

$$(\alpha_{gCg}, \alpha_{gCb}, \alpha_{bCg}, \alpha_{bCb}, \alpha_{gDg}, \alpha_{gDb}, \alpha_{bDg}, \alpha_{bDb}) = (0,0,0,0,0,0,0,0)$$
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Question: Among all these pairs (α, β), can we identify all social norms with the following two properties:

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If these norms exist, how do they look like?

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Remark 3.8. The "*Leading eight*"

- Using analytical methods and numerical computations, Ohtsuki and Iwasa identified eight social norms that satisfy both properties.

Assessment rule	* L1	Consistent Standing L2	Simple Standing L3	* L4	* L5	Stern Judging L6	Staying L7	Judging L8
Good cooperates with Good	g	g	g	g	g	g	g	g
Good cooperates with Bad	g	b	g	g	b	b	g	b
Bad cooperates with Good	g	g	g	g	g	g	g	g
Bad cooperates with Bad	g	g	g	b	g	b	b	b
Good defects against Good	b	b	b	b	b	b	b	b
Good defects against Bad	g	g	g	g	g	g	g	g
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Action rule	L1	L2	L3	L4	L5	L6	L7	L8
Good meets Good	C	C	C	C	C	C	C	C
Good meets Bad	D	D	D	D	D	D	D	D
Bad meets Good	C	C	C	C	C	C	C	C
Bad meets Bad	C	C	D	D	D	D	D	D

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- The norms disagree on how one should assess
  - Good donors who cooperate with bad recipients
  - Bad donors who cooperate with bad recipients
  - Bad donors who defect with bad recipients

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Evolution of indirect reciprocity: The leading eight

Remark 3.9. Stern Judging

- One important rule among the leading eight is called “Stern Judging” (L6):
  The only behaviors that should yield a good reputation are cooperating with good people and defecting with bad people.

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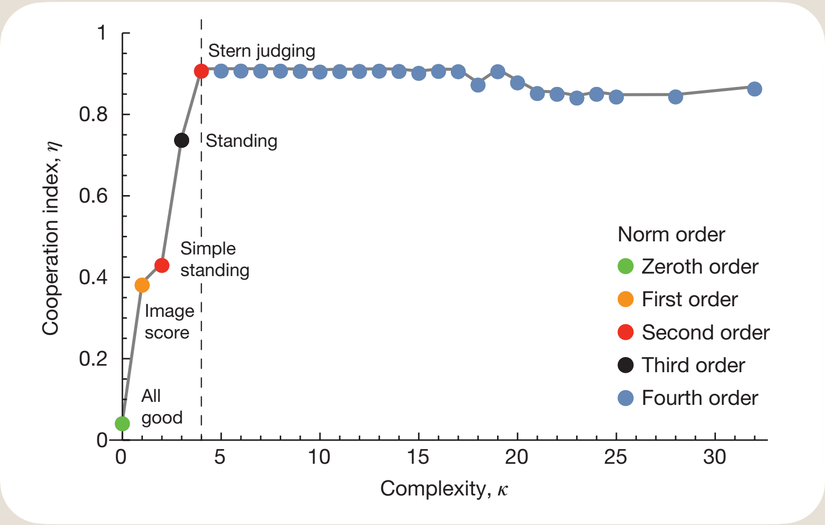
- Among all norms that guarantee full cooperation, this is the one of the lowest complexity (Santos et al 2018).

Social norm complexity and past reputations in the evolution of cooperation

Fernando P. Santos[1,2], Francisco C. Santos[1,2] & Jorge M. Pacheco[2,3,4]



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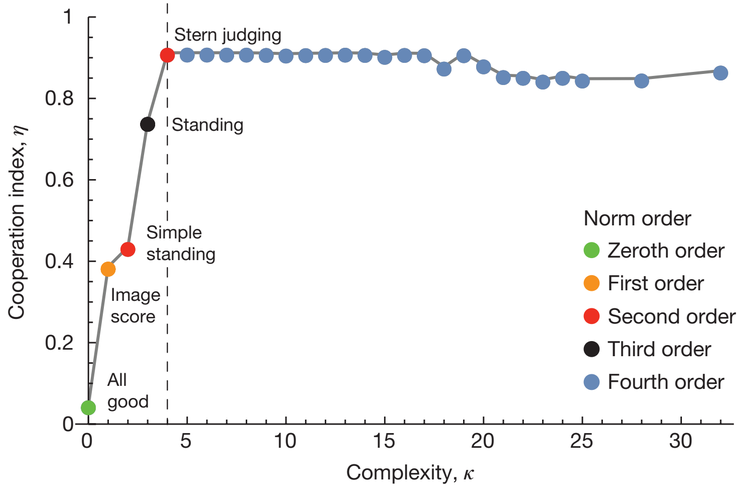

How infants and toddlers react to antisocial others

J. Kiley Hamlin[a,1], Karen Wynn[b], Paul Bloom[b], and Neha Mahajan[b]

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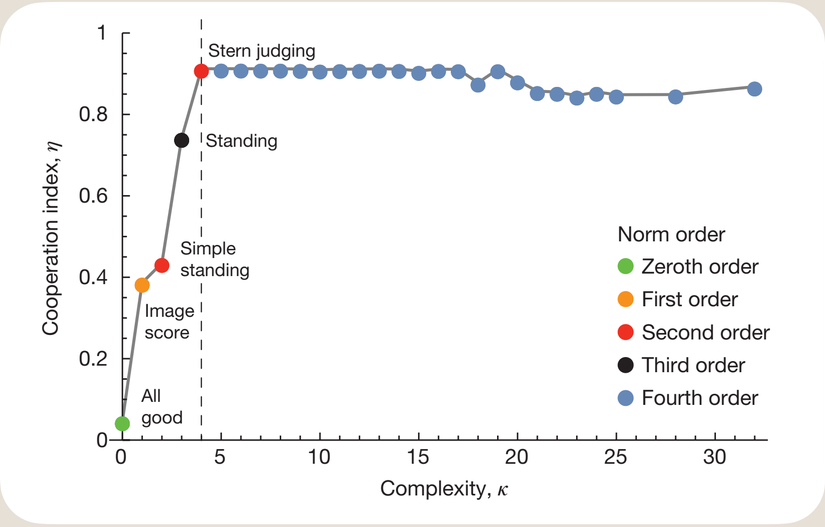

How infants and toddlers react to antisocial others

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Infants prefer a nasty moose if it punishes an unhelpful elephant

Evolution of indirect reciprocity: The impact of noise

Remark 3.10. Indirect reciprocity with noise

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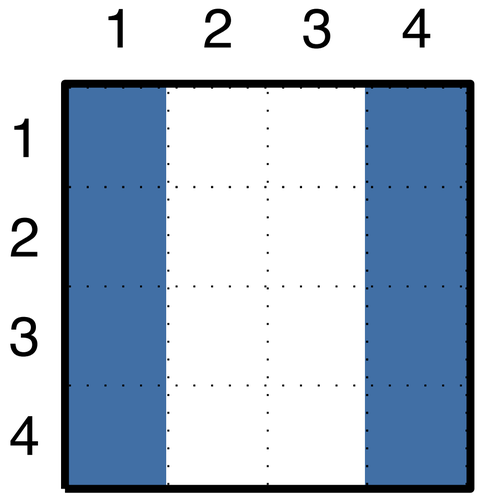

Under public information

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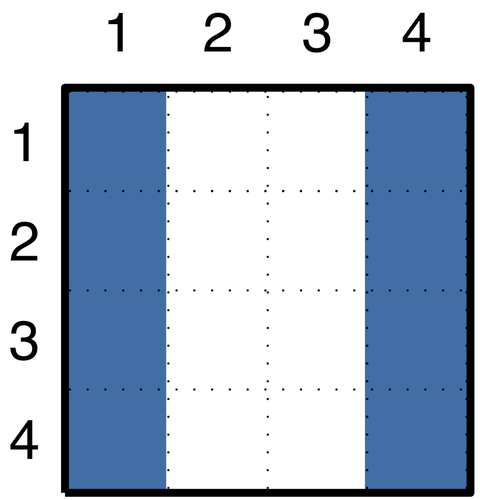
- Under public information and no noise these image matrices only depend on the column index j.
- When there is private information, or some individuals misinterpret a donor's action, there can be disagreements.



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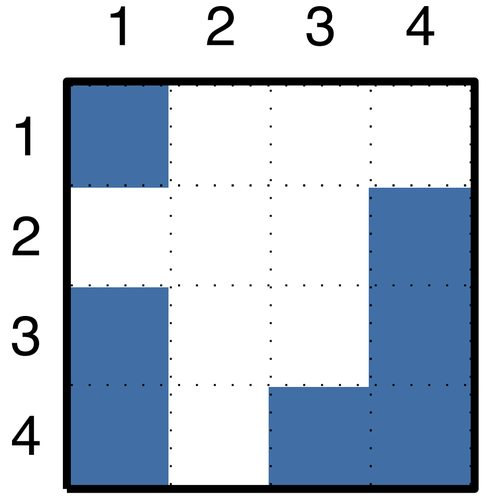

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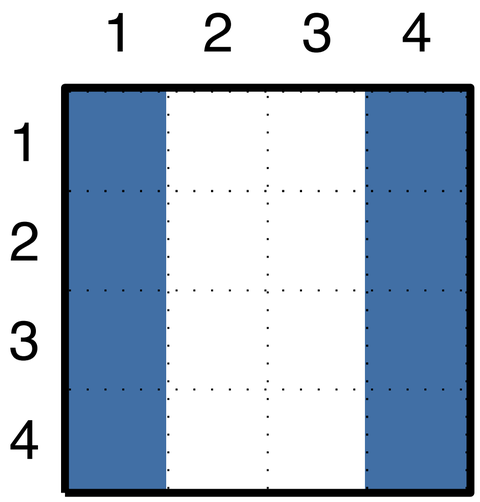
Question: Assume there are a few initial disagreements between the members of a population. Over time, do these disagreements disappear or do they proliferate?
And how does this depend on the population's social norm?



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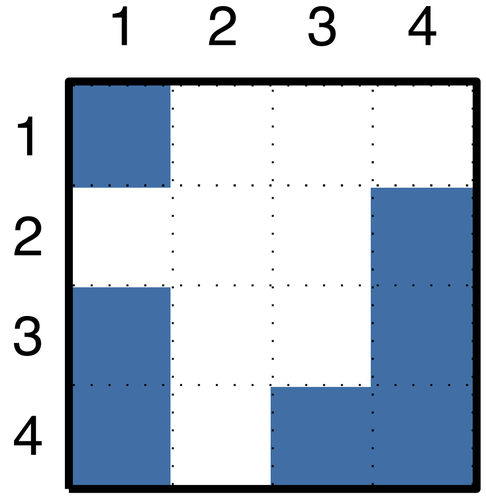


Under private information

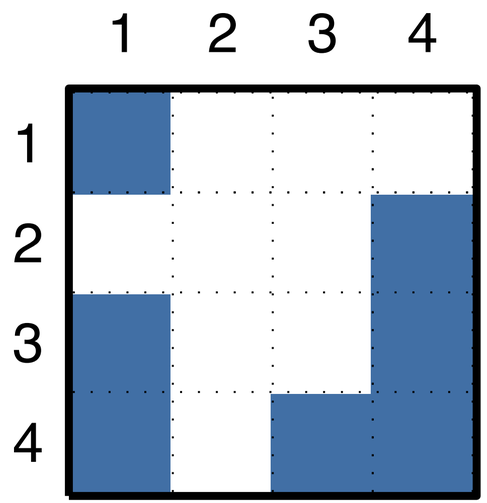
Evolution of indirect reciprocity: The impact of noise

Indirect reciprocity with private, noisy, and incomplete information

Christian Hilbe[a,1], Laura Schmid[a], Josef Tkadlec[a], Krishnendu Chatterjee[a], and Martin A. Nowak[b,c,d]

Remark 3.10. Indirect reciprocity with noise (continued)

- Consider a population in which players assign reputations based on private and noisy information



Under private information

Evolution of indirect reciprocity: The impact of noise

Remark 3.10. Indirect reciprocity with noise (continued)

- Consider a population in which players assign reputations based on private and noisy information

- Moreover, suppose people in the population follow different social norms; one third uses ALLC, one third uses ALLD, and one third uses some leading-eight social norm.

Indirect reciprocity with private, noisy, and incomplete information

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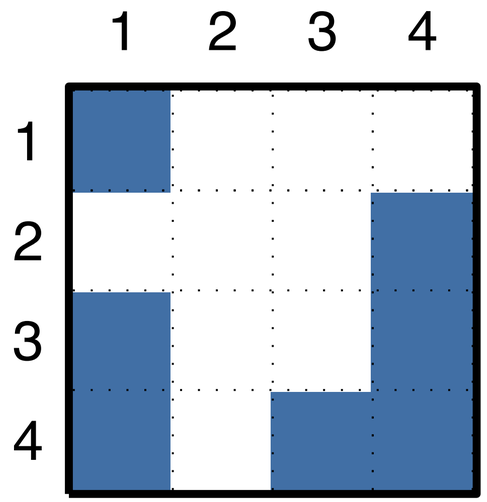

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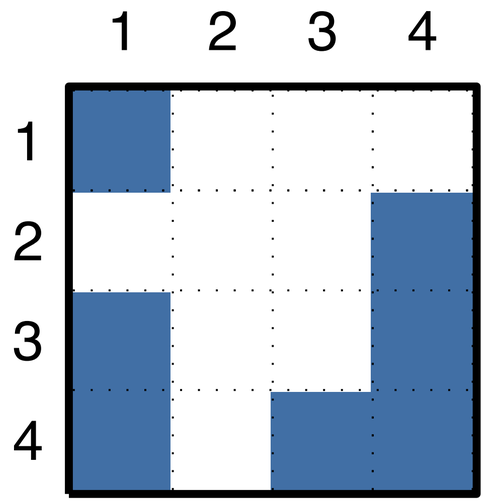

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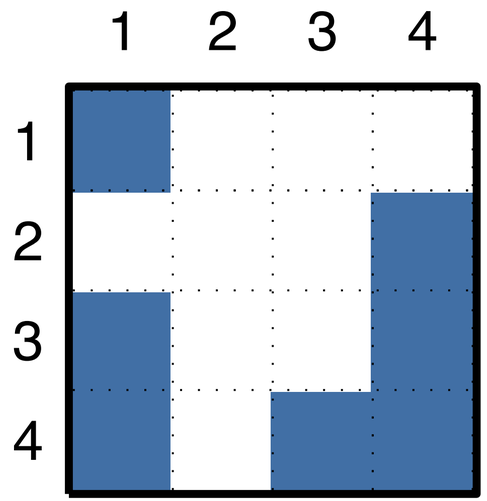
- How do the population's image matrices evolve in time?



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We assume the population consists in equal parts of a leading-eight strategy, of ALLC, and ALLD.
Snapshot after 10^6 interactions:

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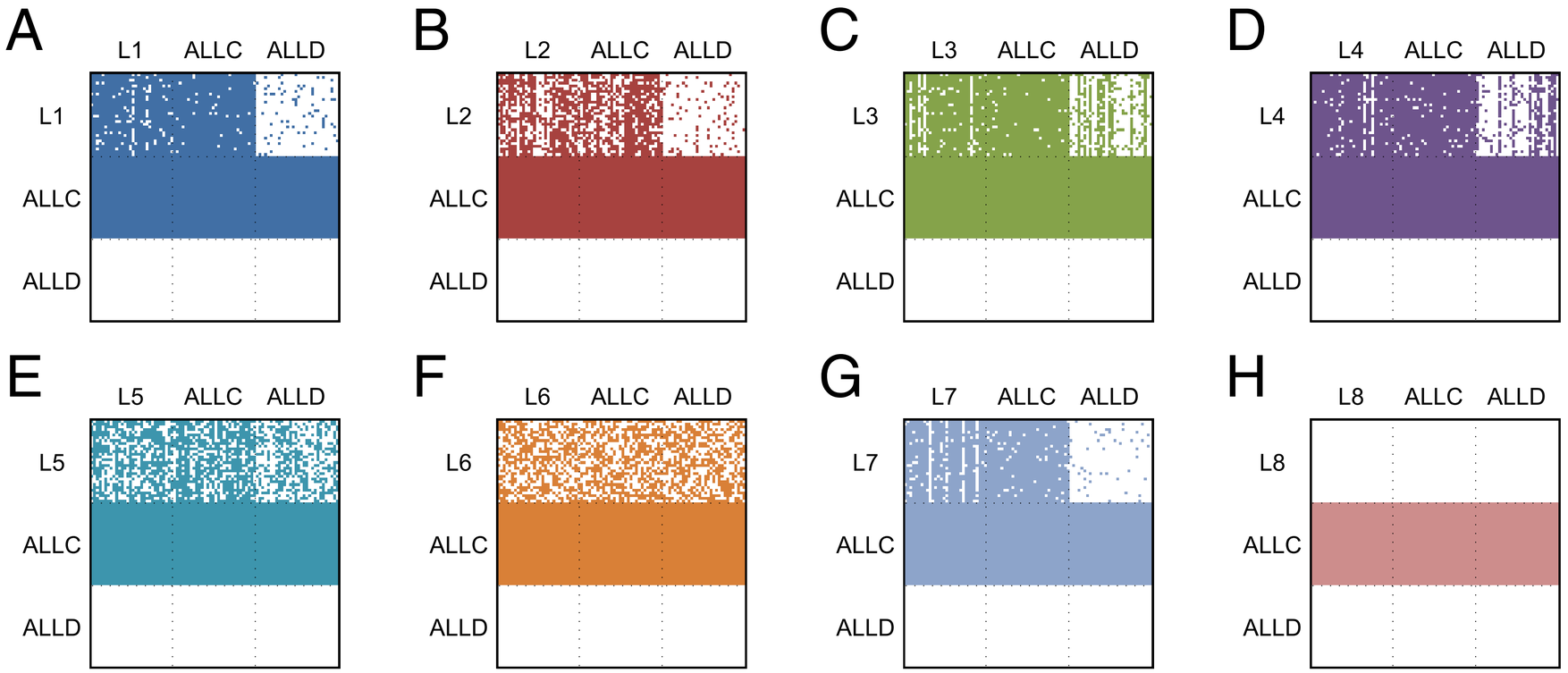

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Christian Hilbe[a,1], Laura Schmid[a], Josef Tkadlec[a], Krishnendu Chatterjee[a], and Martin A. Nowak[b,c,d]

Reputation dynamics with private information

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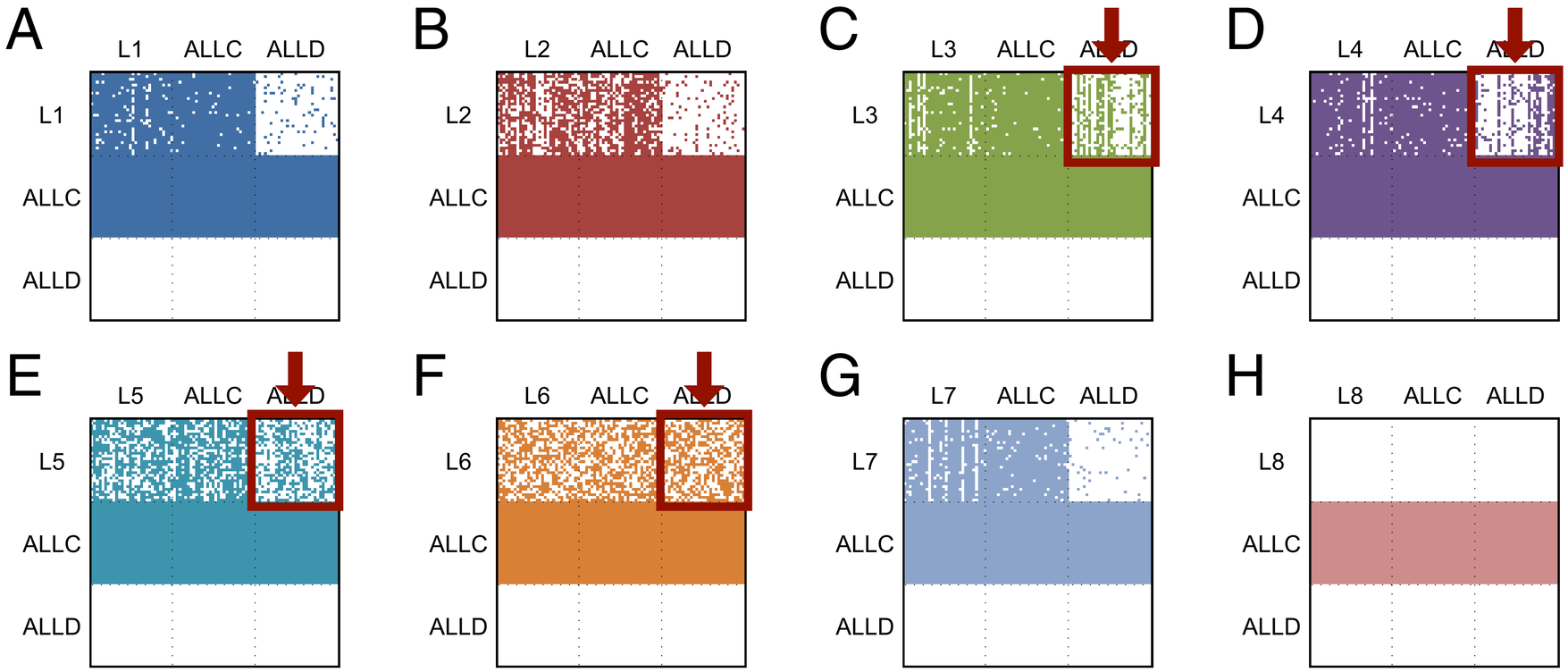

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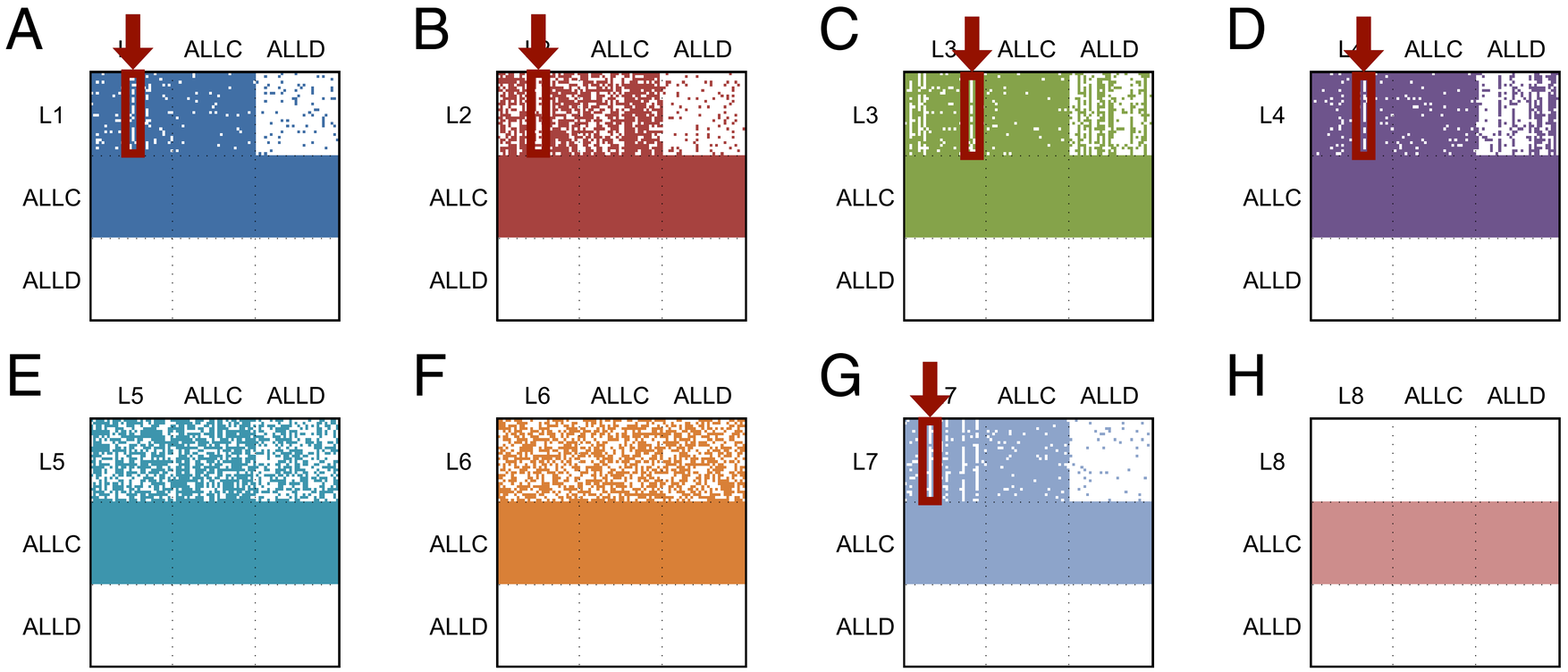

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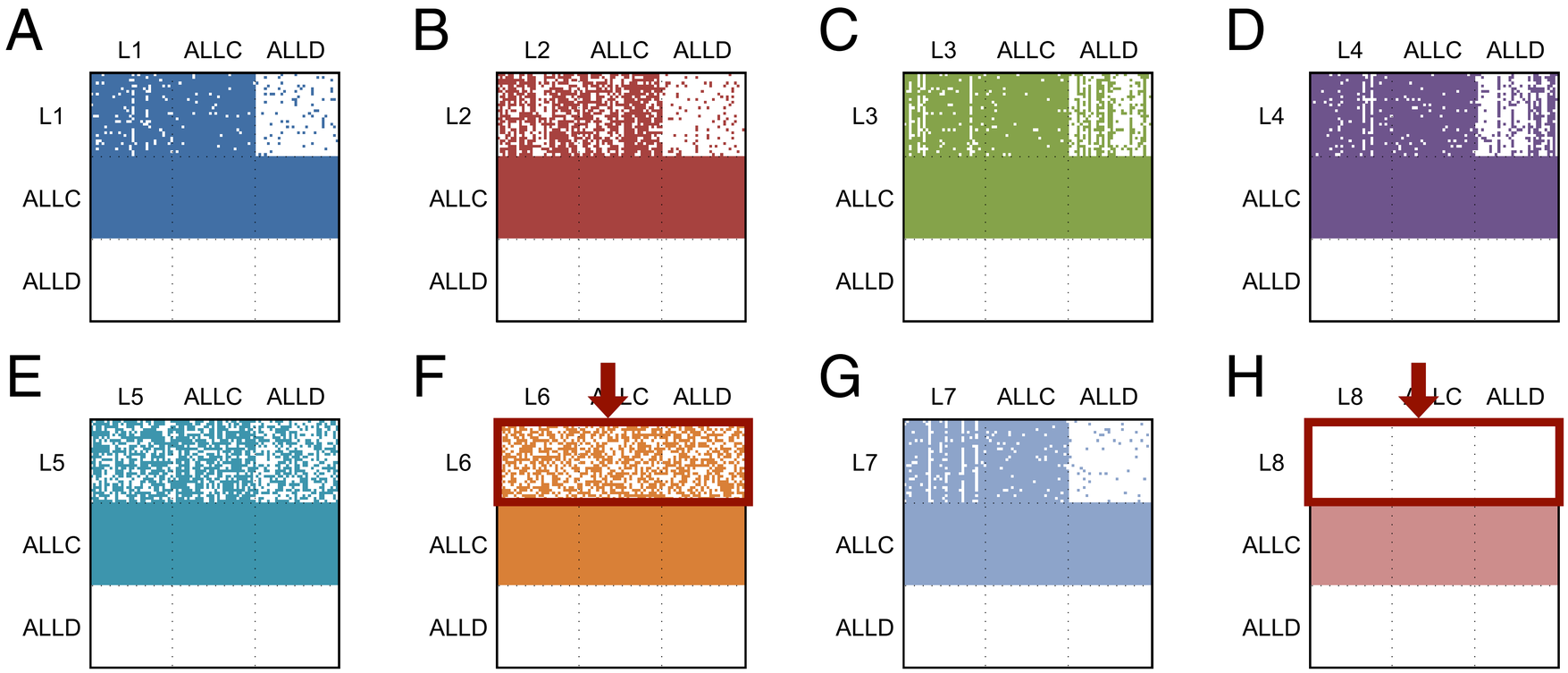

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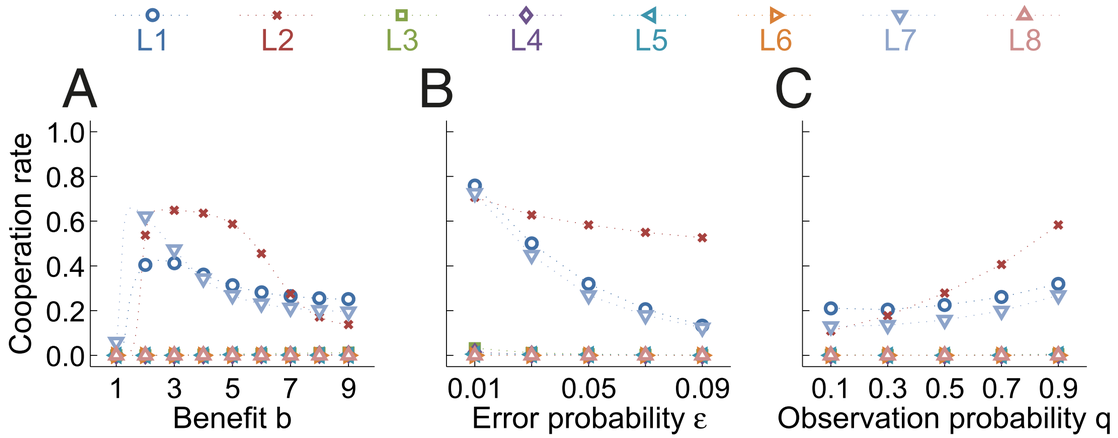

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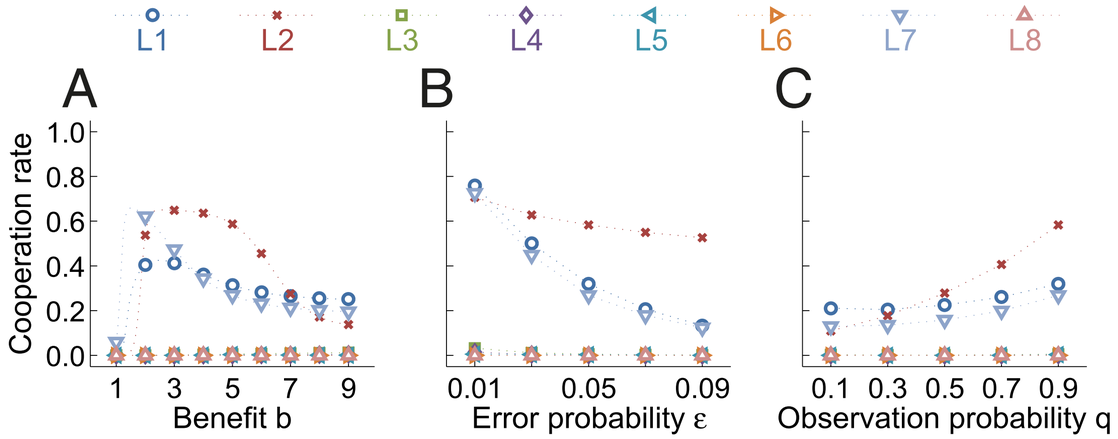

Possible solutions

Empathy

Evolution of empathetic moral evaluation

Arunas L Radzvilavicius[1]*, Alexander J Stewart[2], Joshua B Plotkin[1]*

eLife, 2019

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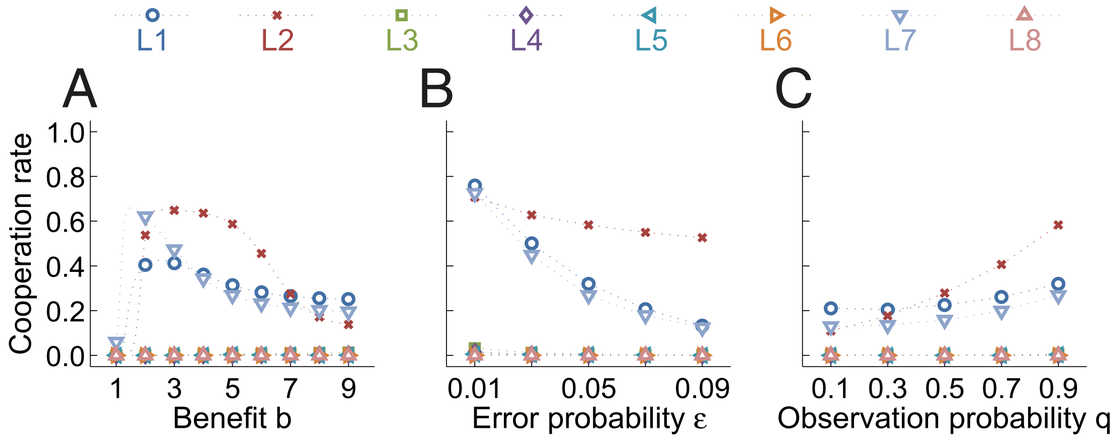

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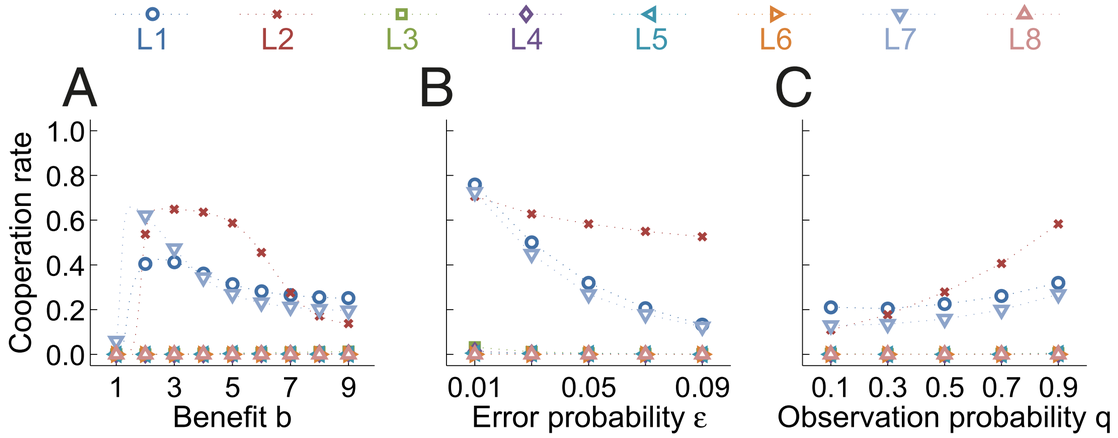

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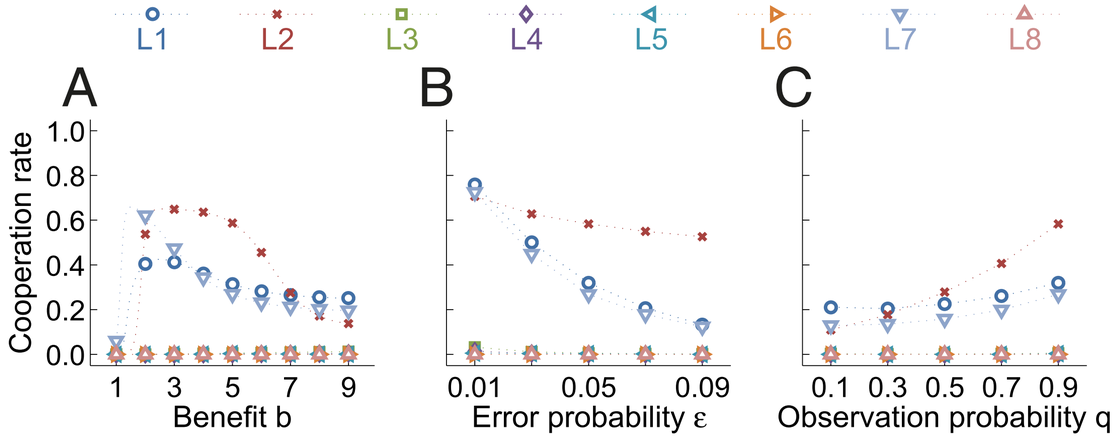

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Indirect reciprocity under opinion synchronization

Yohsuke Murase[a,1] and Christian Hilbe[b]

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Evolution of social norms: Humility

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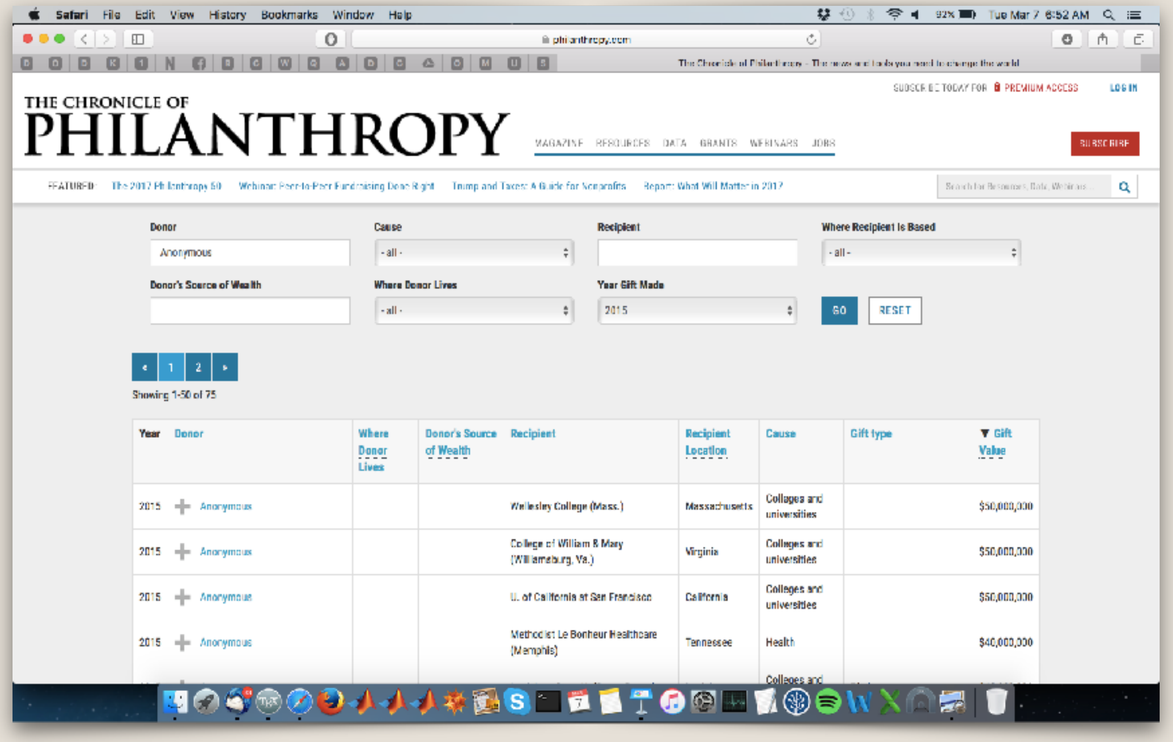

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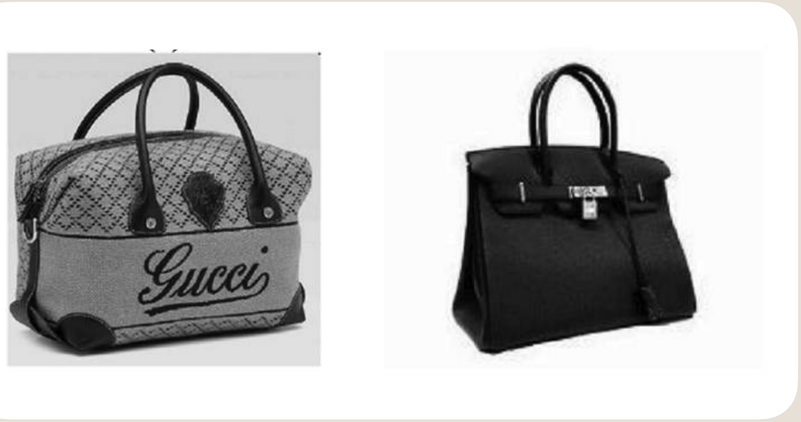

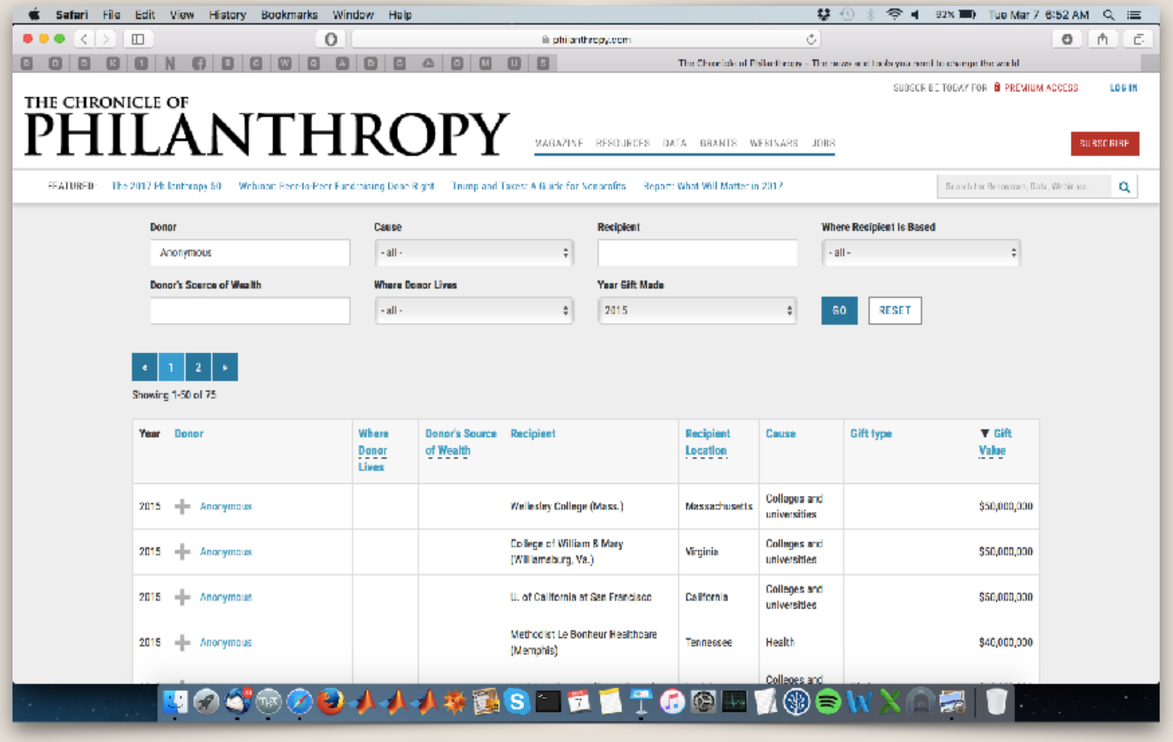

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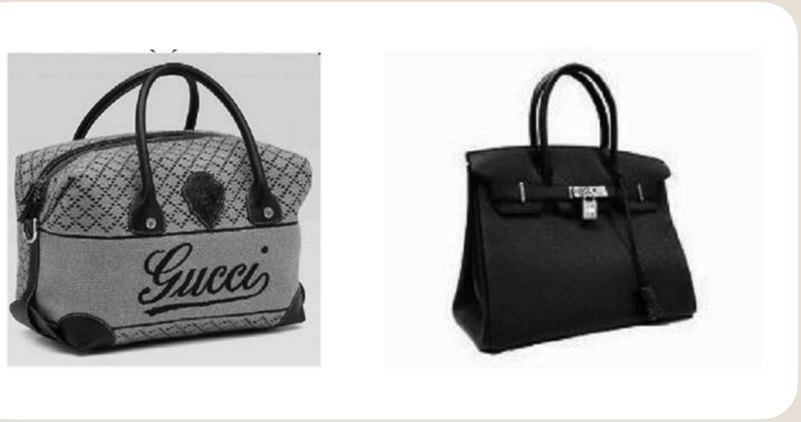
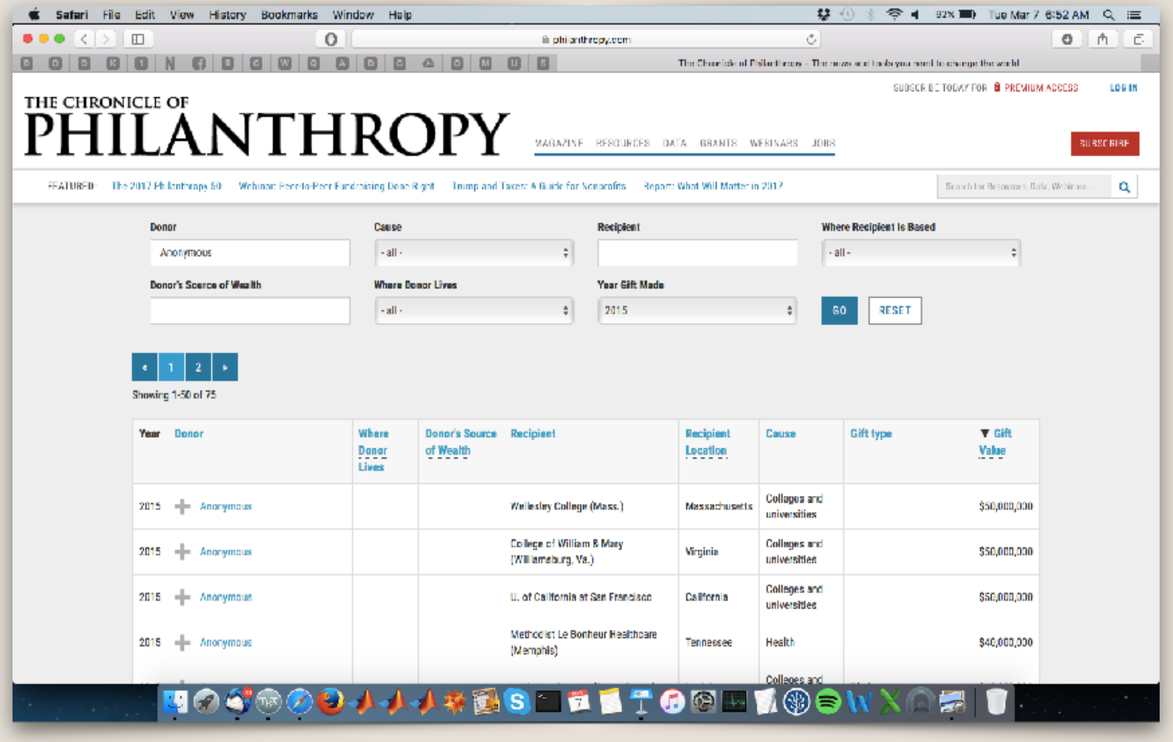
- Why pay a cost to do something good, or purchase something valuable, and then hiding the cost?





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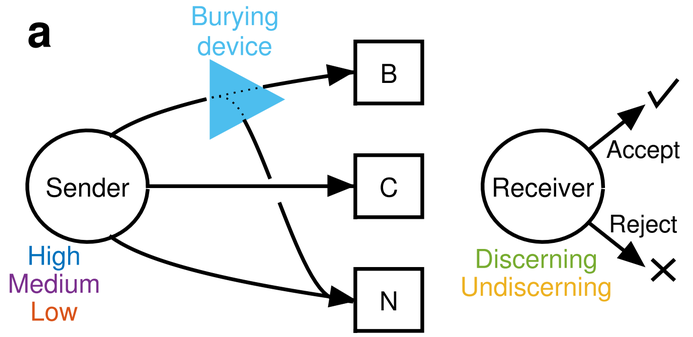

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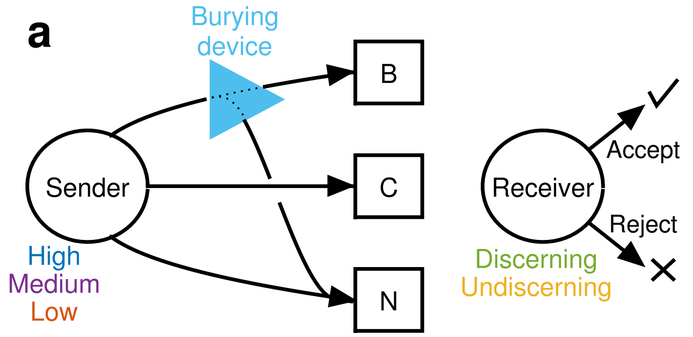

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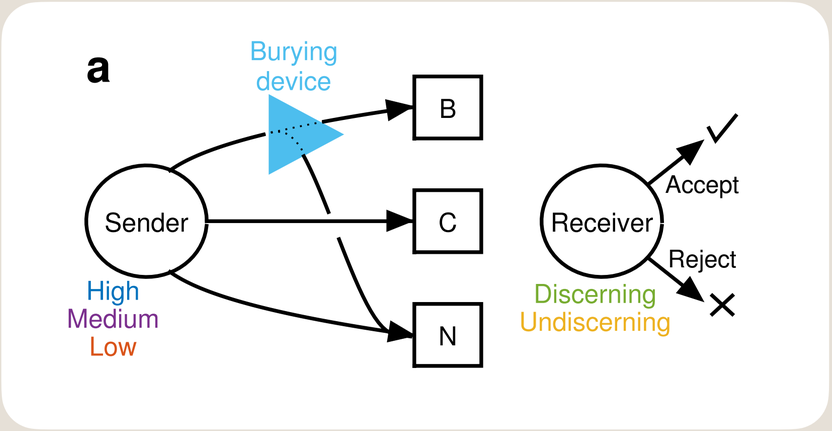

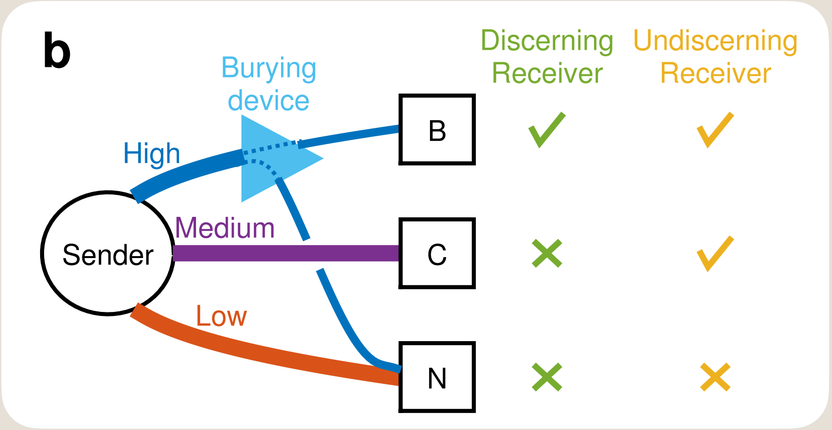

Buried signals equilibrium

Evolution of social norms: Humility

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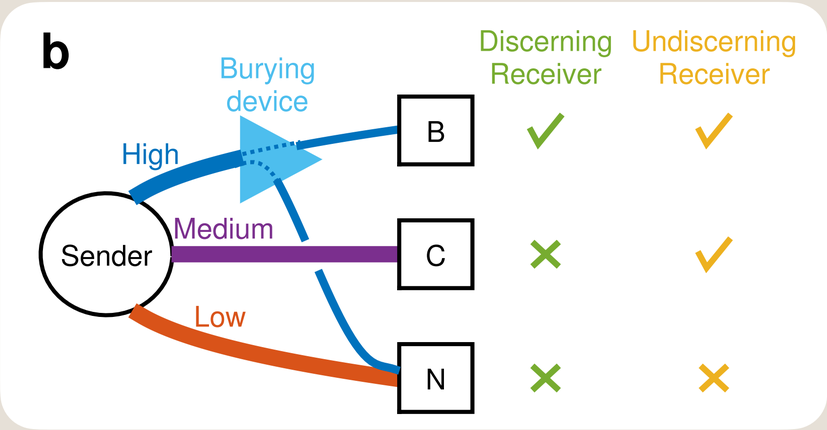

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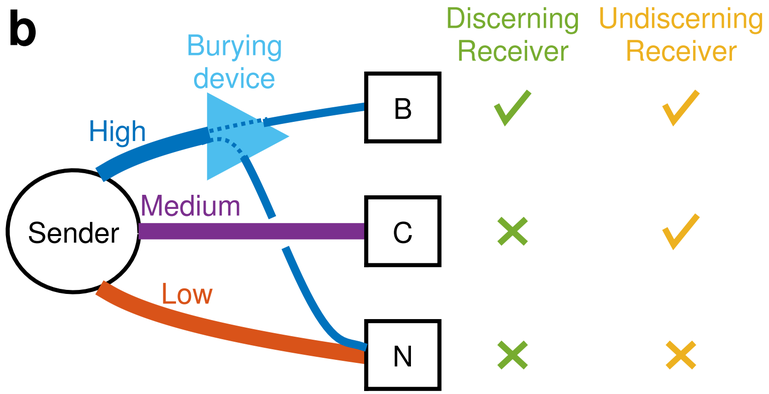

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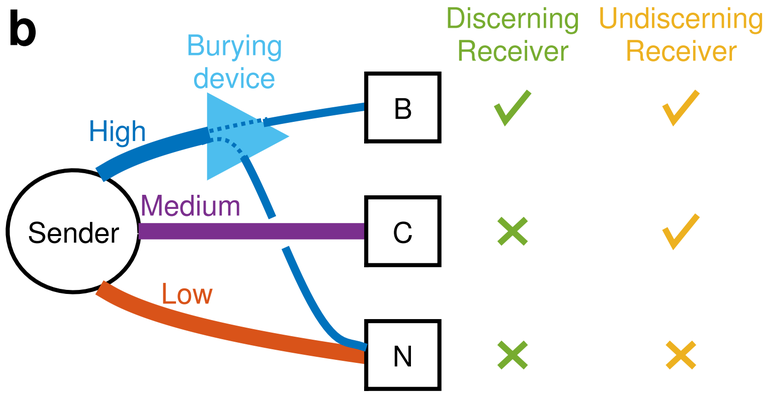
- Burying such signals is a great way of showing that you are only interested in a particular group of receivers.



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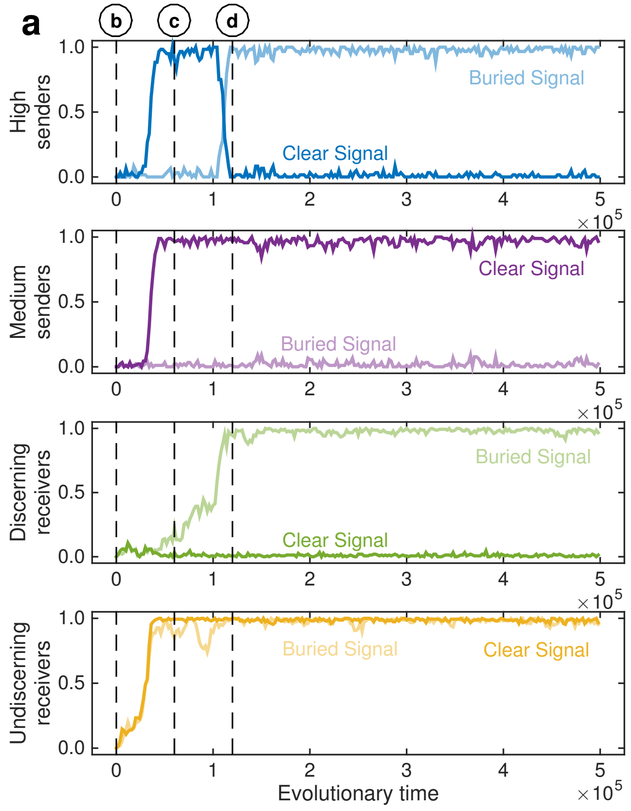

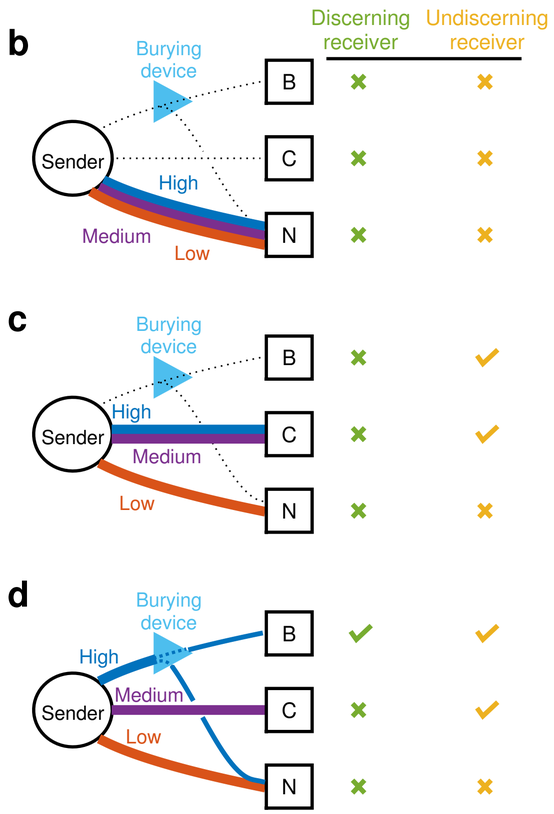

Evolution of the Buried signals equilibrium

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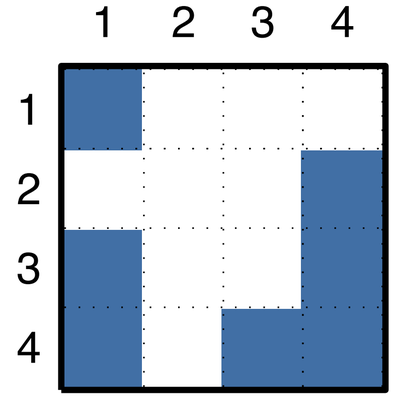

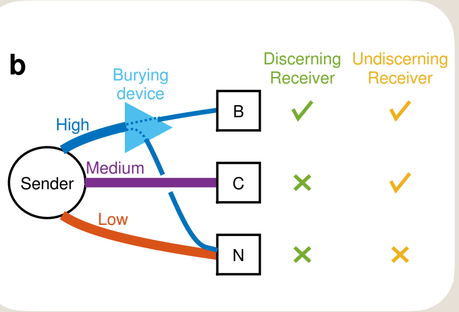

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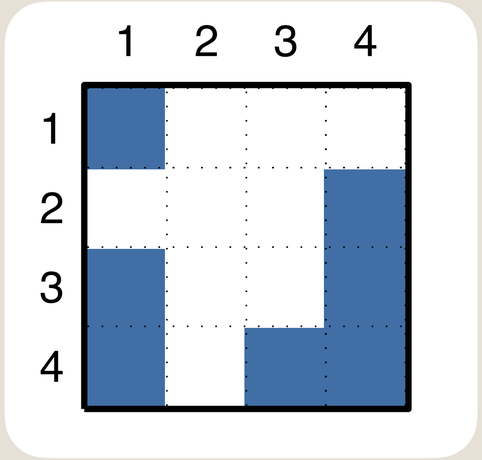

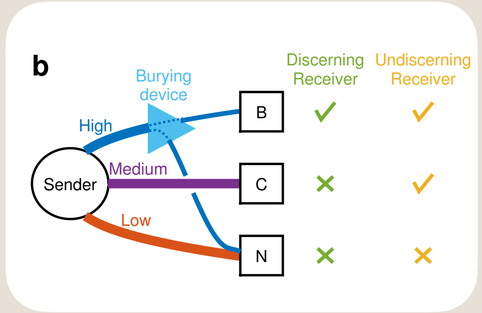

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3. Social norms can also be rather nuanced; as an example, we discussed why people might value modesty. Also such norms can be explained with game theory (in this case: with a signaling model).