CCS guest lecture • 19 November 2024

Learning about and from other agents

Max Taylor-Davies

My background

MEng Bioengineering

Imperial College London, 2017-2021

↓

RA in experimental neuro

University College London, 2021-2022

↓

CDT in robotics and autonomous systems

University of Edinburgh, 2022-
Supervised by Chris Lucas & Neil Bramley

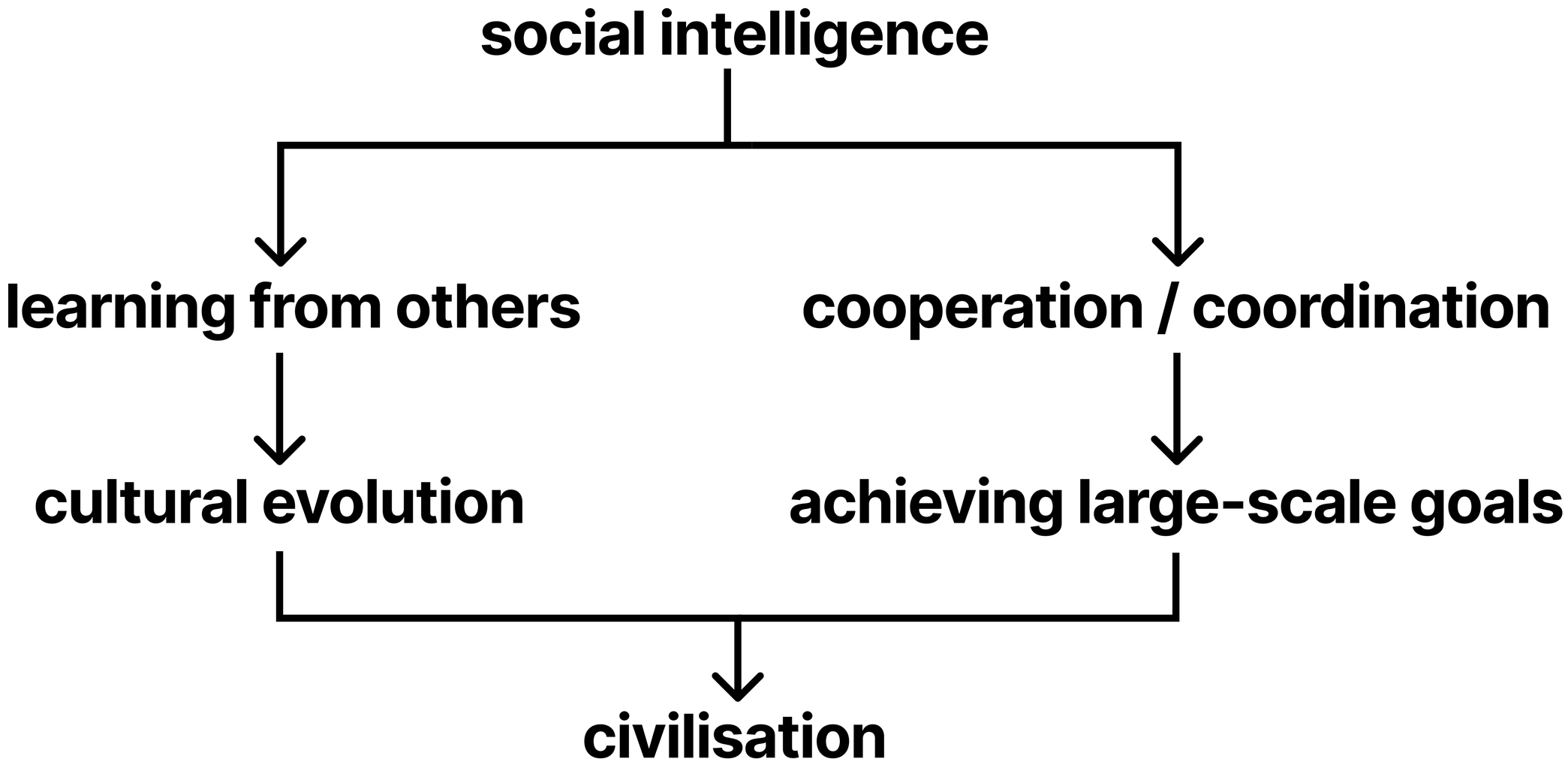
What’s so ✨special✨ about humans?

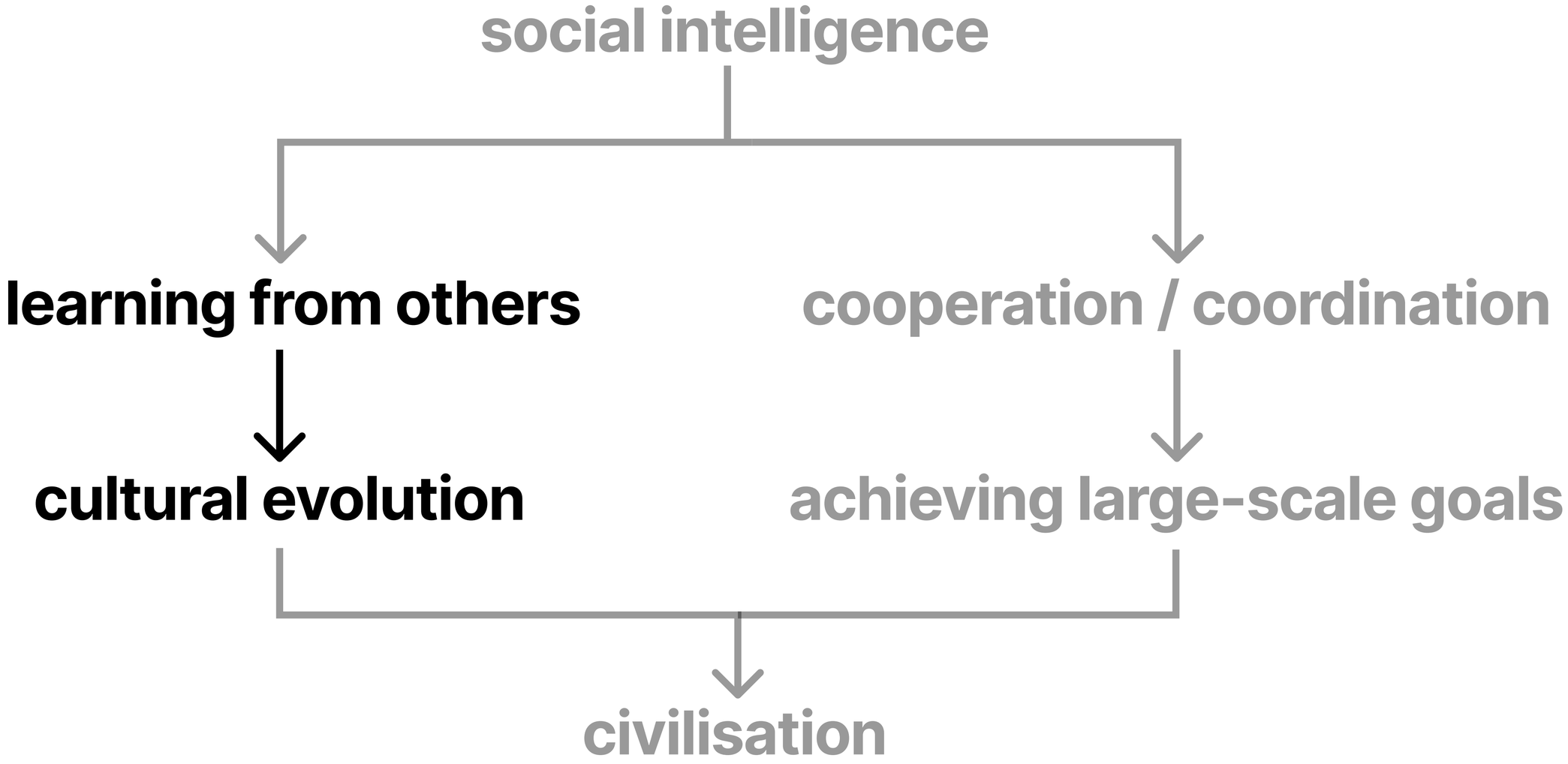
Language?

Tool use?

Abstract reasoning?

My preferred answer: *social* intelligence!


social intelligence
learning from others
cooperation / coordination
cultural evolution
achieving large-scale goals
civilisation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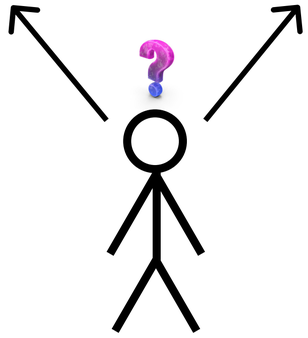
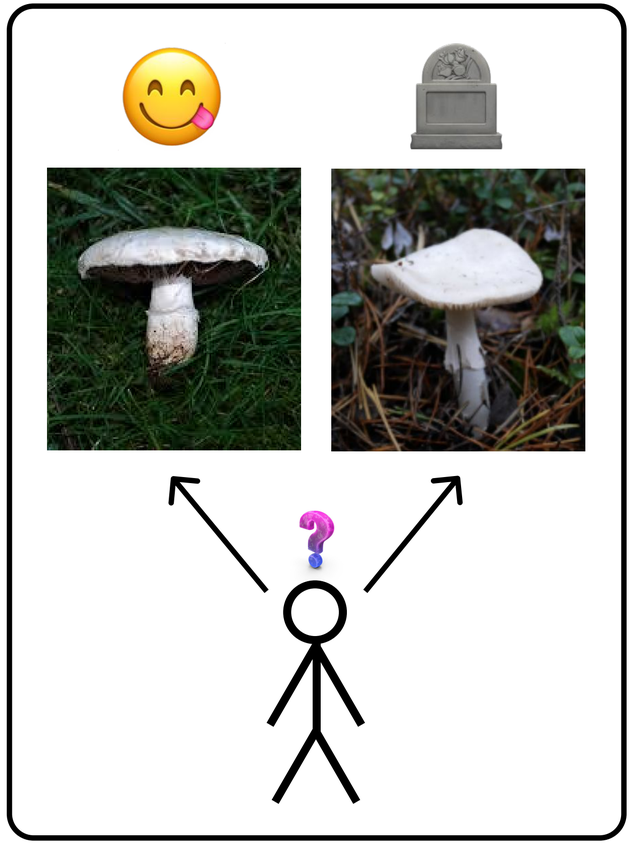
Two core problems

1. How do agents learn adaptive behaviour by observing others?
2. How do agents construct representations of others by inferring latent properties (like beliefs and preferences)?

Why learn socially?



Trial and error



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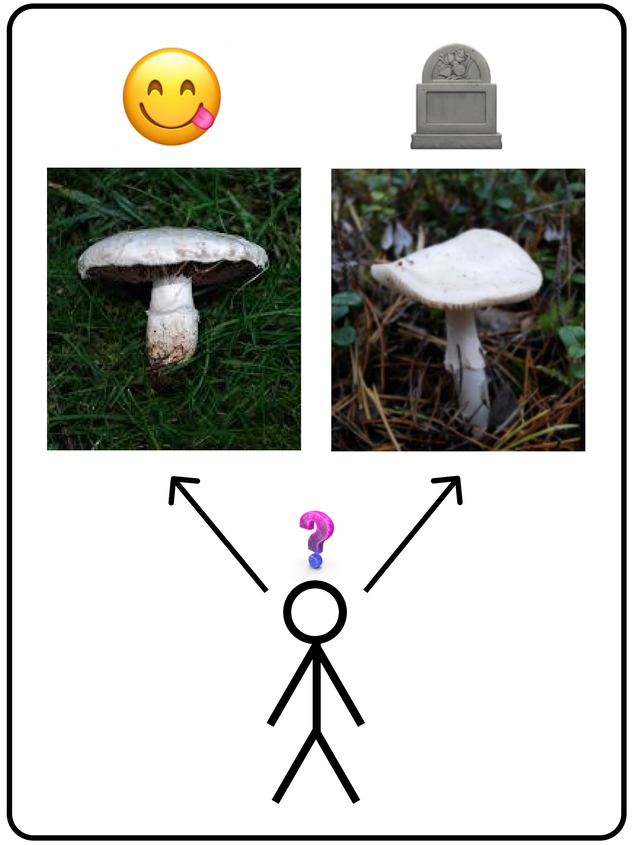
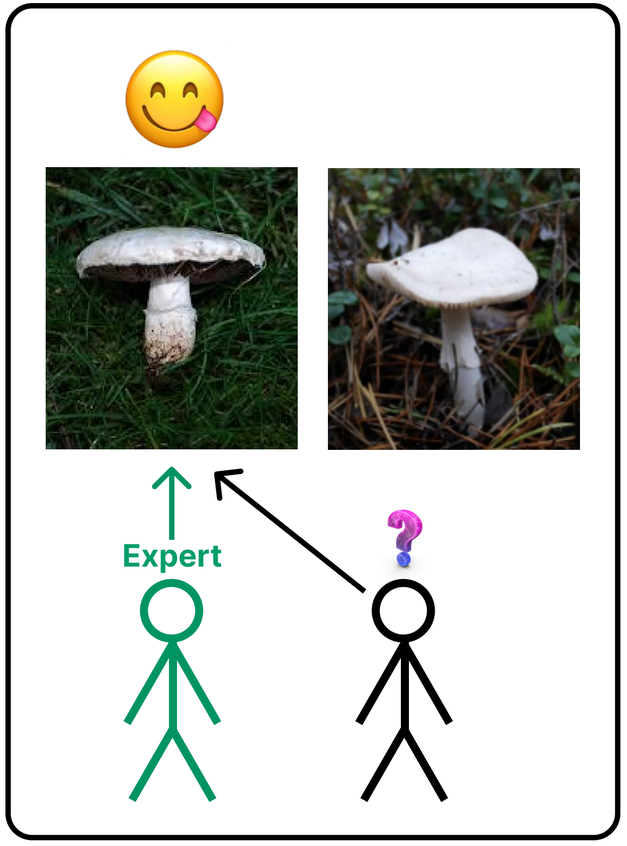
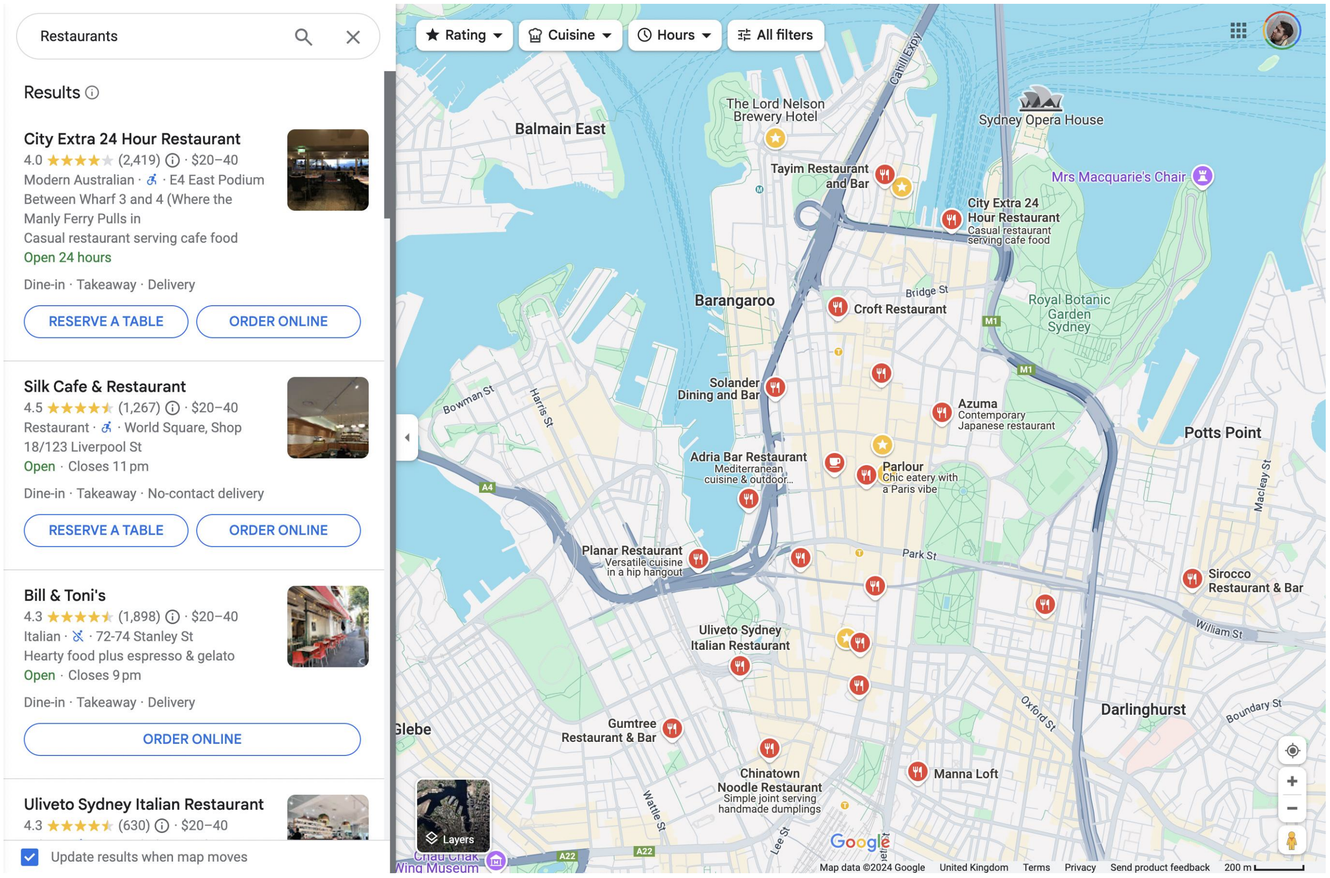


Social learning




Restaurants
Results
City Extra 24 Hour Restaurant
4.0 (2,419) · $20–40
Modern Australian · E4 East Podium Between Wharf 3 and 4 (Where the Manly Ferry Pulls in
Casual restaurant serving cafe food
Open 24 hours
Dine-in · Takeaway · Delivery
RESERVE A TABLE
ORDER ONLINE
Silk Cafe & Restaurant
4.5 (1,267) · $20–40
Restaurant · World Square, Shop 18/123 Liverpool St
Open · Closes 11 pm
Dine-in · Takeaway · No-contact delivery
RESERVE A TABLE
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Bill & Toni's
4.3 (1,898) · $20–40
Italian · 72-74 Stanley St
Hearty food plus espresso & gelato
Open · Closes 9 pm
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Uliveto Sydney Italian Restaurant
4.3 (630) · $20–40
Update results when map moves
Rating
Cuisine
Hours
All filters
Balmain East
The Lord Nelson Brewery Hotel
Tayim Restaurant and Bar
Sydney Opera House
Mrs Macquarie's Chair
City Extra 24 Hour Restaurant
Casual restaurant serving cafe food
Barangaroo
Croft Restaurant
Bridge St
Royal Botanic Garden Sydney
M1
Solander Dining and Bar
Azuma
Contemporary Japanese restaurant
Potts Point
Bowman St
Harris St
Adria Bar Restaurant
Mediterranean cuisine & outdoor...
Parlour
Chic eatery with a Paris vibe
A4
Macleay St
Planar Restaurant
Versatile cuisine in a hip hangout
Park St
Sirocco Restaurant & Bar
William St
Uliveto Sydney Italian Restaurant
Darlinghurst
Oxford St
Boundary St
Glebe
Gumtree Restaurant & Bar
Chinatown Noodle Restaurant
Simple joint serving handmade dumplings
Manna Loft
Wattle St
Lee St
A22
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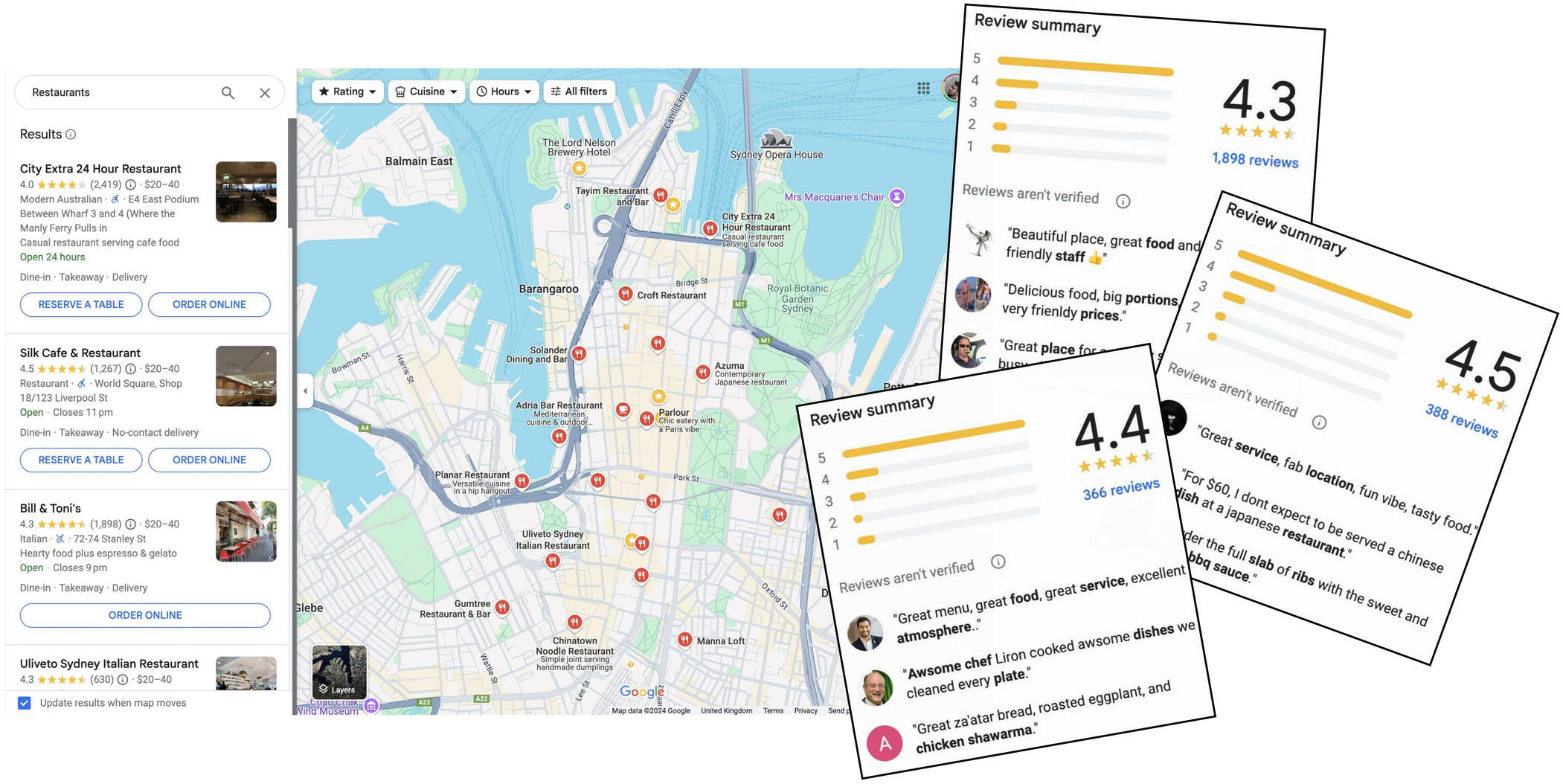
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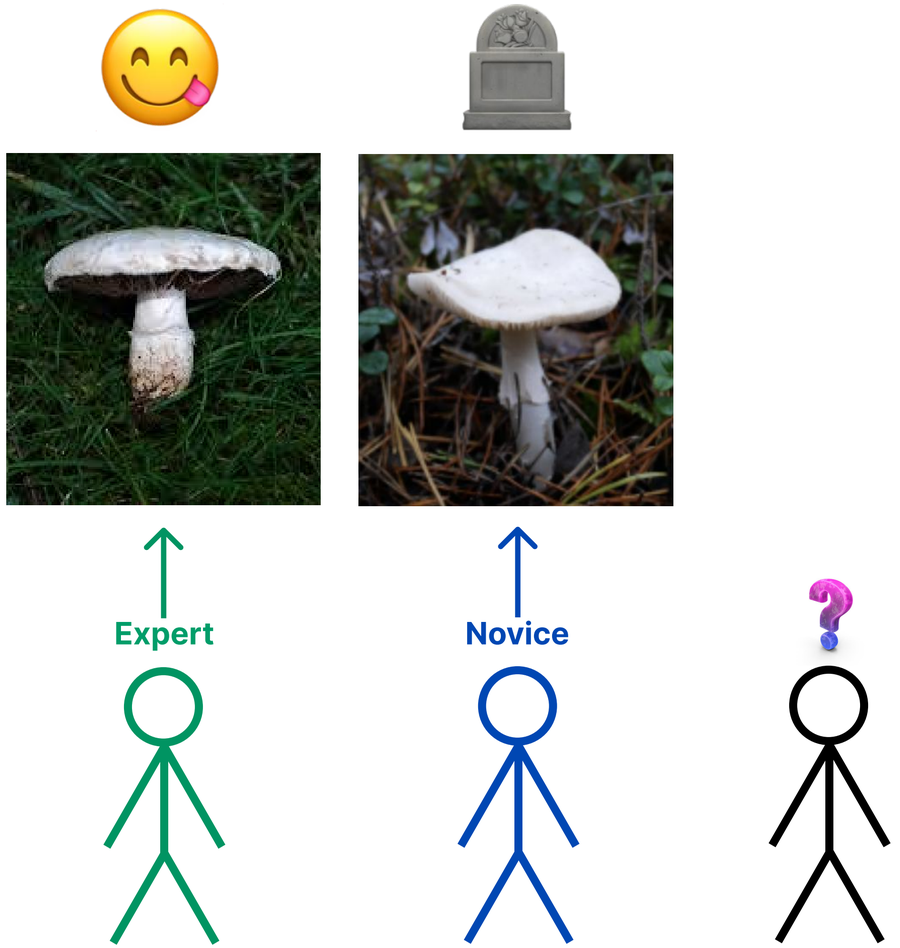
Review summary
4.3
1,898 reviews
Reviews aren't verified
"Beautiful place, great food and friendly staff"
"Delicious food, big portions very frienldy prices."
Review summary
4.5
388 reviews
Reviews aren't verified
"Great service, fab location, fun vibe, tasty food."
"For $60, I dont expect to be served a chinese dish at a japanese restaurant."
bbq sauce."
Review summary
4.4
366 reviews
Reviews aren't verified
"Great menu, great food, great service, excellent atmosphere.."
"Awsome chef Liron cooked awsome dishes we cleaned every plate."
"Great za'atar bread, roasted eggplant, and chicken shawarma."

Social learning is an effective way to deal with uncertainty more

safely: avoid dangers from exploration

efficiently: sidestep the cost of deliberation in large choice spaces

Social learning should be *selective*


Expert
Novice

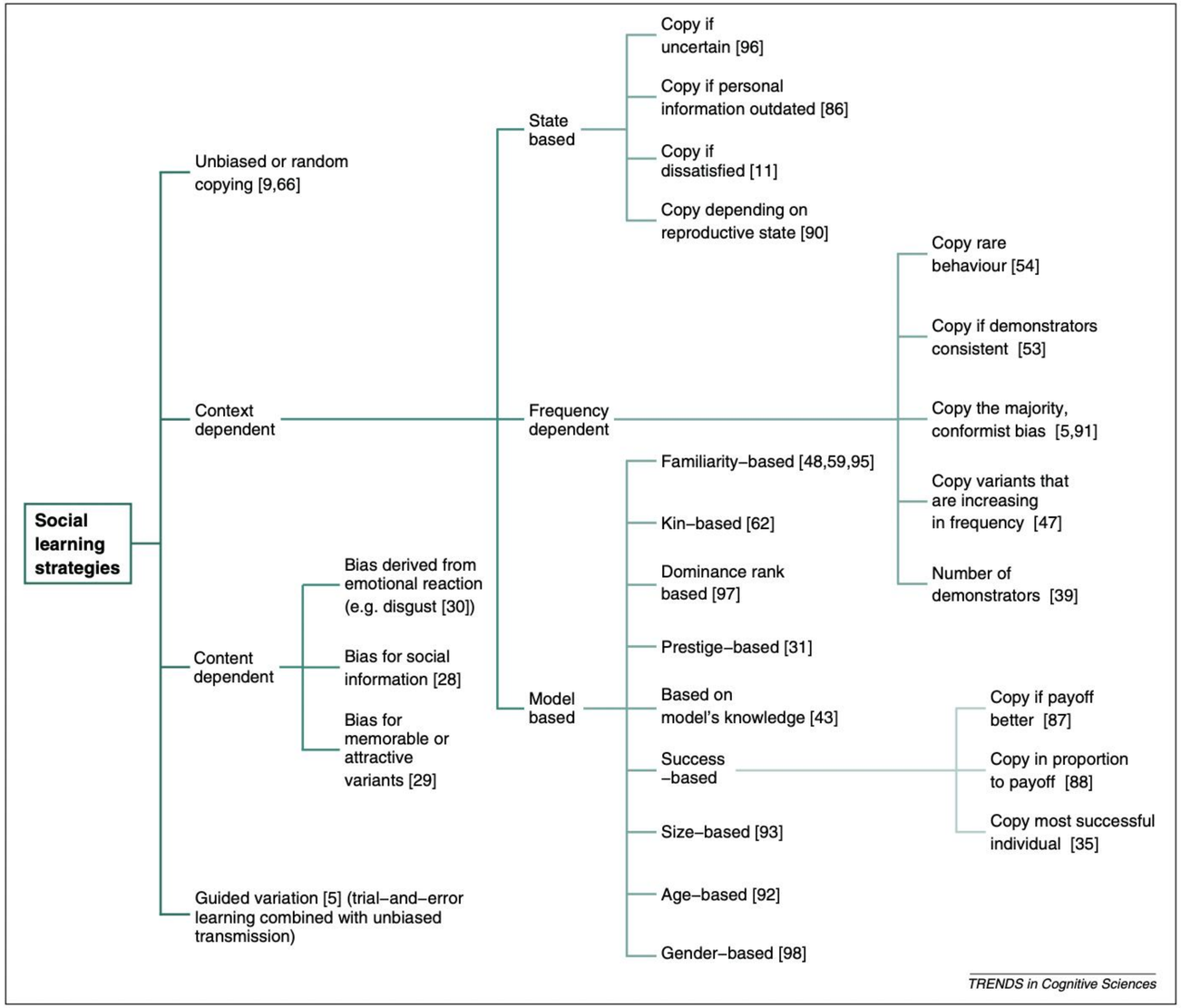
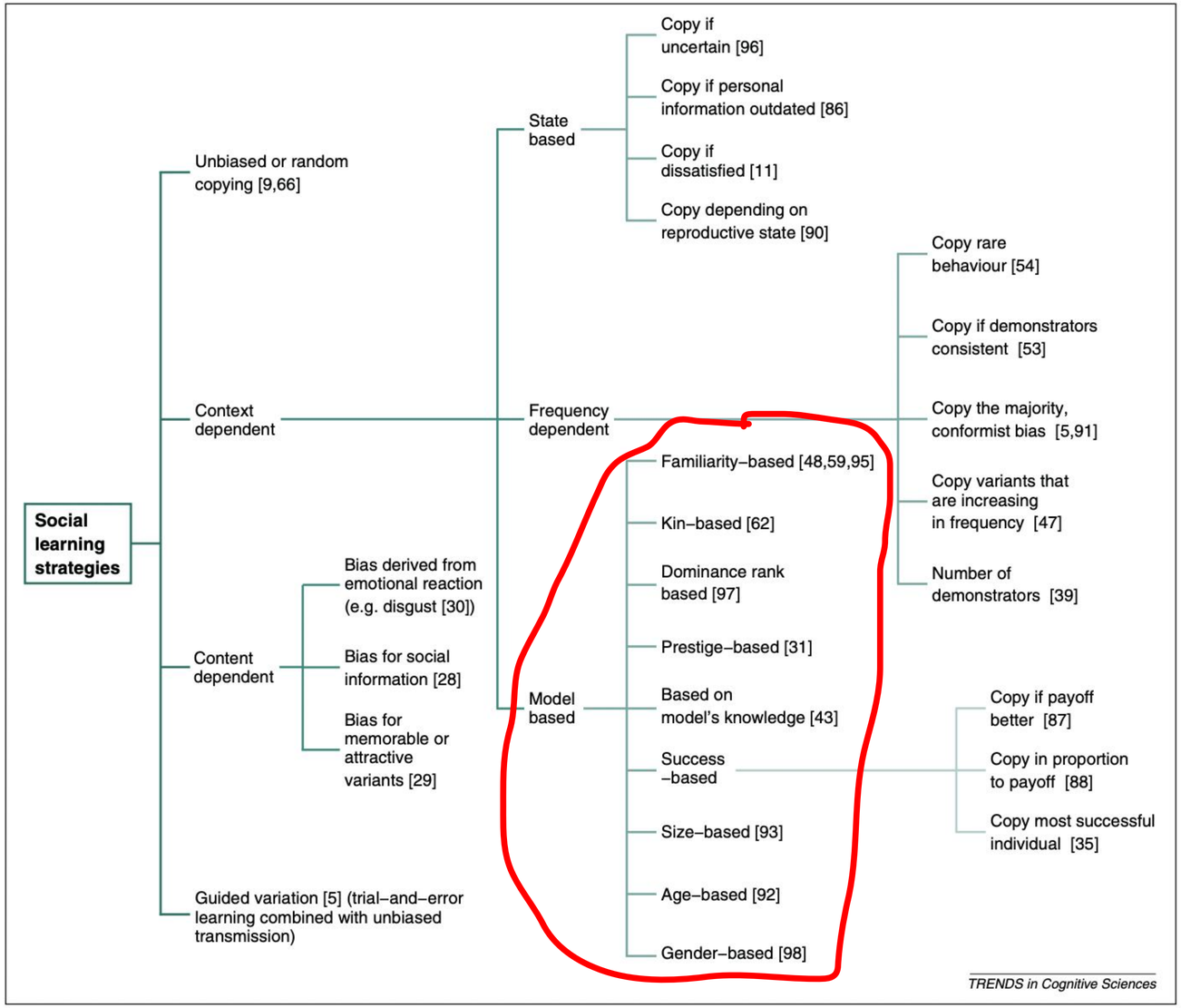


Figure 1. Social learning strategies for which there is significant theoretical or empirical support. The tree structure is purely conceptual and not based on any empirical data on homology or similarity of cognition. The sources given are not necessarily the first descriptions or the strongest evidence, but are intended as literature entry points for readers.



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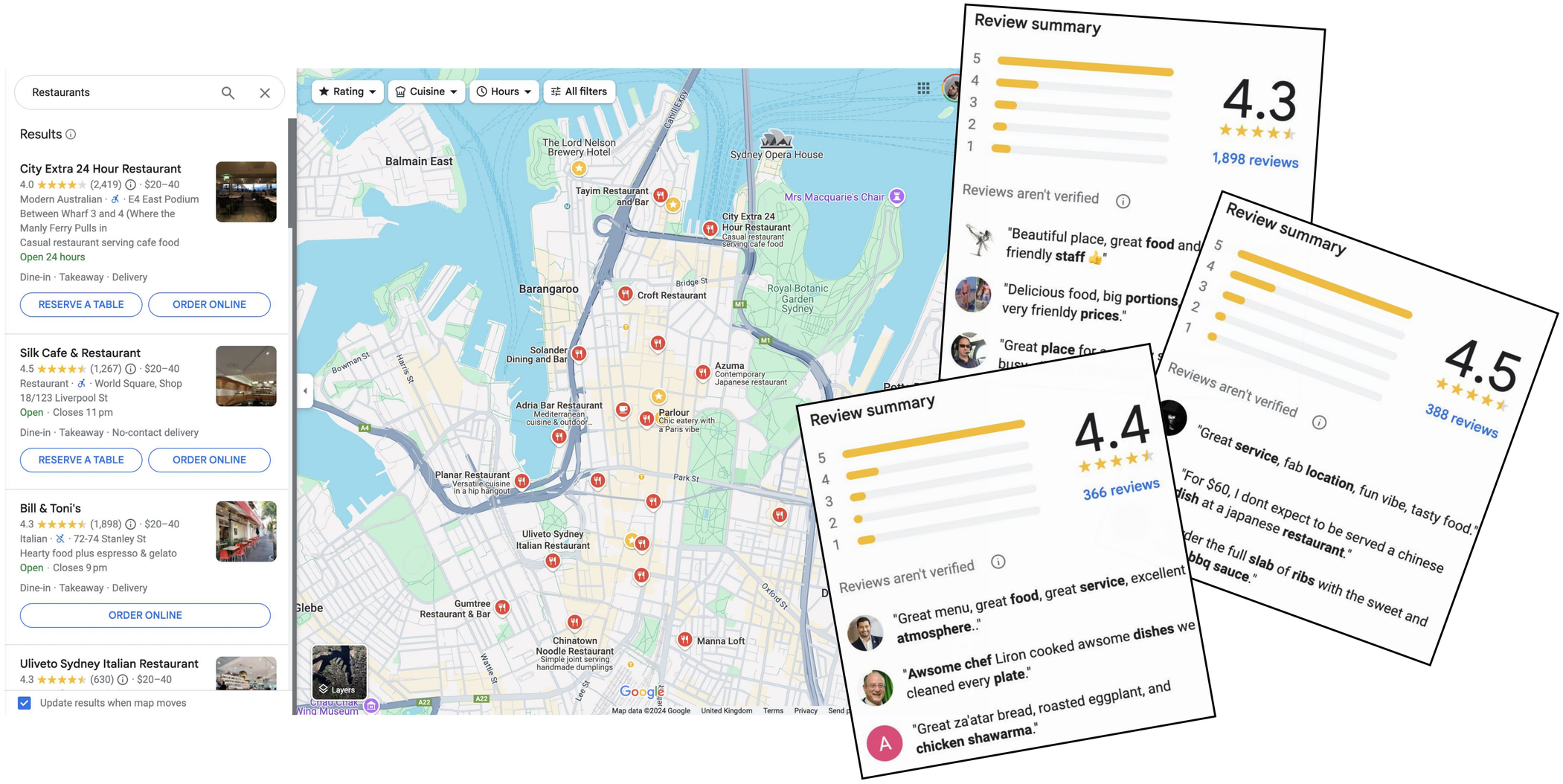
Duffy, G.A., Pike, T.W., & Laland, K.N. (2009). Size-dependent directed social learning in nine-spined sticklebacks. Animal Behaviour, 78, 371-375.

These model-based social learning strategies generally deal with learning from more knowledgeable/proficient/successful agents

But what about when agents have different preferences?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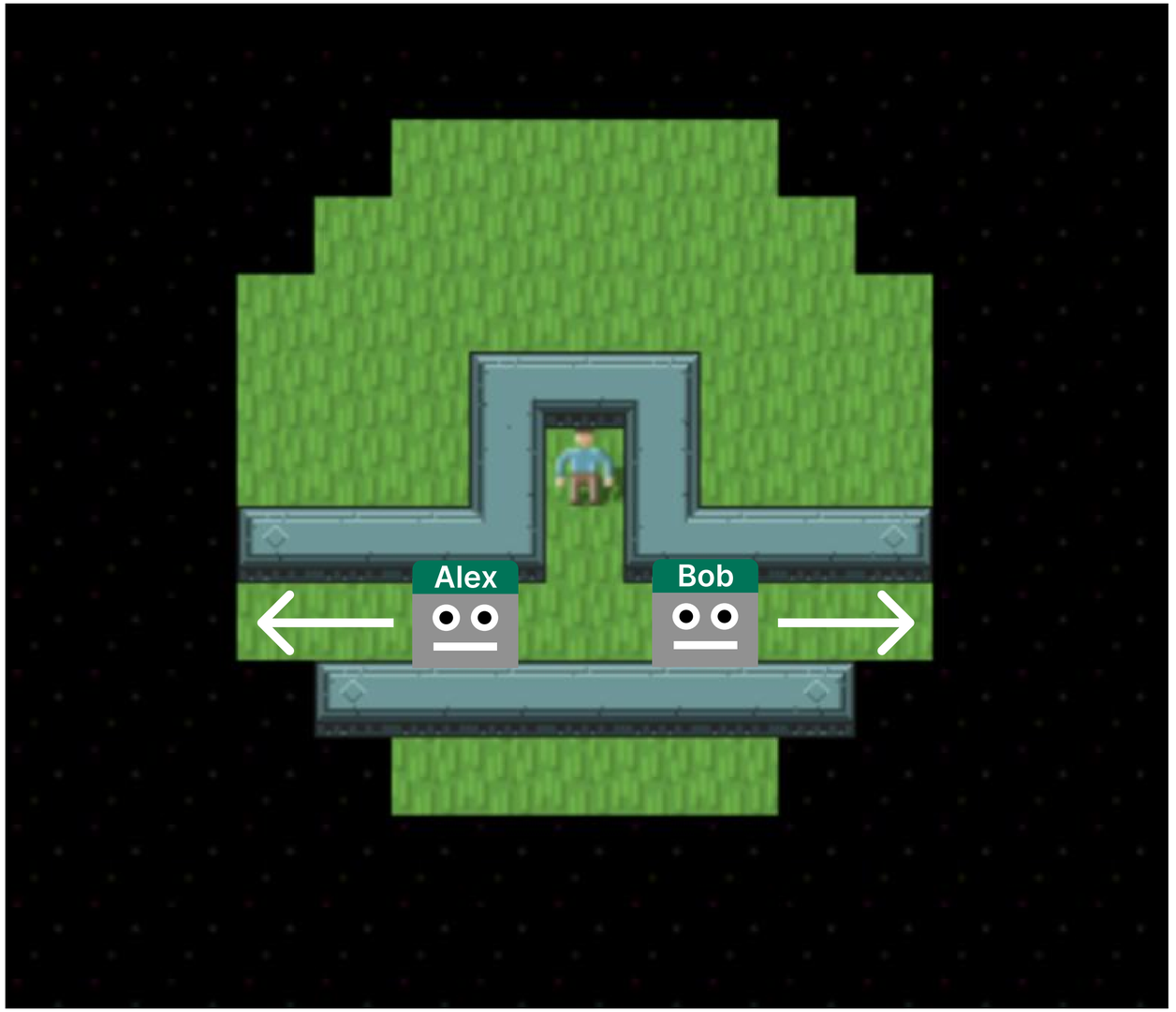
Research question:
do people rationally select social learning targets on the basis of shared preferences?


Alex
Bob

Individual-level rational model

$u^{(m)}$ = utility function of agent m

u^{ego} = utility function of social learner (i.e. participant)

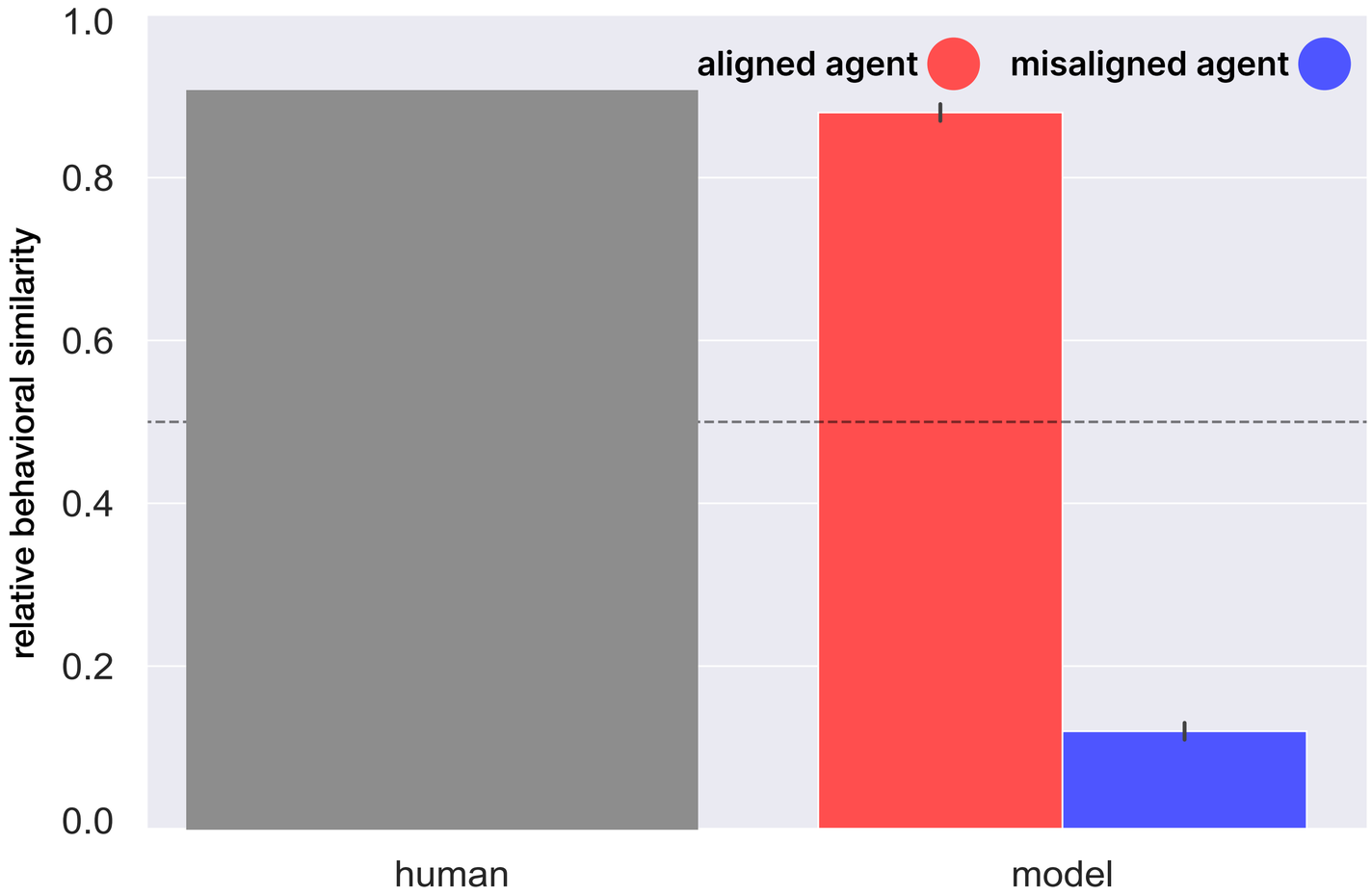
O = observations of agents' past choice behaviour

Step 1: infer $p(u^{(m)}|O)$

Step 2: compute similarity weights $w^{(m)} = \mathbb{E}\left[\text{sim}(u^{\text{ego}}, u^{(m)})\right]$

Step 3: imitate agent m with probability $\propto \exp(w^{(m)})$

Results: selective social learning from preference inference



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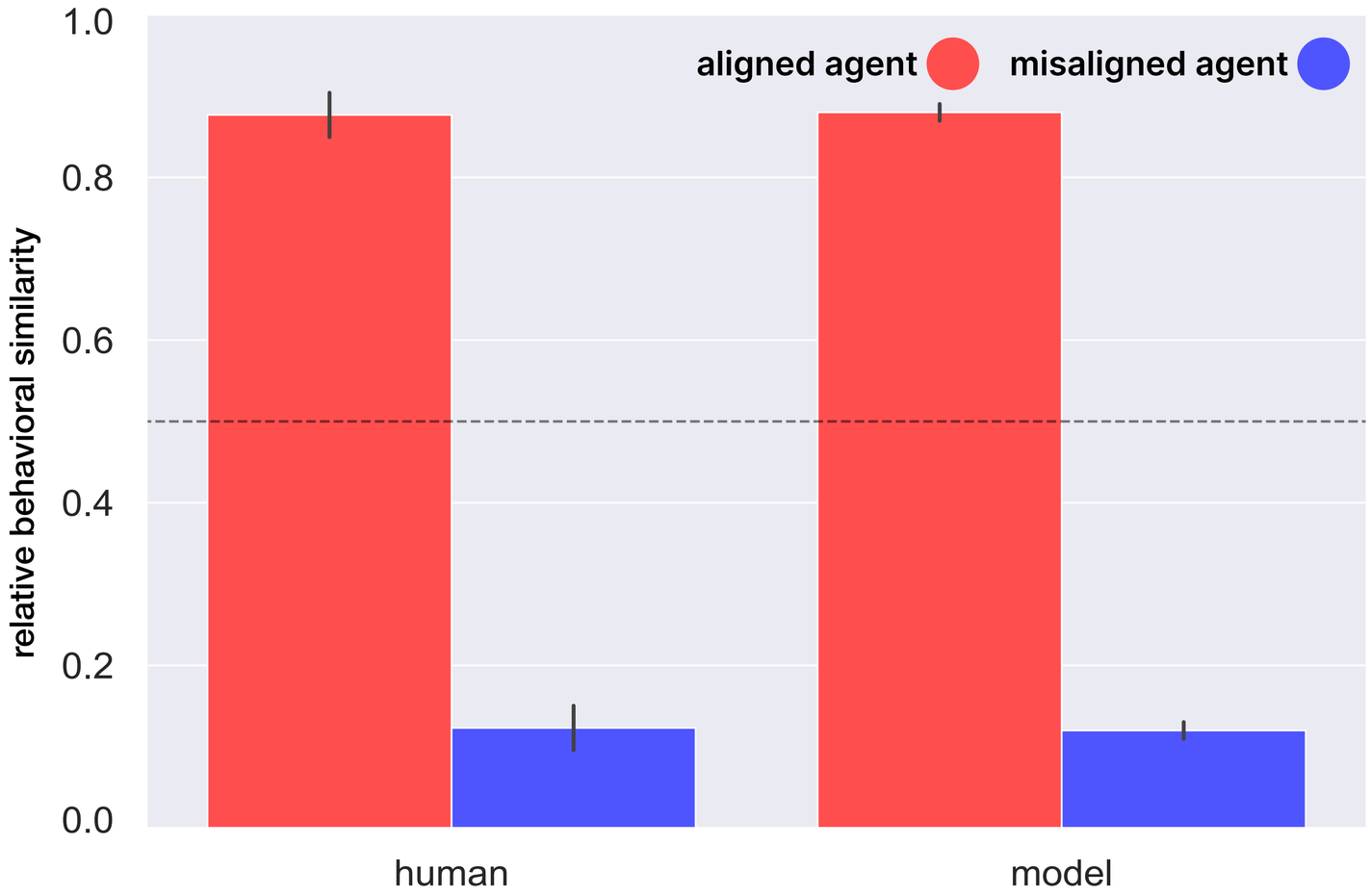


Limitations of the individual-level rational model

Assumes prior observational access to every agent's choice behaviour

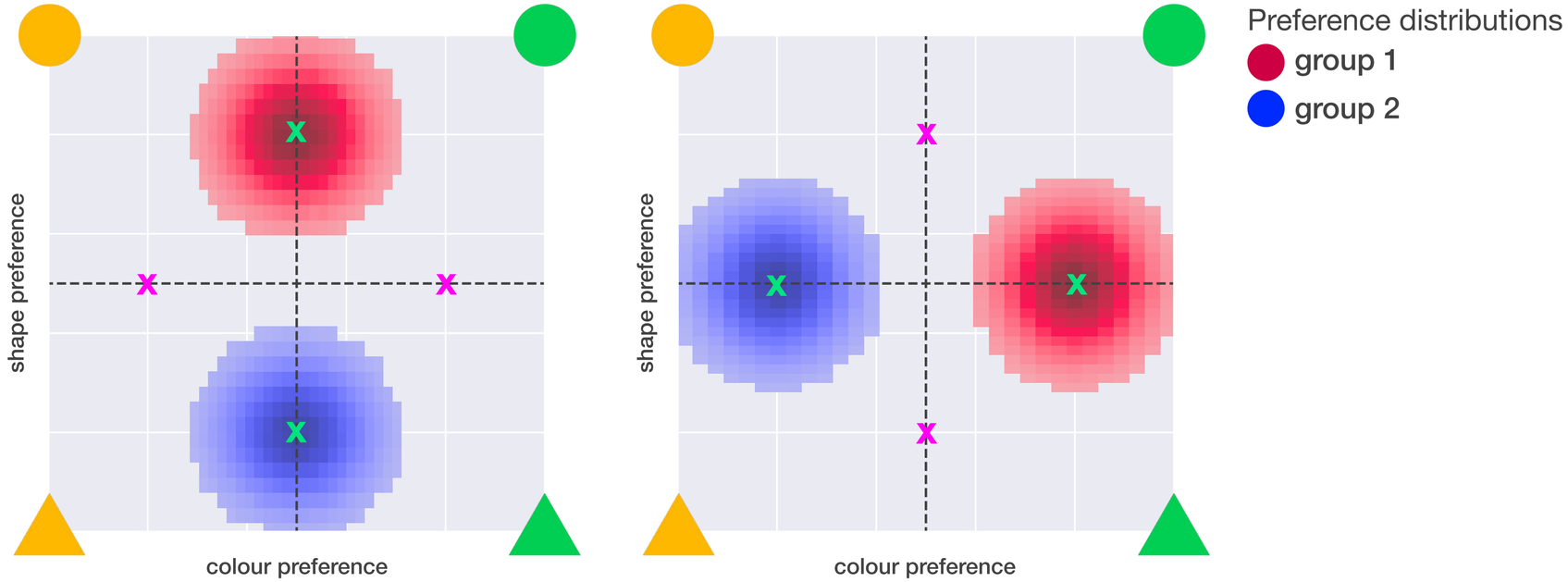
(doesn't enable generalisation across agents)

Cognitive cost (separate inference process for every agent you encounter)

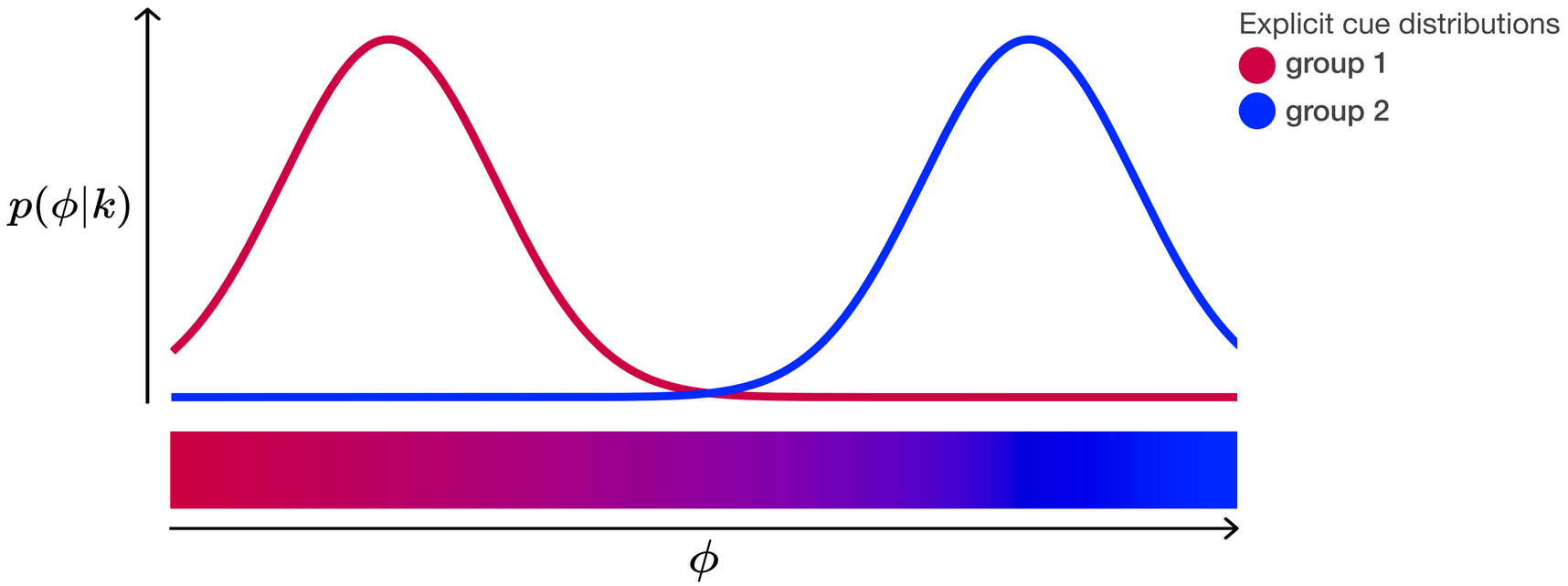
Follow-up study: *group-based* selective social learning under preference variation

4 items (2 feature dimensions)

Agents are organised into 2 groups



New variable: agent m expresses **explicit visual cue** $\phi^{(m)}$ as a noisy signal of their latent group identity $z^{(m)}$



New task: select imitation target on the basis of these explicit cues

Naïve ingroup bias model

“Copy the agent who looks most like me”

$$w^{(m)} = 1 - \left|\phi^{(m)} - \phi^{\text{ego}}\right|$$

imitate agent m with probability $\propto \exp(w^{(m)})$

Group-level rational model

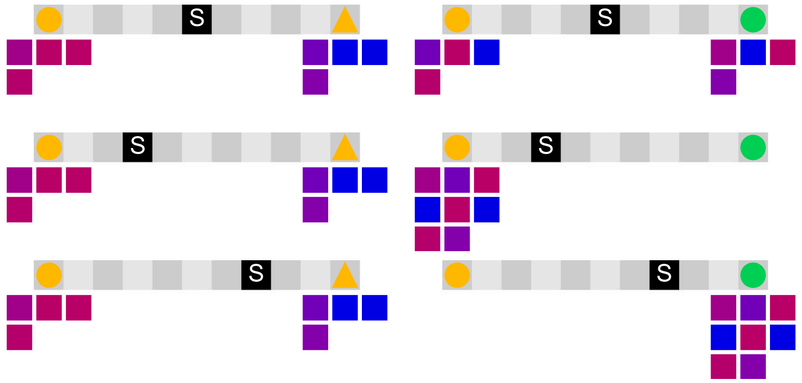
Infer the relationship between group identity and preferences

$z^{(m)}$ = latent group membership of agent m

$u^{(m)}, \phi^{(m)}$ = utility function + explicit cue of agent m

$u^{\text{ego}}, \phi^{\text{ego}}$ = utility function + explicit cue of social learner (i.e. participant)

O = observations of other agents' past behaviour and explicit cues



Step 1: use O to infer group distributions $p(\phi|\hat{z}),\ p(u|\hat{z})$

Step 2: faced with new set of agents (not in O), estimate, for each

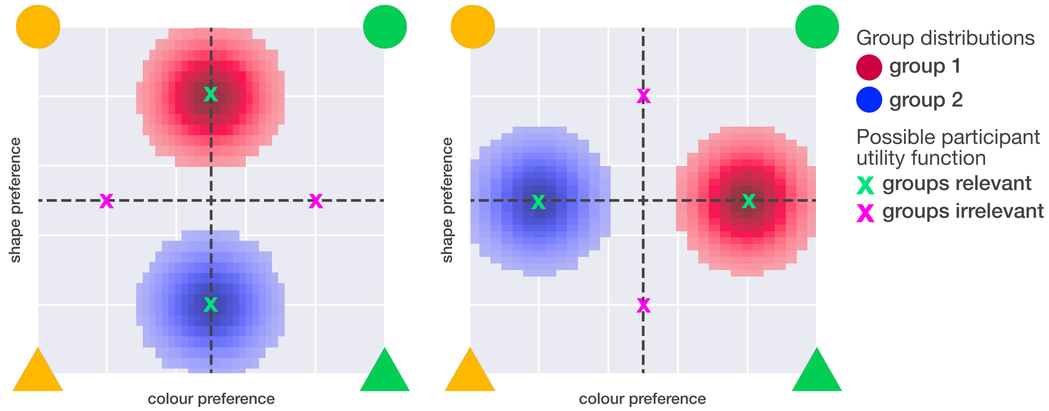
$$p(u^{(m)}|\phi^{(m)}) \propto \sum_{z} p(u^{(m)}|z)p(z|\phi^{(m)})$$

Step 3: compute similarity weights $w^{(m)} = \mathbb{E}\left[\text{sim}(u^{\text{ego}}, u^{(m)})\right]$

Step 4: imitate agent m with probability $\propto \exp(w^{(m)})$

Two beween-participant factors:

1. whether groups correspond to dimension **relevant** to participant's utility function

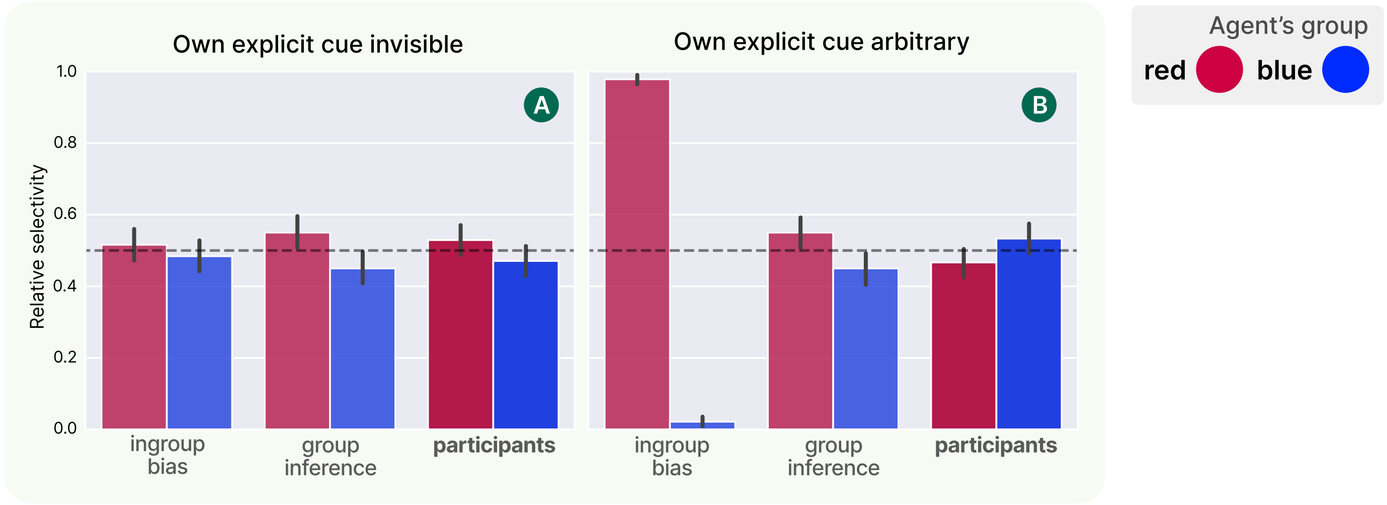


2. participant's own explicit cue

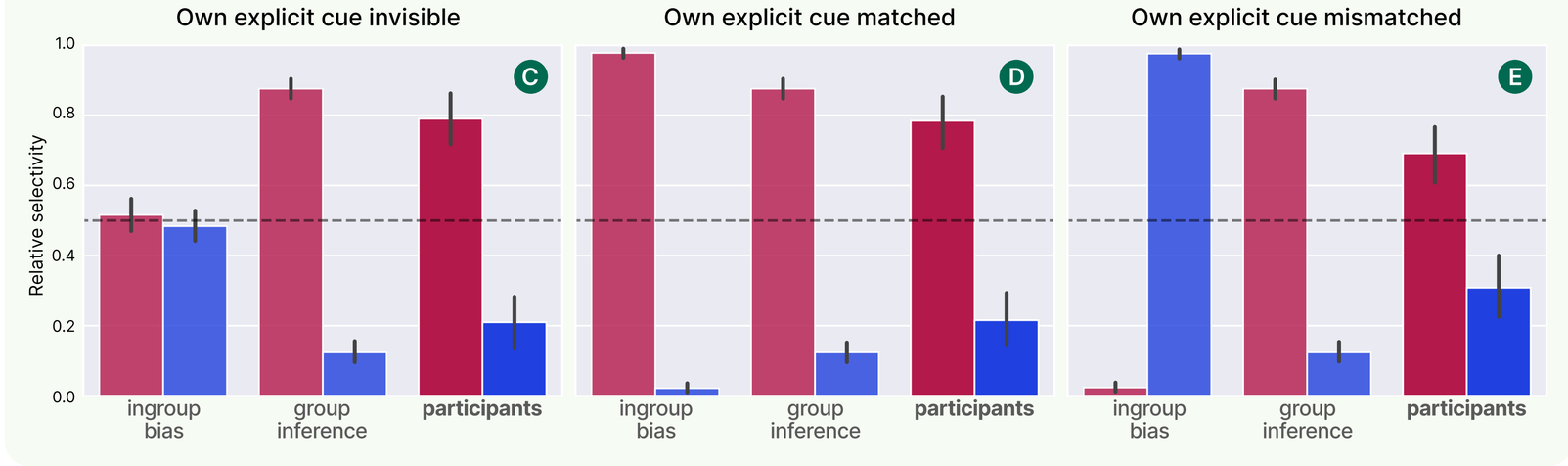
If groups relevant: **hidden / matched / mismatched**

If groups not relevant: **hidden / arbitrary**

Groups irrelevant



Groups relevant



Takeaways

1. Given direct access to agents' choice behaviour, people can use theory-of-mind to select **preference-aligned** social learning targets

2. In the absence of direct choice evidence, people can use the relationships inferred between **group identity, explicit visual cues, and preferences** to generalise the same kind of strategy to **unfamiliar agents**

3. They do this even when their own 'group cue' is **actively mislabeled** -- overriding the ingroup bias when other evidence suggests it is not adaptive

Acknowledgements

Chris Lucas

Neil Bramley