Inference and Learning from Others

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  - What effects of these errors?

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Cursed Thinking:

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Extensive Imitation is Irrational and Harmful

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  - overconfidently wrong social beliefs

Plugging my papers on inferring from others:

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- Eyster and Rabin (2005), *Econometrica*
- Eyster and Rabin (2010), *AEJ Theory*
- Eyster and Rabin (2012)
- Eyster, Rabin, and Vayanos (2013),
- **Eyster and Rabin (2013),**
- Eyster, Rabin, and Weizsacker (in progress)
- Gagnon-Bartsch and Rabin (in progress)

↬

Today

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2. Rational Observational Learning

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Note: Today and virtually all on this topic $\longrightarrow$ Erik Eyster

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Rational-Herding Literature:

Extensive Imitation is Irrational and Harmful

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

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But:

- We are skeptical people so reluctant to imitate.

$\looparrowright$

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  - redundancy neglect and mislearning

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Extensive Imitation is Irrational and Harmful

A Night with Venus, A Lifetime with Merury

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- Tens of millions had disease, millions died from it

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    - (But standard practice was to combine salvarsan with mercury)

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- Asking why used for 450 years.

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Paper: extended example, inspired by medical examples, of issues.

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When most drugs false positives (and docs know this!),

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- And even mild redundancy neglect guarantees adoption of a bad drug.

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Extensive Imitation is Irrational and Harmful

A Night with Venus, a Lifetime with Mercury

Instead, now: extended example not in paper.

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- Mercury vs. this example vs. main model vs. Avery-Zemsky vs. dozens other examples ... all same .

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Extensive Imitation is Irrational and Harmful

Dining Out

Modification of the canonical two-state, two signal, two-restaurant model of social learning.

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  - When $\eta \to 1$, information is very rare.
  - (Lots results independent of η)

$\looparrowright$

- Each Player k chooses among nine choices: she can dine in Restaurant A, dine in Restaurant B, or dine at home.

Extensive Imitation is Irrational and Harmful

Dining Out

- Each Player k chooses among nine choices: she can dine in Restaurant A, dine in Restaurant B, or dine at home.
  - Goes to a restaurant if she thinks there is more than 60% chance it is good, and stays at home if that is not true at either restaurant.

Extensive Imitation is Irrational and Harmful

Dining Out

- Each Player k chooses among nine choices: she can dine in Restaurant A, dine in Restaurant B, or dine at home.
  - Goes to a restaurant if she thinks there is more than 60% chance it is good, and stays at home if that is not true at either restaurant.
- Depending on confidence in restaurant's quality, may go alone, or take one, two, or three of her relatives.

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- Depending on confidence in restaurant's quality, may go alone, or take one, two, or three of her relatives.
- Superscripts for the number of people she takes:

$p(\omega_A)$	[0,10),[10,20),[20,30),[30,40)	[40,60]	(60,70],(70,80],(80,90],(90,100]
Choice	$B^{+++}, B^{++}, B^{+}, B$	H	$A, A^{+}, A^{++}, A^{+++}$

Extensive Imitation is Irrational and Harmful

Dining Out

Three people choose restaurants each period,

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- Signal conditionally i.i.d. given state

Extensive Imitation is Irrational and Harmful
Dining Out

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- Signal conditionally i.i.d. given state
- Each after observing

Extensive Imitation is Irrational and Harmful

Dining Out

Three people choose restaurants each period,

- Signal conditionally i.i.d. given state
- Each after observing her own signal,

Three people choose restaurants each period,

- Signal conditionally i.i.d. given state
- Each after observing her own signal, and the full actions (three locations, and party size), in order,

Three people choose restaurants each period,

- Signal conditionally i.i.d. given state
- Each after observing her own signal, and the full actions (three locations, and party size), in order, taken in all previous periods.

$\looparrowright$

Extensive Imitation is Irrational and Harmful
Dining Out

What predictions does full rationality make?

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- $\emptyset$ signal, observes nothing but $H \longrightarrow$ stay home.

Extensive Imitation is Irrational and Harmful

Dining Out

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- (alone, because beliefs exactly .7 $\longrightarrow$ alone).

Extensive Imitation is Irrational and Harmful

Dining Out

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Suppose in period 2 observe exactly one A in period 1.

Extensive Imitation is Irrational and Harmful

Dining Out

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- What do as a function of your signal?

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Suppose in period 2 observe exactly one A in period 1.

- What do as a function of your signal?
- You will realize that the three signals in period 1 were $\{\alpha, \emptyset, \emptyset\}$.

Extensive Imitation is Irrational and Harmful

Dining Out

What predictions does full rationality make?

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- (alone, because beliefs exactly .7 $\rightarrow$ alone).

Suppose in period 2 observe exactly one A in period 1.

- What do as a function of your signal?
- You will realize that the three signals in period 1 were $\{\alpha, \emptyset, \emptyset\}$.
    - $\beta \rightarrow H$.

What predictions does full rationality make?

- $\emptyset$ signal, observes nothing but $H \rightarrow$ stay home.
- α or β signal, observes nothing but $H \rightarrow$ go to restaurant.
- (alone, because beliefs exactly .7 $\rightarrow$ alone).

Suppose in period 2 observe exactly one A in period 1.

- What do as a function of your signal?
- You will realize that the three signals in period 1 were $\{\alpha, \emptyset, \emptyset\}$.
  - $\beta \rightarrow H$.
  - $\emptyset \rightarrow A$.

What predictions does full rationality make?

- $\emptyset$ signal, observes nothing but $H \to$ stay home.
- α or β signal, observes nothing but $H \to$ go to restaurant.
- (alone, because beliefs exactly .7 $\to$ alone).

Suppose in period 2 observe exactly one A in period 1.

- What do as a function of your signal?
- You will realize that the three signals in period 1 were $\{\alpha, \emptyset, \emptyset\}$.
    - $\beta \to H$.
    - $\emptyset \to A$.
    - $\alpha \to A^{++}$

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

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

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

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

- Key logic: guys in period 2 did *not* get any additional information.
    - (If did, would not have gone alone.)

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

- Key logic: guys in period 2 did *not* get any additional information.
  - (If did, would not have gone alone.)
  - Period 3: rationally realize no new information in Period-2 followers.

$\looparrowright$

Extensive Imitation is Irrational and Harmful

Dining Out

	actions	response
Period 1:	$\{A, H, H\}$	
Period 2:	$\{A, A, A\}$	
Period 3:	$\{A, A, A\}$	
Period 4:	$\{A, A, A\}$	
Period 5:	$\{A, A, A\}$	

Extensive Imitation is Irrational and Harmful

Dining Out

	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:		$\beta \to H$, $\emptyset \to A$, $\alpha \to A^{++}$

Extensive Imitation is Irrational and Harmful

Dining Out

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

- Understanding redundancy information in actions: hard.

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

$\looparrowright$

Herding without sufficiently increased enthusiasm is a bad sign:

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

Herding without sufficiently increased enthusiasm is a bad sign:

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

3 A, 3 H $\rightarrow \omega_A, \omega_B$ equally likely!

Extensive Imitation is Irrational and Harmful

Dining Out

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:		$\beta \to B,\ \emptyset \to H,\ \alpha \to A$	

3 A, 3 H $\to$ ω_A, ω_B equally likely!

- Do we get that?

↬

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

You shouldn't go to A even if get α!

$\looparrowright$

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

Go to B no matter what!

$\looparrowright$

Extensive Imitation is Irrational and Harmful

Dining Out

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

Extensive Imitation is Irrational and Harmful

Dining Out

	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:		$\beta \to B,\ \emptyset \to H,\ \alpha \to A$	

$\looparrowright$

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

	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:		$\beta \to H,\ \emptyset \to A,\ \alpha \to A^{++}$	

Will a β signal help stop the herd?

$\looparrowright$

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Dining Out

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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Dining Out

	actions	response	signals
Period 1:	$\{A, A, A\}$		$\{\alpha, \alpha, \alpha\}$
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- Enough.

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Dining Out

	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.
- Things fare more complicated if

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Dining Out

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

- Enough.
- Things fare more complicated if don't observe order

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Dining Out

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

- Enough.
- Things fare more complicated if don't observe order don't observe all

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Dining Out

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

- Enough.
- Things fare more complicated if don't observe order don't observe all heterogenous preferences

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

- Enough.

- Things fare more complicated if don't observe order don't observe all heterogenous preferences
  - But nothing makes the severe limits to imitation go away

↬

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

Extensive Imitation is Irrational and Harmful
Dining Out

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

- Cannot observe order of play.

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

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Dining Out

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

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- **Signals rare**
- In period 3,

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

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

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

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

Extensive Imitation is Irrational and Harmful

Dining Out

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

- Cannot observe order of play.
- **Signals rare**
- In period 3,
  - If see $\{H, H, H, H, H, H\}$, then believe .5
  - If see $\{A, H, H, H, H, H\}$, then believe .7
  - If see $\{A, A, H, H, H, H\}$, then believe .84
  - If see $\{A, A, A, H, H, H\}$, then believe .5
  - If see $\{A, A, A, A, H, H\}$, then believe .7
  - If see $\{A, A, A, A, A, H\}$, then believe .3
- (Example combines Callender-Horner and Eyster-Rabin intuitions)

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

- Cannot observe order of play.
- **Signals rare**
- In period 3,
  - If see $\{H, H, H, H, H, H\}$, then believe .5
  - If see $\{A, H, H, H, H, H\}$, then believe .7
  - If see $\{A, A, H, H, H, H\}$, then believe .84
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  - If see $\{A, A, A, A, A, H\}$, then believe .3
- (Example combines Callender-Horner and Eyster-Rabin intuitions)

One old and one new example:

↬

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

Extensive Imitation is Irrational and Harmful

Dining Out

	actions	response	signals
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Anti-imitation!

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Extensive Imitation is Irrational and Harmful

Dining Out

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Now: formal, continuous framework

- Lots of structure ... simple results

$\looparrowright$

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Extensive Imitation is Irrational and Harmful

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Observation structure:

Extensive Imitation is Irrational and Harmful

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- $\mathcal{N} = \{\{1, 2, \ldots\}, \{D(1), D(2), \ldots\}\}$ is observation structure

↬

Extensive Imitation is Irrational and Harmful

Impartial Inference and the Limits of Imitation

- Player k chooses action $\alpha_k \in [0, 1]$ to maximize $E\{-(\alpha_k - \omega)^2\}$ given her information, $I_{k\rightleftharpoons}$
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The quadruple of distinct players (i, j, k, l) in $\mathcal{N}$ forms a *diamond* if $i \in ID(j) \cap ID(k)$, $j \notin ID(k)$, $k \notin ID(j)$, and $\{j, k\} \subset D(l)$

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- Canonical single-file models of Banerjee (1992) and Bikchandani, Hirshleifer, and Welch (1992) do not include diamonds

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Extensive Imitation is Irrational and Harmful

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Definition

k *imitates* j if $a_k(a_j, a^k_{-j}; s_k)$ is weakly increasing (but not constant) in a_j $\rightleftharpoons$

Definition

k *anti-imitates* j if $a_k(a_j, a^k_{-j}; s_k)$ weakly decreasing (not constant) in a_j $\rightleftharpoons$

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Extensive Imitation is Irrational and Harmful

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Assume the observation structure $\mathcal{N}$ generates impartial inference. Then some player anti-imitates another if and only if $\mathcal{N}$ contains a shield

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- Proposition 1 shows that any impartial-inference setting that contains a shield includes at least one player who anti-imitates another
- Proof does some accounting based on simple single-shield correlation-subtraction intuition.

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- Single-file: each person imitates only her immediate predecessor
- More generally: if no player anti-imitates, then no player imitates two predecessors who both observe an earlier, common predecessor
- But sharing no common observation excludes virtually all social learners (except at the beginning) in almost all settings of interest

↬

Extensive Imitation is Irrational and Harmful

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Player k's action a_k is *contrarian* given signal s_k and history a^{k-1} iff $a_k \neq 0$ and $\mathrm{sgn}(a_k) = -\,\mathrm{sgn}(s_k) = -\,\mathrm{sgn}(a_j)$ for every $j \in D(k)$

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Proposition

Assume $\mathcal{N}$ generates impartial inference$_{\rightleftharpoons}$

1. *If some player's action is contrarian, then $\mathcal{N}$ contains a shield$_{\rightleftharpoons}$*
2. *If $\mathcal{N}$ contains a shield and players' private signals are drawn from the density $f^{(\omega)}$ that is everywhere positive on $[\underline{s}, \overline{s}]$, then with positive probability some player's action is contrarian$_{\rightleftharpoons}$*

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- Then:

$$A_t = S_t + n \sum_{i=1}^{t-1} (-1)^{i-1} (n-1)^{i-1} A_{t-i}$$

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  - $A_1 = S_1$, $A_2 = S_2 + 3A_1$⇌
  - $A_3 = S_3 + 3A_2 - 6A_1$⇌
  - $A_4 = S_4 + 3S_3 - 6A_2 + 12A_1$

↪

Extensive Imitation is Irrational and Harmful

Redundancy Neglect

What happens if people do not anti-imitate, and imitate more broadly than predicted by full rationality?

Extensive Imitation is Irrational and Harmful

Redundancy Neglect

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Definition

Social learning is *strictly and boundedly increasing in private signals* if

1. (strictly increasing) for each Player t, and each $a^{t-1} \in \mathbb{R}^{t-1}$,

$$\hat{s}^t > s^t \Rightarrow a_t(a^{t-1}, \hat{s}_t) > a_t(a^{t-1}, s_t)$$

2. (boundedly increasing) there exists $K \in \mathbb{R}_{++}$ such that for each Player t, each $a^{t-1} \in \mathbb{R}^{t-1}$, and each $s^t, \hat{s}^t \in \mathbb{R}$,

$$\left| a_t(a^{t-1}, \hat{s}_t) - a_t(a^{t-1}, s_t) \right| \leq K \left| \hat{s}_t - s_t \right|$$

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Definition

Players use social-learning rules that *neglect redundancy* if there exist an integer N and a constant $c > 0$ with the property that for each Player $t \geq N+1$, each $a^{t-N-1} \in \mathbb{R}^{t-N-1}$, each $s_t \in \mathbb{R}$, and each $z' > z \geq 0$,

$$a_t(a^{t-N-1}, \underbrace{z', z', \ldots, z'}_{N \text{ times}}, s_t) - a_t(a^{t-N-1}, \underbrace{z, z, \ldots, z}_{N \text{ times}}, s_t) \geq (1+c)(z' - z)$$

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- RN is joint assumption about observation structure and imitation
  - encompasses all sorts of combinations of assumptions about whom people observe and whom they imitate

- Also allows people to under-infer from their predecessors, as in partially-cursed equilibrium (Eyster and Rabin (2005)), so long as they neglect redundancy:

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- someone can treat all predecessors' actions as half as informative as they are at the same time as she mistakenly imitates many predecessors instead of just one.
- The condition is, intuitively, that the sum total of influence from underweighting individuals and overcounting predecessors is greater than the influence of one person, correctly interpreted.

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Suppose players social-learning rules are strictly and boundedly increasing in private signals as well as neglect redundancy, and that no player anti-imitates any other. Then, with positive probability, society converges to the action that corresponds to certain beliefs in the wrong state.

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- redundancy-neglecting doctors can converge with near certainty to a bad medicine ... and believe it works with near certainty

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- BRTNI players give the past 100 players 100 times the weight that they should get
- Proposition says that far milder over-imitation leads society astray
- If everyone treats their predecessors' actions as embodying just two conditionally independent signals, instead of one, then society sometimes converges to complete confidence in the wrong state.

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- When observed recent actors provide independent information, they should all be imitated
- But when those recent players themselves imitate earlier actions, those earlier actions should be subtracted

↬