

Models of Inference and Learning from Others

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Now: \Rightarrow

- Errors in inference from volitional agents, per se
 - Volitional agents: we can (or should!) use our understanding of their motives as additional source of information.
- In fact, Behavioral GT weird history... Mistakes in game any different than elsewhere? \Rightarrow When see sample of independent "people flips" may make same errors as when see sample of independent coin flips.



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- We often see information that is not there.



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 - (And: **If** one wanted any globally defined prediction of beliefs about others, Nash-like assumptions wipes the floor with Level-K, etc. No contest.)

↷

Winner's curse in trade/lemons: Example \Rightarrow

- Firm has book value $v \sim U[0, 1]$. \Rightarrow
- Firm knows book value, Raider does not. \Rightarrow
- Firm values at v and Raider at $\frac{3}{2}v$. \Rightarrow
- Raider makes TIOLI offer b to Firm. \Rightarrow
- PBE: Firm sells iff $v < b \implies$ average value $\frac{3}{2} \left(\frac{1}{2}b\right) = \frac{3}{4}b < b$ \Rightarrow
- Optimal (lemon-flavoured) bid: $b^* = 0$ \Rightarrow
- Experimental Evidence: Bazerman and Samuelson (1985):
 - 59% of subjects bid in $[0.5, 0.75]$, and 92% bid more than 0. \Rightarrow
 - Subjects lose money on average.

↪

Cursed equilibrium: \Leftarrow

- Firm accepts iff $v < b$.
- Raider understands higher $b \implies$ more likely accepted: \Leftarrow predicts true $\text{prob}(b \text{ accepted}) = b$.
 - Doesn't attend to lemons problem when bidding? \Leftarrow
- As if Raider thinks sales independent of v . \Leftarrow
- Raider solves $\max_b b(\frac{3}{2}E[v] - b) = \frac{3}{4}b - b^2$ and $b^* = \frac{3}{8} = .38$. \Leftarrow
- (Note: even most extreme form of our model too low.)

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- Variously all cursed vs. some rational, some cursed.

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 - Increasing difference in opinion, w/o understanding adverse selection.



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Inference and Learning from Others

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Inference and Learning from Others

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Inference and Learning from Others

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 - It is not the epistemologically, scientifically relevant “explanation”
- **Celerier & Vallee (2015)** paper ... shocking stuff.



Inference and Learning from Others

Generalization of “cursedness”

Inference and Learning from Others

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Inference and Learning from Others

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Inference and Learning from Others

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 - But now talk solely about observational learning.

↪

Rational-Herding Literature:

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Inference and Learning from Others

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- Extensive imitation \Rightarrow not rational \Rightarrow
- Extensive imitation \Rightarrow social confirmation bias & false beliefs.

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Inference and Learning from Others

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- **Behavioral implications** of full rationality in observational learning \Rightarrow
- Very different implications of inferential naivety.

\curvearrowright

Review of Canonical Rational-Herding Models

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Banerjee (1992), Bikhchandani, Hirshleifer and Welch (1992).

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- Canonical example:

\curvearrowright

Inference and Learning from Others

Canonical model: Either A or B is good—but not both (?)—and binary private i.i.d. signals. A when you believe $\omega = 1$, B when $\omega = 0$. α signal of $\omega = 1$, β of $\omega = 0$;

Inference and Learning from Others

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<u>player</u>	<u>signal</u>	<u>action</u>
1	α	A
2	β	B
3	α	A
4	α	A
5	β	[A]
6	α	[A]
7	β	[A]
8	α	[A]
9	β	[A]
10	β	[A]



Efficiency facts of rational herding models:

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 - (Debated in literature: is even non-aggregation really likely?)

↪

Inference and Learning from Others

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\rightarrow

Inference and Learning from Others

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 - (Lots results independent of η)

↪

Inference and Learning from Others

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$p(\omega_A)$ $[0,10), [10,20), [20,30), [30,40)$ $[40,60]$ $(60,70], (70,80], (80,90], (90,100]$

Choice B^{+++}, B^{++}, B^+, B H A, A^+, A^{++}, A^{+++}

\Downarrow

Three people choose restaurants each period,

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- General punchlines not based on specifics.

↪

Inference and Learning from Others

What predictions does full rationality make?

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 - $\emptyset \rightarrow A$. \Rightarrow
 - $\alpha \rightarrow A^{++}$

\rightarrow

If observe:

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\}$

Period 2: $\{A, A, A\}$

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\} \Rightarrow$

Period 2: $\{A, A, A\}$

What do (as function of signal)?

\curvearrowright

Inference and Learning from Others

actions

response

Period 1: $\{A, H, H\}$

Period 2: $\{A, A, A\}$

Period 3: $\beta \rightarrow H, \emptyset \rightarrow A, \alpha \rightarrow A^{++}$

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{A, A, A\}$		$\{\emptyset, \emptyset, \emptyset\}$
Period 3:		$\beta \rightarrow H, \emptyset \rightarrow A, \alpha \rightarrow A^{++}$	

Inference and Learning from Others

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- Key logic: guys in period 2 did *not* get any additional information.

Inference and Learning from Others

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Inference and Learning from Others

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Period 2:	$\{A, A, A\}$		$\{\emptyset, \emptyset, \emptyset\}$
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 - (If did, would not have gone alone.) \Rightarrow
 - Period 3: rationally realize no new information in Period-2 followers.

\rightarrow

If observe:

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\}$

Period 2: $\{A, A, A\}$

Period 3: $\{A, A, A\}$

Period 4: $\{A, A, A\}$

Period 5: $\{A, A, A\}$

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\}$
Period 2: $\{A, A, A\} \Rightarrow$
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What do as (as function of signal)?

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Inference and Learning from Others

actions

response

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Period 2: $\{A, A, A\}$

Period 3: $\{A, A, A\}$

Period 4: $\{A, A, A\}$

Period 5: $\{A, A, A\}$

Period 6: $\beta \rightarrow H, \emptyset \rightarrow A, \alpha \rightarrow A^{++}$

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{A, A, A\}$		$\{\emptyset, \emptyset, \emptyset\}$
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- Understanding redundancy information in actions: hard.

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
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Period 6: $\beta \rightarrow H, \emptyset \rightarrow A, \alpha \rightarrow A^{++}$

- Understanding redundancy information in actions: hard. \Rightarrow
- But it matters a lot.

\curvearrowright

If observe:

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\}$

Period 2: $\{A, A, H\}$

Inference and Learning from Others

If observe: \Rightarrow

actions

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Period 2: $\{A, A, H\}$

What do (as function of signal)?

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Inference and Learning from Others

Herding without sufficiently increased enthusiasm is a bad sign:

actions

response

Period 1: $\{A, H, H\}$

Period 2: $\{A, A, H\}$

Period 3: $\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$

Inference and Learning from Others

Herding without sufficiently increased enthusiasm is a bad sign:

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{A, A, H\}$		$\Rightarrow \{\emptyset, \emptyset, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

Inference and Learning from Others

Herding without sufficiently increased enthusiasm is a bad sign:

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{A, A, H\}$		$\{\emptyset, \emptyset, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	
\Rightarrow			
3 A, 3 H $\rightarrow \omega_A, \omega_B$ equally likely!			

Inference and Learning from Others

Herding without sufficiently increased enthusiasm is a bad sign:

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
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Period 3: $\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$
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- Do we get that?

\Downarrow

If observe:

Inference and Learning from Others

If observe: \Rightarrow

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Inference and Learning from Others

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What do (as function of signal)?

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Inference and Learning from Others

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response

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Inference and Learning from Others

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Period 3:		$\beta \rightarrow B^{++}, \emptyset \rightarrow B, \alpha \rightarrow H$	

You shouldn't go to A even if get α !

\curvearrowright

If observe:

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\}$

Period 2: $\{H, H, H\}$

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\}$ \Leftarrow

Period 2: $\{H, H, H\}$

What do (as function of signal)?

\Leftarrow

Inference and Learning from Others

actions

response

Period 1: $\{A, H, H\}$

Period 2: $\{H, H, H\}$

Period 3: $\beta \rightarrow B^{+++}, \emptyset \rightarrow B^{++}, \alpha \rightarrow B$

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{H, H, H\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B^{+++}, \emptyset \rightarrow B^{++}, \alpha \rightarrow B$	

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{H, H, H\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B^{+++}, \emptyset \rightarrow B^{++}, \alpha \rightarrow B$	

Go to B no matter what!

$\nabla \rightarrow$

If observe:

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\}$
Period 2: $\{A^{++}, A, A\}$
Period 3: $\{A^{++}, A, A\}$

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\} \Rightarrow$

Period 2: $\{A^{++}, A, A\}$

Period 3: $\{A^{++}, A, A\}$

What do (as function of signal)?

$\varphi \rightarrow$

Inference and Learning from Others

actions

response

Period 1: $\{A, H, H\}$

Period 2: $\{A^{++}, A, A\}$

Period 3: $\{A^{++}, A, A\}$

Period 4: $\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{A^{++}, A, A\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 3:	$\{A^{++}, A, A\}$		$\{\emptyset, \beta, \beta\}$
Period 4:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

↷

If observe:

Inference and Learning from Others

If observe: \Rightarrow

actions

- Period 1: $\{A, H, H\}$
- Period 2: $\{A^{++}, A, A\}$
- Period 3: $\{A^{++}, A^{++}, A\}$
- Period 4: $\{A^{++}, A^{++}, A\}$
- Period 5: $\{A^{++}, A^{++}, A^{++}\}$

Inference and Learning from Others

If observe: \Rightarrow

actions

Period 1: $\{A, H, H\}$
Period 2: $\{A^{++}, A, A\}$ \Rightarrow
Period 3: $\{A^{++}, A^{++}, A\}$
Period 4: $\{A^{++}, A^{++}, A\}$
Period 5: $\{A^{++}, A^{++}, A^{++}\}$

What do (as function of signal)?

\mapsto

Inference and Learning from Others

actions

response

Period 1: $\{A, H, H\}$
Period 2: $\{A^{++}, A, A\}$
Period 3: $\{A^{++}, A^{++}, A\}$
Period 4: $\{A^{++}, A^{++}, A\}$
Period 5: $\{A^{++}, A^{++}, A^{++}\}$

Period 6: $\beta \rightarrow H, \emptyset \rightarrow A, \alpha \rightarrow A^{++}$

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{A^{++}, A, A\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 3:	$\{A^{++}, A^{++}, A\}$		$\{\emptyset, \emptyset, \beta\}$
Period 4:	$\{A^{++}, A^{++}, A\}$		$\{\alpha, \alpha, \emptyset\}$
Period 5:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 6:		$\beta \rightarrow H, \emptyset \rightarrow A, \alpha \rightarrow A^{++}$	

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{A^{++}, A, A\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 3:	$\{A^{++}, A^{++}, A\}$		$\{\emptyset, \emptyset, \beta\}$
Period 4:	$\{A^{++}, A^{++}, A\}$		$\{\alpha, \alpha, \emptyset\}$
Period 5:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 6:		$\beta \rightarrow H, \emptyset \rightarrow A, \alpha \rightarrow A^{++}$	

Will a β signal help stop the herd?

↷

If observe:

If observe: \Rightarrow

actions

Period 1: $\{A, A, A\}$
Period 2: $\{A^{++}, A^{++}, A^{++}\}$

If observe: \Rightarrow

actions

Period 1: $\{A, A, A\}$ \Rightarrow
Period 2: $\{A^{++}, A^{++}, A^{++}\}$

What do (as function of signal)?

\Downarrow

Inference and Learning from Others

actions

response

Period 1:

$\{A, A, A\}$

Period 2:

$\{A^{++}, A^{++}, A^{++}\}$

Period 3:

$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough.

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough. \Rightarrow
- Things far more complicated if

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough. \Rightarrow
- Things far more complicated if \Rightarrow don't observe order,

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough. \Leftarrow
- Things far more complicated if \Leftarrow don't observe order, \Leftarrow don't observe all, or

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough. \Leftarrow
- Things far more complicated if \Leftarrow don't observe order, \Leftarrow don't observe all, or \Leftarrow heterogenous preferences

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough. \Leftarrow
- Things far more complicated if \Leftarrow don't observe order, \Leftarrow don't observe all, or \Leftarrow heterogenous preferences \Leftarrow
 - But nothing makes the severe limits to imitation go away

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough. \Rightarrow
- Things far more complicated if \Rightarrow don't observe order, \Rightarrow don't observe all, or \Rightarrow heterogenous preferences \Rightarrow
 - But nothing makes the severe limits to imitation go away \Rightarrow
- **Others' beliefs massively correlated**

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough. \Rightarrow
- Things far more complicated if \Rightarrow don't observe order, \Rightarrow don't observe all, or \Rightarrow heterogenous preferences \Rightarrow
 - But nothing makes the severe limits to imitation go away \Rightarrow
- **Others' beliefs massively correlated** \Rightarrow
 - \Rightarrow **musn't imitate too much.**

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
Period 2:	$\{A^{++}, A^{++}, A^{++}\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B, \emptyset \rightarrow H, \alpha \rightarrow A$	

- Enough. \Rightarrow
- Things far more complicated if \Rightarrow don't observe order, \Rightarrow don't observe all, or \Rightarrow heterogenous preferences \Rightarrow
 - But nothing makes the severe limits to imitation go away \Rightarrow
- **Others' beliefs massively correlated** \Rightarrow
 - \Rightarrow **musn't imitate too much.** \Rightarrow



Inference and Learning from Others

Same setting (same signals, players per period, etc.) but:

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play.

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare**

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare** \Rightarrow
- In period 3, if see

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare** \Rightarrow
- In period 3, if see \Rightarrow
 - If see $\{H, H, H, H, H, H\}$, then believe

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare** \Rightarrow
- In period 3, if see \Rightarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Rightarrow .5$

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Leftarrow

- Cannot observe order of play. \Leftarrow
- **Signals rare** \Leftarrow
- In period 3, if see \Leftarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, H, H, H, H, H\}$, then believe

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Leftarrow

- Cannot observe order of play. \Leftarrow
- **Signals rare** \Leftarrow
- In period 3, if see \Leftarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Leftarrow .7$

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare** \Rightarrow
- In period 3, if see \Rightarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Rightarrow .5$ \Rightarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Rightarrow .7$ \Rightarrow
 - If see $\{A, A, H, H, H, H\}$, then believe

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Leftarrow

- Cannot observe order of play. \Leftarrow
- **Signals rare** \Leftarrow
- In period 3, if see \Leftarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Leftarrow .7$ \Leftarrow
 - If see $\{A, A, H, H, H, H\}$, then believe $\Leftarrow .84$

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare** \Rightarrow
- In period 3, if see \Rightarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Rightarrow .5$ \Rightarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Rightarrow .7$ \Rightarrow
 - If see $\{A, A, H, H, H, H\}$, then believe $\Rightarrow .84$ \Rightarrow
 - If see $\{A, A, A, H, H, H\}$, then believe \Rightarrow

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare** \Rightarrow
- In period 3, if see \Rightarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Rightarrow .5$ \Rightarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Rightarrow .7$ \Rightarrow
 - If see $\{A, A, H, H, H, H\}$, then believe $\Rightarrow .84$ \Rightarrow
 - If see $\{A, A, A, H, H, H\}$, then believe $\Rightarrow .5$

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Leftarrow

- Cannot observe order of play. \Leftarrow
- **Signals rare** \Leftarrow
- In period 3, if see \Leftarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Leftarrow .7$ \Leftarrow
 - If see $\{A, A, H, H, H, H\}$, then believe $\Leftarrow .84$ \Leftarrow
 - If see $\{A, A, A, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, A, A, A, H, H\}$, then believe \Leftarrow

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Leftarrow

- Cannot observe order of play. \Leftarrow
- **Signals rare** \Leftarrow
- In period 3, if see \Leftarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Leftarrow .7$ \Leftarrow
 - If see $\{A, A, H, H, H, H\}$, then believe $\Leftarrow .84$ \Leftarrow
 - If see $\{A, A, A, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, A, A, A, H, H\}$, then believe $\Leftarrow .7$ \Leftarrow

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare** \Rightarrow
- In period 3, if see \Rightarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Rightarrow .5$ \Rightarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Rightarrow .7$ \Rightarrow
 - If see $\{A, A, H, H, H, H\}$, then believe $\Rightarrow .84$ \Rightarrow
 - If see $\{A, A, A, H, H, H\}$, then believe $\Rightarrow .5$ \Rightarrow
 - If see $\{A, A, A, A, H, H\}$, then believe $\Rightarrow .7$ \Rightarrow
 - If see $\{A, A, A, A, A, H\}$, then believe \Rightarrow

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Leftarrow

- Cannot observe order of play. \Leftarrow
- **Signals rare** \Leftarrow
- In period 3, if see \Leftarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Leftarrow .7$ \Leftarrow
 - If see $\{A, A, H, H, H, H\}$, then believe $\Leftarrow .84$ \Leftarrow
 - If see $\{A, A, A, H, H, H\}$, then believe $\Leftarrow .5$ \Leftarrow
 - If see $\{A, A, A, A, H, H\}$, then believe $\Leftarrow .7$ \Leftarrow
 - If see $\{A, A, A, A, A, H\}$, then believe $\Leftarrow .3$ \Leftarrow

Inference and Learning from Others

Same setting (same signals, players per period, etc.) but: \Rightarrow

- Cannot observe order of play. \Rightarrow
- **Signals rare** \Rightarrow
- In period 3, if see \Rightarrow
 - If see $\{H, H, H, H, H, H\}$, then believe $\Rightarrow .5$ \Rightarrow
 - If see $\{A, H, H, H, H, H\}$, then believe $\Rightarrow .7$ \Rightarrow
 - If see $\{A, A, H, H, H, H\}$, then believe $\Rightarrow .84$ \Rightarrow
 - If see $\{A, A, A, H, H, H\}$, then believe $\Rightarrow .5$ \Rightarrow
 - If see $\{A, A, A, A, H, H\}$, then believe $\Rightarrow .7$ \Rightarrow
 - If see $\{A, A, A, A, A, H\}$, then believe $\Rightarrow .3$ \Rightarrow

One old and one new example:

\rightarrow

Inference and Learning from Others

actions

response

Period 1: $\{A, H, H\}$

Period 2: $\{H, H, H\}$

Period 3: $\beta \rightarrow B^{+++}, \emptyset \rightarrow B^{++}, \alpha \rightarrow B$

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{H, H, H\}$		$= \{\beta, \beta, \beta\}$

Period 3: $\beta \rightarrow B^{+++}, \emptyset \rightarrow B^{++}, \alpha \rightarrow B$

	actions	response
Period 1:	$\{B, H, H\}$	
Period 2:	$\{H, H, H\}$	

Period 3: $\beta \rightarrow A, \emptyset \rightarrow A^{++}, \alpha \rightarrow A^{+++}$

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{H, H, H\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B^{+++}, \emptyset \rightarrow B^{++}, \alpha \rightarrow B$	

	actions	response	signals
Period 1:	$\{B, H, H\}$		$\{\beta, \emptyset, \emptyset\}$
Period 2:	$\{H, H, H\}$		$\{\alpha, \alpha, \alpha\}$
Period 3:		$\beta \rightarrow A, \emptyset \rightarrow A^{++}, \alpha \rightarrow A^{+++}$	

Inference and Learning from Others

	actions	response	signals
Period 1:	$\{A, H, H\}$		$\{\alpha, \emptyset, \emptyset\}$
Period 2:	$\{H, H, H\}$		$\{\beta, \beta, \beta\}$
Period 3:		$\beta \rightarrow B^{+++}, \emptyset \rightarrow B^{++}, \alpha \rightarrow B$	

	actions	response	signals
Period 1:	$\{B, H, H\}$		$\{\beta, \emptyset, \emptyset\}$
Period 2:	$\{H, H, H\}$		$\{\alpha, \alpha, \alpha\}$
Period 3:		$\beta \rightarrow A, \emptyset \rightarrow A^{++}, \alpha \rightarrow A^{+++}$	

Anti-imitation!

Inference and Learning from Others

Lesson?

Inference and Learning from Others

Lesson? \Leftrightarrow

- Choosing a restaurant may be hard!

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson:

Inference and Learning from Others

Lesson? \Leftrightarrow

- Choosing a restaurant may be hard! \Leftrightarrow

More interesting lesson: \Leftrightarrow

- Most natural learning environments...

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
 - Great deal redundancy.

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
 - Great deal redundancy. \Rightarrow
- Theorem 1

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
 - Great deal redundancy. \Rightarrow
- Theorem 1 \Rightarrow ('False but not misleading'):

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
 - Great deal redundancy. \Rightarrow
- Theorem 1 \Rightarrow ('False but not misleading'): \Rightarrow
 - Almost all non-single-file environments, rationality implies 'anti-imitation'.

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
 - Great deal redundancy. \Rightarrow
- Theorem 1 \Rightarrow ('False but not misleading'): \Rightarrow
 - Almost all non-single-file environments, rationality implies 'anti-imitation'. \Rightarrow
 - Intuition: if two recent guys both imitating earlier guy but not each other—imitate both,

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
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- Theorem 1 \Rightarrow ('False but not misleading'): \Rightarrow
 - Almost all non-single-file environments, rationality implies 'anti-imitation'. \Rightarrow
 - Intuition: if two recent guys both imitating earlier guy but not each other—imitate both, \Rightarrow
 - **but subtract off source of correlation... earlier guy.**

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
 - Great deal redundancy. \Rightarrow
- Theorem 1 \Rightarrow ('False but not misleading'): \Rightarrow
 - Almost all non-single-file environments, rationality implies 'anti-imitation'. \Rightarrow
 - Intuition: if two recent guys both imitating earlier guy but not each other—imitate both, \Rightarrow
 - **but subtract off source of correlation... earlier guy.** \Rightarrow
- Theorem 2:

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
 - Great deal redundancy. \Rightarrow
- Theorem 1 \Rightarrow ('False but not misleading'): \Rightarrow
 - Almost all non-single-file environments, rationality implies 'anti-imitation'. \Rightarrow
 - Intuition: if two recent guys both imitating earlier guy but not each other—imitate both, \Rightarrow
 - **but subtract off source of correlation... earlier guy.** \Rightarrow
- Theorem 2: \Rightarrow
 - What few environments that don't demand 'anti-imitation'

Inference and Learning from Others

Lesson? \Rightarrow

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More interesting lesson: \Rightarrow

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- Theorem 1 \Rightarrow ('False but not misleading'): \Rightarrow
 - Almost all non-single-file environments, rationality implies 'anti-imitation'. \Rightarrow
 - Intuition: if two recent guys both imitating earlier guy but not each other—imitate both, \Rightarrow
 - **but subtract off source of correlation... earlier guy.** \Rightarrow
- Theorem 2: \Rightarrow
 - What few environments that don't demand 'anti-imitation' \Rightarrow (e.g., single-file),

Inference and Learning from Others

Lesson? \Rightarrow

- Choosing a restaurant may be hard! \Rightarrow

More interesting lesson: \Rightarrow

- Most natural learning environments... \Rightarrow
 - Great deal redundancy. \Rightarrow
- Theorem 1 \Rightarrow ('False but not misleading'): \Rightarrow
 - Almost all non-single-file environments, rationality implies 'anti-imitation'. \Rightarrow
 - Intuition: if two recent guys both imitating earlier guy but not each other—imitate both, \Rightarrow
 - **but subtract off source of correlation... earlier guy.** \Rightarrow
- Theorem 2: \Rightarrow
 - What few environments that don't demand 'anti-imitation' \Rightarrow (e.g., single-file), \Rightarrow imitate all you see as if seeing only one person.



Inference and Learning from Others

Harder to see:

Inference and Learning from Others

Harder to see: \Rightarrow

- Rational observational learning in this case:

Inference and Learning from Others

Harder to see: \Rightarrow

- Rational observational learning in this case: \Rightarrow
 - Eventually will herd on $\{B^{+++}\}$ or $\{A^{+++}\}$.

Inference and Learning from Others

Harder to see: \Rightarrow

- Rational observational learning in this case: \Rightarrow
 - Eventually will herd on $\{B^{+++}\}$ or $\{A^{+++}\}$. \Rightarrow
 - More than 95% of time \rightarrow right restaurant.

Inference and Learning from Others

Harder to see: \Rightarrow

- Rational observational learning in this case: \Rightarrow
 - Eventually will herd on $\{B^{+++}\}$ or $\{A^{+++}\}$. \Rightarrow
 - More than 95% of time \rightarrow right restaurant. \Rightarrow
 - Intuition: any lesser certainty, contrary signal will moderate behavior.

Inference and Learning from Others

Harder to see: \Rightarrow

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 - More than 95% of time \rightarrow right restaurant. \Rightarrow
 - Intuition: any lesser certainty, contrary signal will moderate behavior. \Rightarrow
- **When signals rare:**

Inference and Learning from Others

Harder to see: \Rightarrow

- Rational observational learning in this case: \Rightarrow
 - Eventually will herd on $\{B^{+++}\}$ or $\{A^{+++}\}$. \Rightarrow
 - More than 95% of time \rightarrow right restaurant. \Rightarrow
 - Intuition: any lesser certainty, contrary signal will moderate behavior. \Rightarrow
- **When signals rare:** \Rightarrow
 - Roughly 30% of time herd starts in wrong direction,

Harder to see: \Rightarrow

- Rational observational learning in this case: \Rightarrow
 - Eventually will herd on $\{B^{+++}\}$ or $\{A^{+++}\}$. \Rightarrow
 - More than 95% of time \rightarrow right restaurant. \Rightarrow
 - Intuition: any lesser certainty, contrary signal will moderate behavior. \Rightarrow
- **When signals rare:** \Rightarrow
 - Roughly 30% of time herd starts in wrong direction, \Rightarrow
 - stays wrong $<$ 5% time.

Harder to see: \Rightarrow

- Rational observational learning in this case: \Rightarrow
 - Eventually will herd on $\{B^{+++}\}$ or $\{A^{+++}\}$. \Rightarrow
 - More than 95% of time \rightarrow right restaurant. \Rightarrow
 - Intuition: any lesser certainty, contrary signal will moderate behavior. \Rightarrow
- **When signals rare:** \Rightarrow
 - Roughly 30% of time herd starts in wrong direction, \Rightarrow
 - stays wrong $< 5\%$ time. \Rightarrow
 - $\rightarrow > 25\%$ of time: herd in wrong direction followed by reversal...

Harder to see: \Rightarrow

- Rational observational learning in this case: \Rightarrow
 - Eventually will herd on $\{B^{+++}\}$ or $\{A^{+++}\}$. \Rightarrow
 - More than 95% of time \rightarrow right restaurant. \Rightarrow
 - Intuition: any lesser certainty, contrary signal will moderate behavior. \Rightarrow
- **When signals rare:** \Rightarrow
 - Roughly 30% of time herd starts in wrong direction, \Rightarrow
 - stays wrong $<$ 5% time. \Rightarrow
 - \rightarrow $>$ 25% of time: herd in wrong direction followed by reversal... \Rightarrow
 - somebody observing at least 50 people going to one restaurant and none to other decides stay home based on opposite signal.

\rightarrow

Inference and Learning from Others

Rationality does not just demand great care.

Inference and Learning from Others

Rationality does not just demand great care. \Rightarrow

- demands something people get wrong in systematic direction.

Inference and Learning from Others

Rationality does not just demand great care. \Rightarrow

- demands something people get wrong in systematic direction. \Rightarrow

What happens if instead people neglect redundancy?

Inference and Learning from Others

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- demands something people get wrong in systematic direction. \Rightarrow

What happens if instead people neglect redundancy? \Rightarrow

- ER (2010) particular extreme form.

Inference and Learning from Others

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What happens if instead people neglect redundancy? \Rightarrow

- ER (2010) particular extreme form. \Rightarrow
- “Britney” behaves as if all she is observing are independent.

Inference and Learning from Others

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When signals are rare,

Inference and Learning from Others

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What happens if instead people neglect redundancy? \Rightarrow

- ER (2010) particular extreme form. \Rightarrow
- “Britney” behaves as if all she is observing are independent. \Rightarrow

When signals are rare, \Rightarrow

- Tommy:

Inference and Learning from Others

Rationality does not just demand great care.⇒

- demands something people get wrong in systematic direction.⇒

What happens if instead people neglect redundancy?⇒

- ER (2010) particular extreme form.⇒
- “Britney” behaves as if all she is observing are independent.⇒

When signals are rare,⇒

- Tommy:⇒
 - less than 5% chance society converges to wrong restaurant,

Inference and Learning from Others

Rationality does not just demand great care.⇒

- demands something people get wrong in systematic direction.⇒

What happens if instead people neglect redundancy?⇒

- ER (2010) particular extreme form.⇒
- “Britney” behaves as if all she is observing are independent.⇒

When signals are rare,⇒

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Inference and Learning from Others

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Deconstructing Overconfidence

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- Per A&R, B, B-C, & R:
 - Base-rate neglect is over-reaction to information in one sense,
 - but induces *underconfidence*

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 - Only *comparative* confidence and optimism matter

Deconstructing Overconfidence

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 - But overconfidence isn't one of them, unless specify leaders more overconfident about winning wars than about diplomatic ability, etc.

Inference and Learning from Others

- A short history of Vitamin C

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↪