Cognition

PSYC 2040

L12: Social Cognition

Part 2

social inference

- revisiting simple reference games
- inferences during communication
- inferences during helping
- inferences during learning and teaching

inference = recursive thinking

ground truth

	blue square	blue circle	green square
blue	1	1	0
circle	0	1	0
square	1	0	1
green	0	0	1

level-0 listener

	blue square	blue circle	green square
blue	0.5	0.5	0
circle	0	1	0
square	0.5	0	0.5
green	0	0	1

level-1 speaker

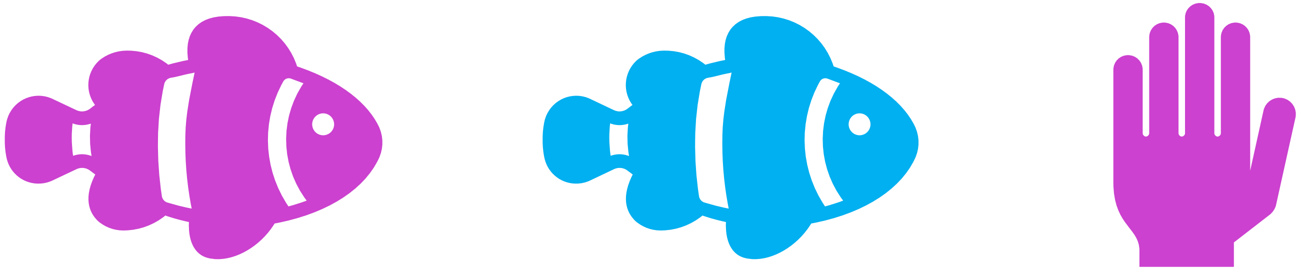
	blue square	blue circle	green square
blue	0.5	0.33	0
circle	0	0.67	0
square	0.5	0	0.33
green	0	0	0.67

level-2 listener

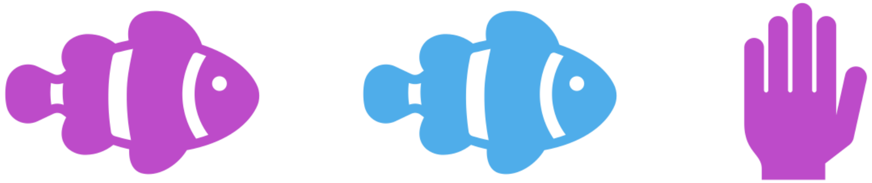
	blue square	blue circle	green square
blue	0.60	0.40	0
circle	0	1	0
square	0.60	0	0.40
green	0	0	1

Frank and Goodman (2012)

inference activity



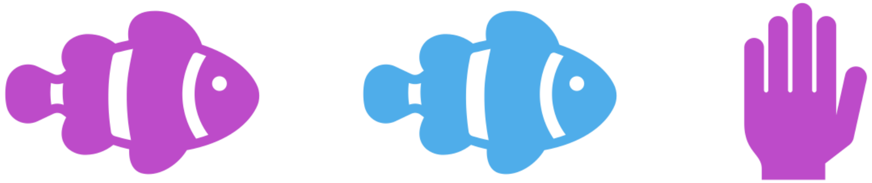
inference activity



- if I said “pink” which object would a level-0 listener think I am referring to?
- what about a level-2 listener?

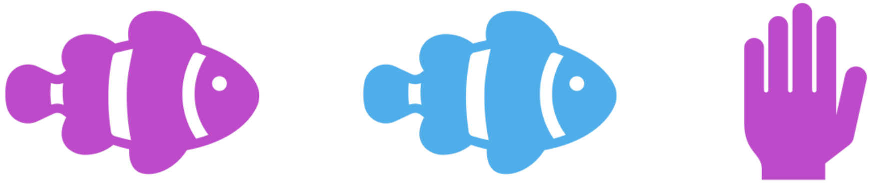
	pink fish	blue fish	pink glove
pink			
fish			
blue			
glove			

ground truth



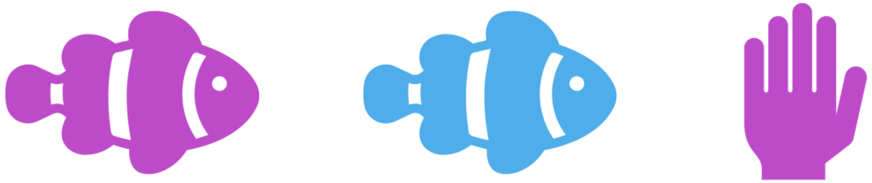
	pink fish	blue fish	pink glove
pink	1	0	1
fish	1	1	0
blue	0	1	0
glove	0	0	1

level-0 listener



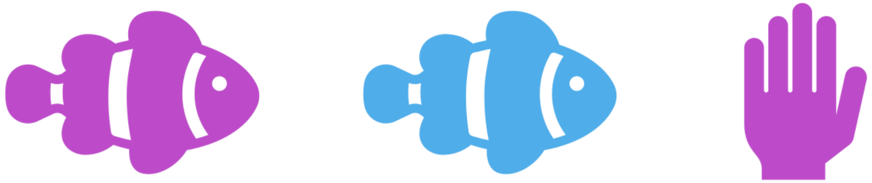
	pink fish	blue fish	pink glove
pink	0.5	0	0.5
fish	0.5	0.5	0
blue	0	1	0
glove	0	0	1

level-1 speaker



	pink fish	blue fish	pink glove
pink	0.5	0	0.33
fish	0.5	0.33	0
blue	0	0.67	0
glove	0	0	0.67

level-2 listener



	pink fish	blue fish	pink glove
pink	0.60	0	0.40
fish	0.60	0.40	0
blue	0	1	0
glove	0	0	1

communication as search and inference

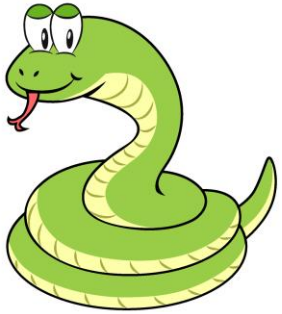
- communication requires rapid access to concepts from the lexicon + assessing which words/utterances would be most useful

cat

~~dangerous~~

~~predator~~

feline



associative reference games: Connector

- a two-player cooperative language game
  based on Codenames
  - speaker: one-word clue
  - guesser: two words
- how do people search through their semantic memory to come up with clues and guesses?

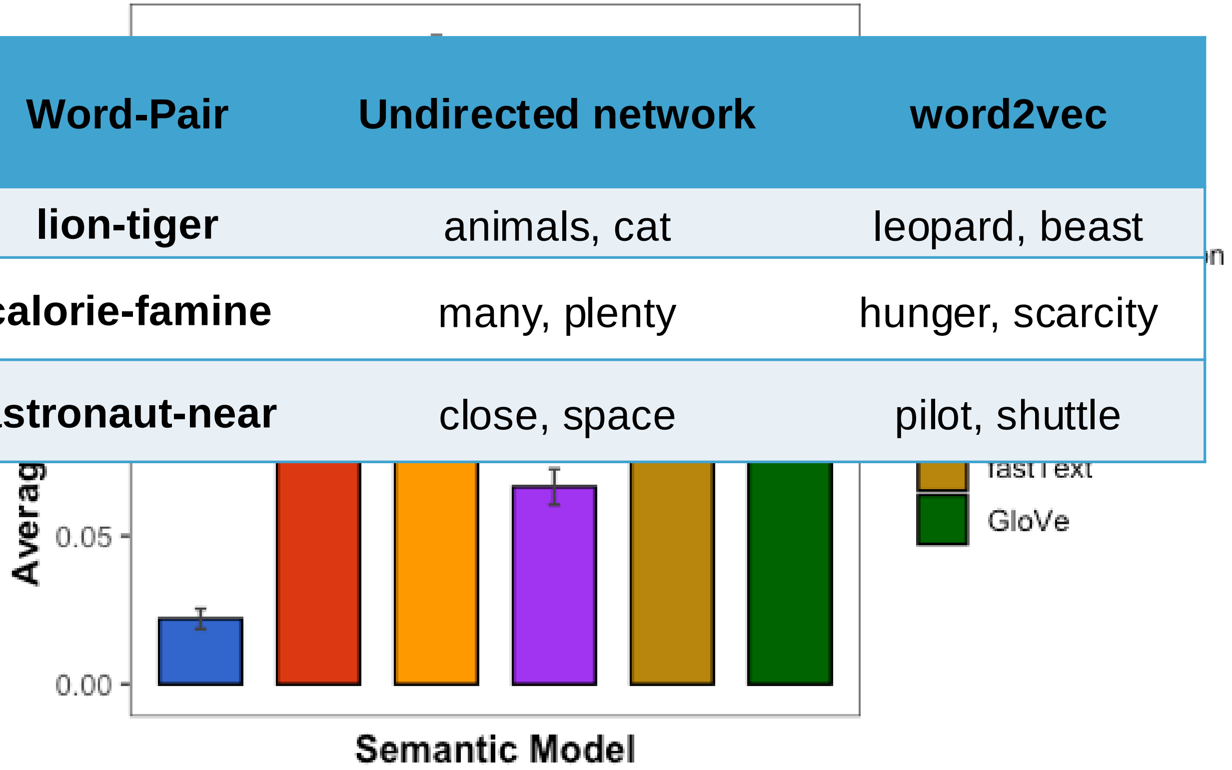
associative reference games: Connector

- use word representations from different language models to approximate semantic memory
    - free association networks
    - language models (word2vec-type)
- each word is represented as a “vector” in a multidimensional space
- distances between words can then be estimated via cosine similarity

predicting speaker responses

- for each word-pair, compute nearest neighbors to the two target words for all models
- compare the words predicted by semantic models to speaker's responses in the game
- free association networks outperformed language models

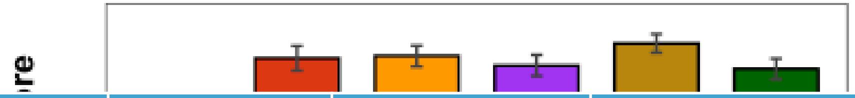
Word-Pair	Undirected network	word2vec
lion-tiger	animals, cat	leopard, beast
calorie-famine	many, plenty	hunger, scarcity
astronaut-near	close, space	pilot, shuttle



Kumar, Steyvers, Balota (2021, *Cognitive Science*)

predicting guesser responses

- compute nearest two words on the board from the given clue within each semantic model
- evaluate model accuracy in predicting Guesser responses in the game
- associative networks and language models both predicted guesser responses equally well

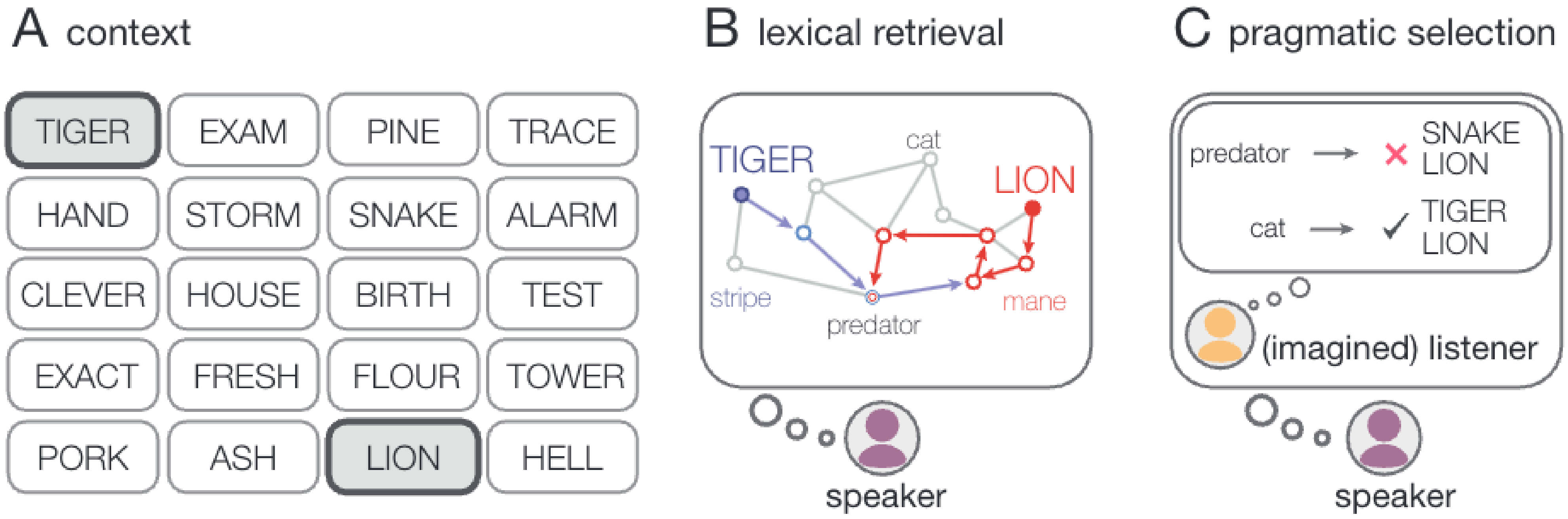


Word pair	Clue	Guesser response	Undirected prediction	Word2vec prediction
lion-tiger	cat	lion-tiger	lion, tiger	snake, tiger
astronaut-near	space	astronaut-sky	astronaut-sky	astronaut-sky

Semantic Model

Kumar, Steyvers, & Balota (under review), *Cognitive Science*

cognitive processes



Kumar and Hawkins (2025; *JEP: General*)

cognitive processes

TIGER	EXAM	PINE	TRACE
HAND	STORM	SNAKE	ALARM
CLEVER	HOUSE	BIRTH	TEST
EXACT	FRESH	FLOUR	TOWER
PORK	ASH	LION	HELL

- speaker selection = utility calculus

feline
claws

cat

animal
mammal

utility = diagnosticity + accessibility

level-k reasoning about what a potential guesser would do

random walks starting from each word and converging on clues

Kumar and Hawkins (2025; *JEP: General*)

experiments

E1: two-player
- speakers gave 1-word clues
- guessers picked two words

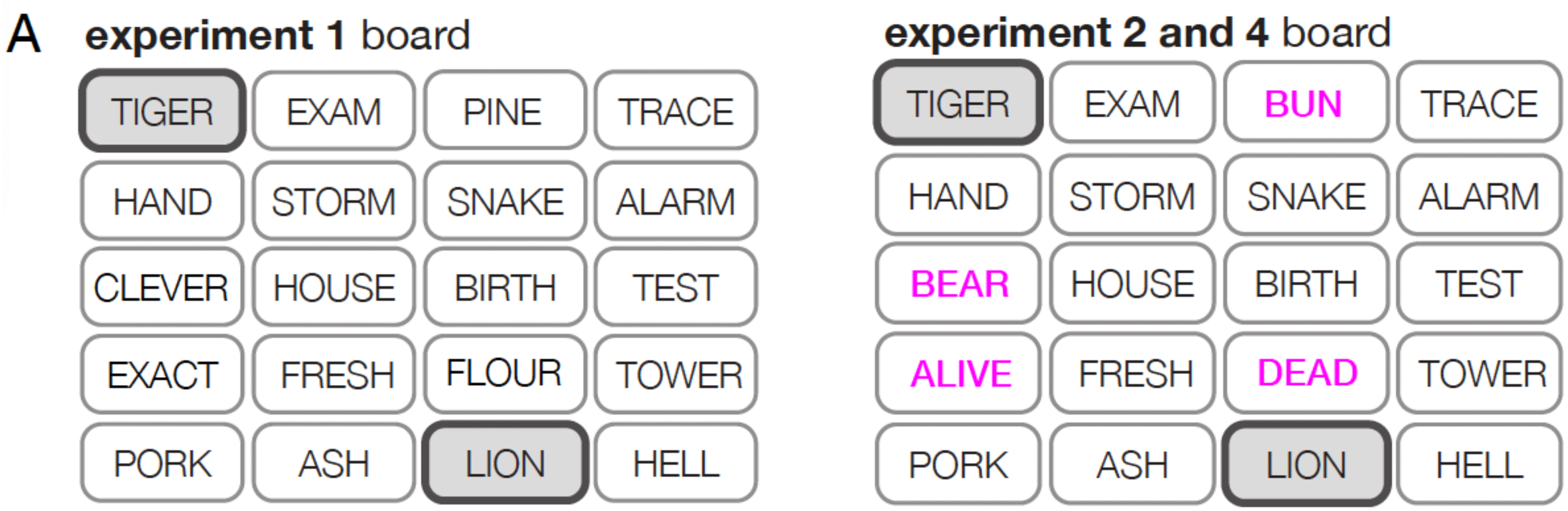
E2: single-player
- words on some boards were changed
- speakers asked to rate clues

E3: single-player
- no board
- speakers produced free associations to target words

E4: two-player
- words on some boards were changed
- speakers & guessers produced candidates before final selection

experiment 1:
minimal distractors

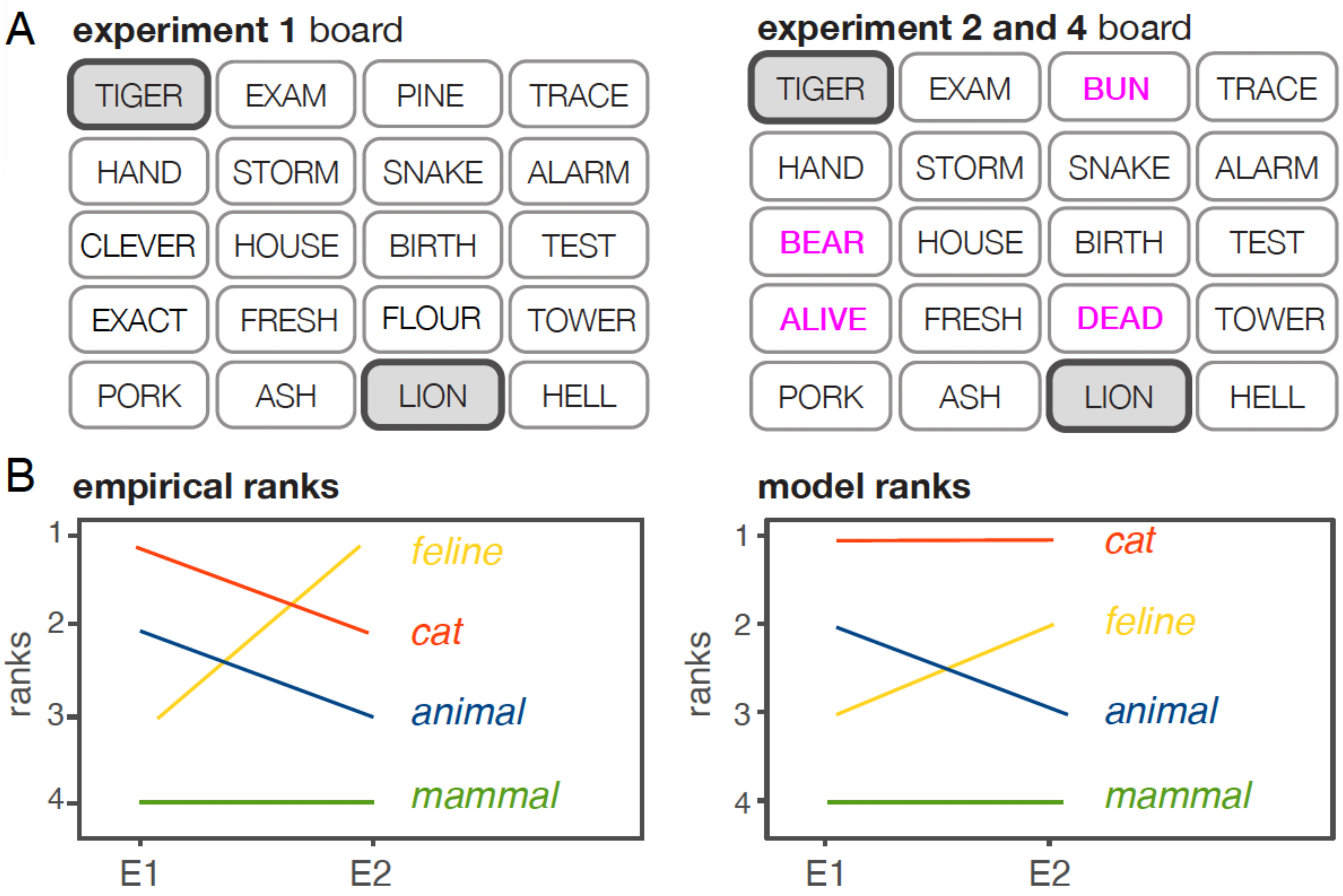
experiment 2/4:
powerful
distractors



Kumar and Hawkins (2025; *JEP: General*)

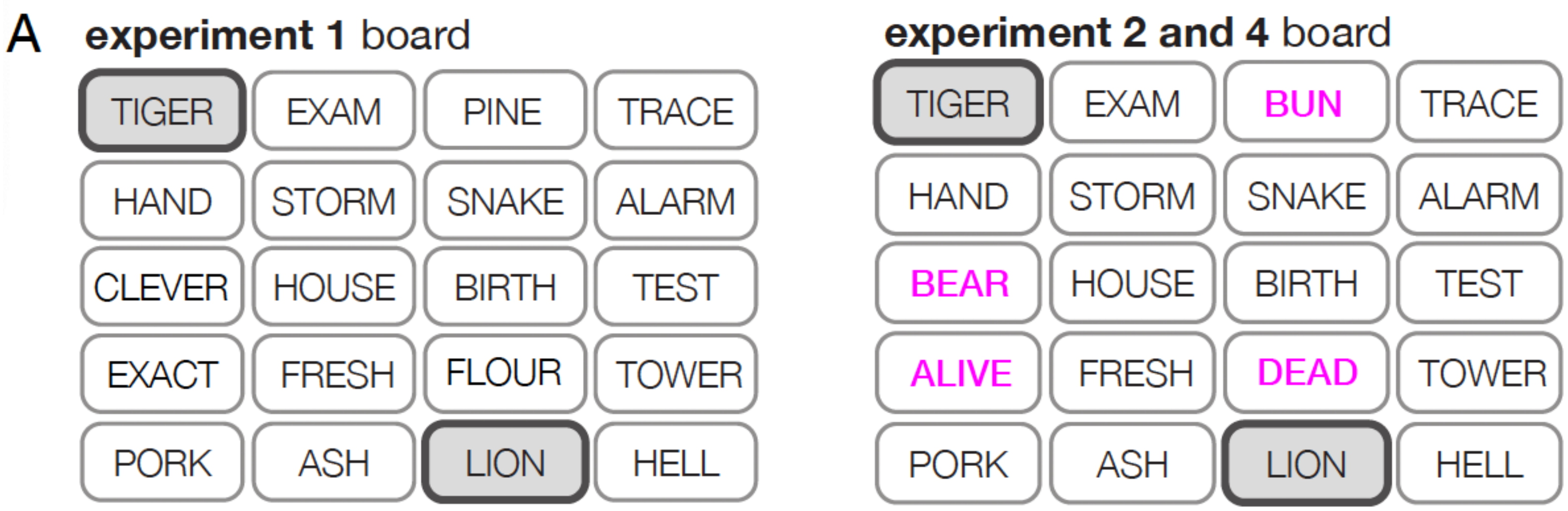
speakers
are sensitive to
diagnosticity

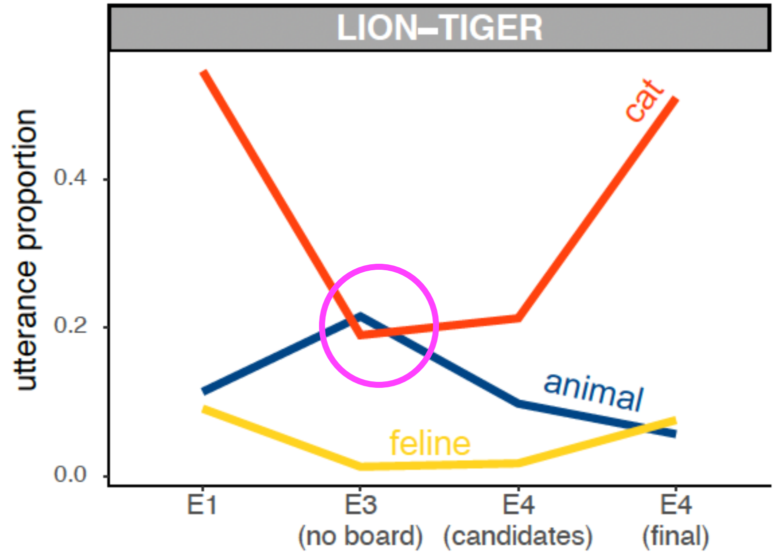
models
are sensitive to
diagnosticity



Kumar and Hawkins (2025; *JEP: General*)

speakers
are sensitive to
accessibility



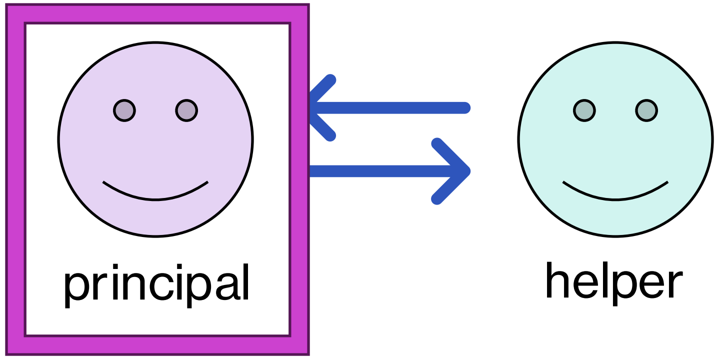


Kumar and Hawkins (2025; *JEP: General*)

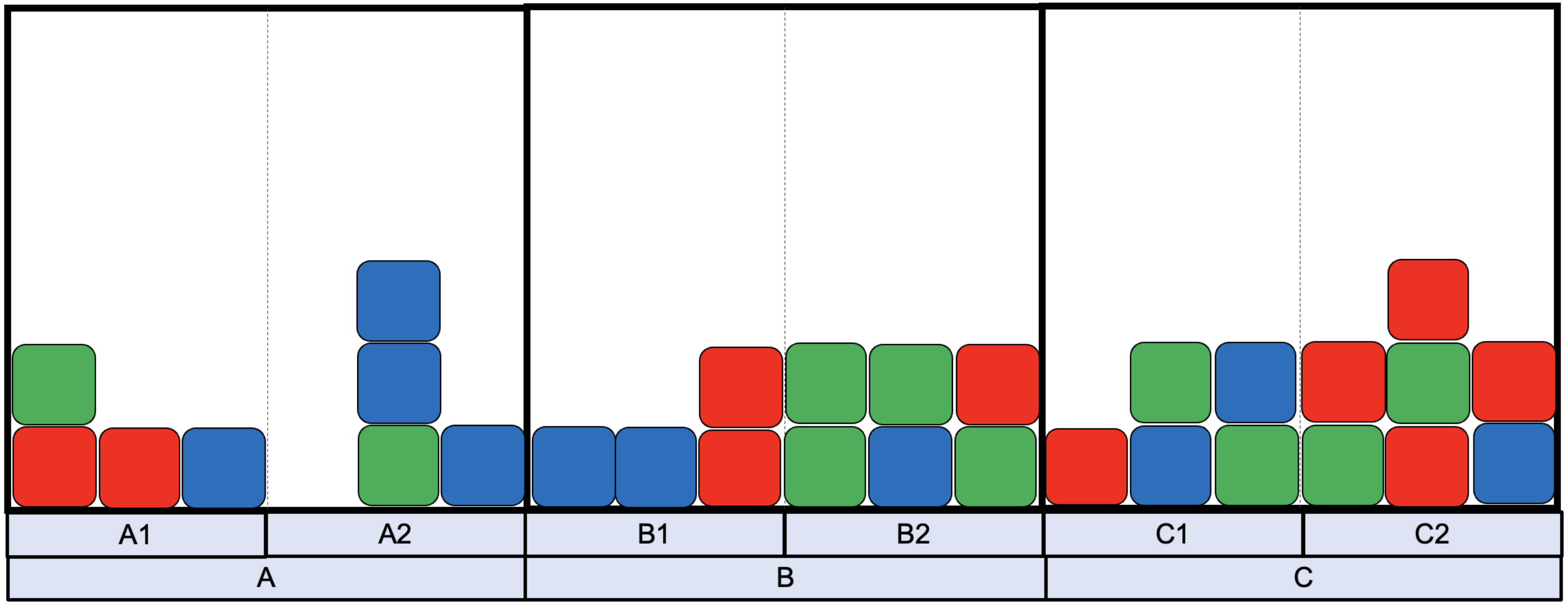
helping

- helping has inherently cognitive roots
- infants (and animals) appear to help without any extrinsic reward
- what cognitive mechanisms underlie wanting help or being helped?

move-a-block

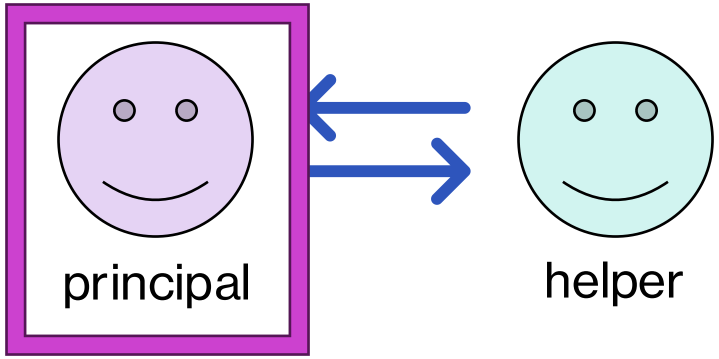


goal: move all blue blocks to room C



Kumar & Steyvers (2023, *CogSci Proceedings*

move-a-block



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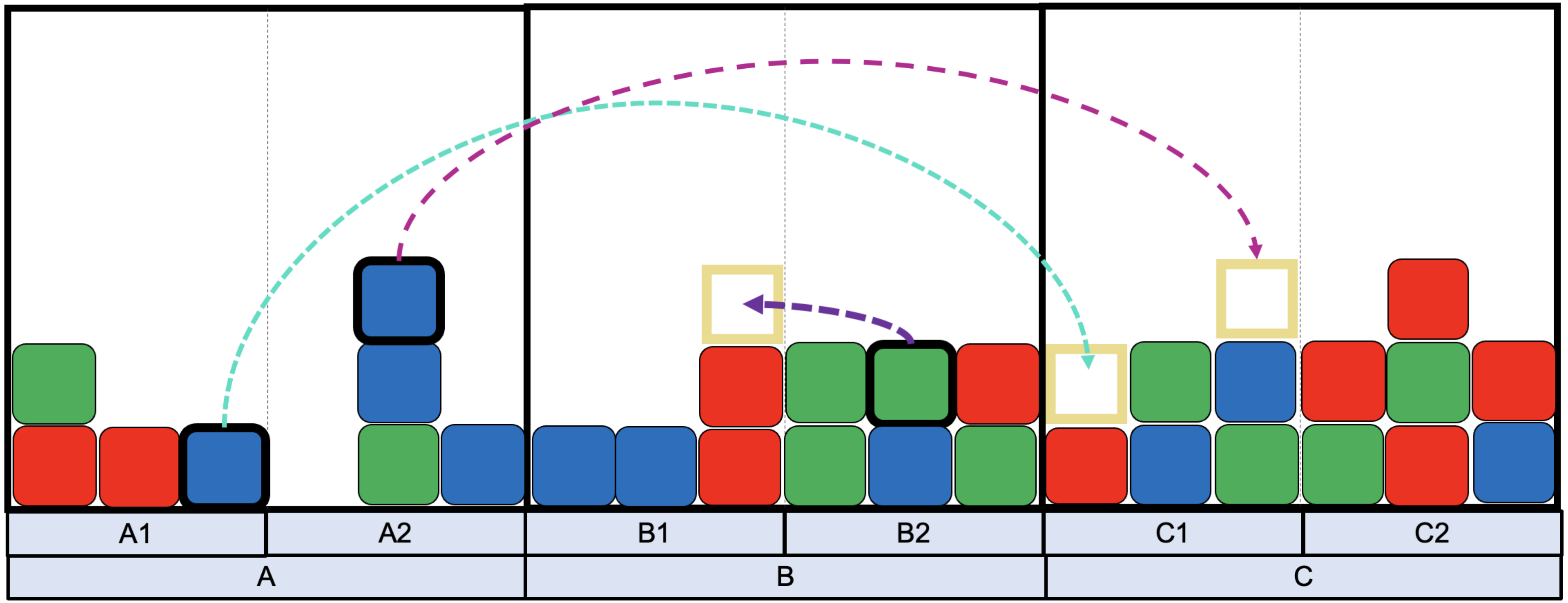
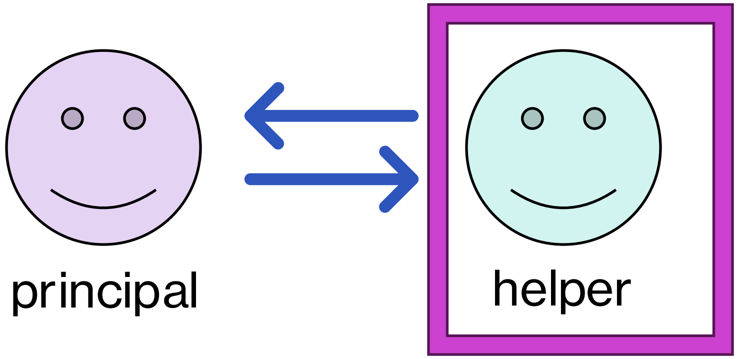
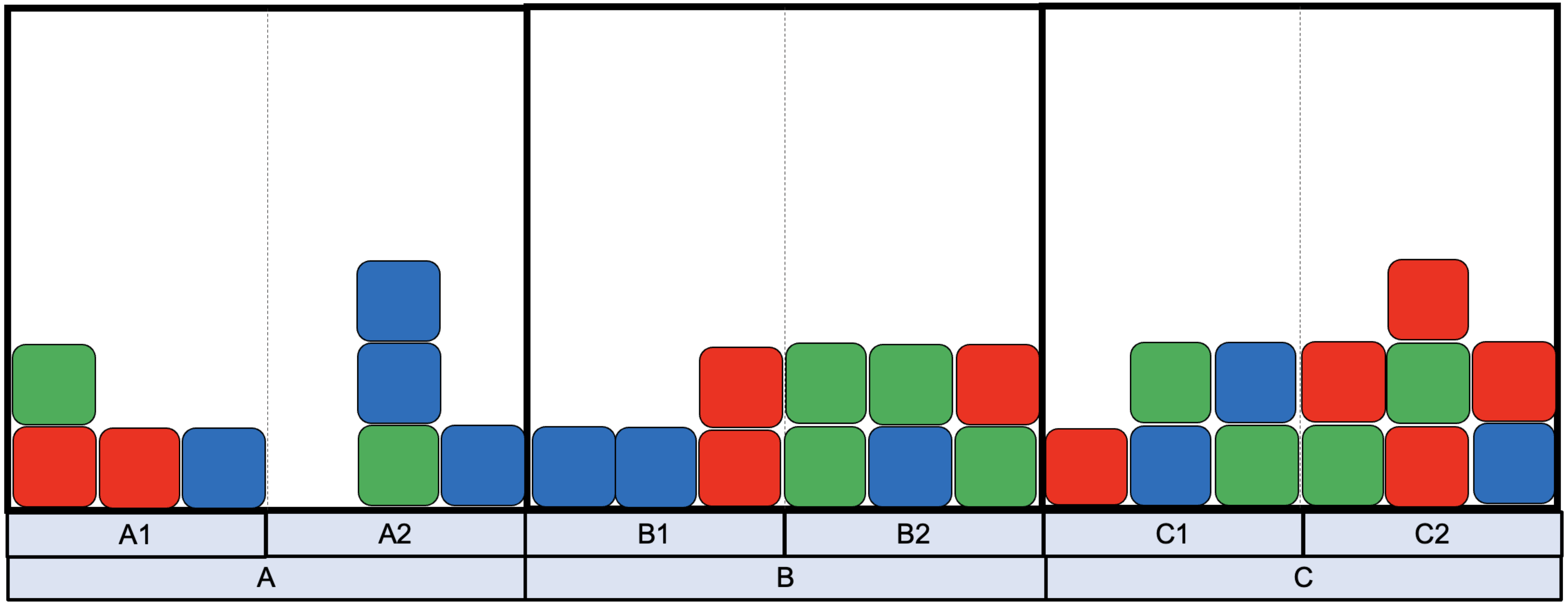


Kumar & Steyvers (2023, *CogSci Proceedings*

move-a-block

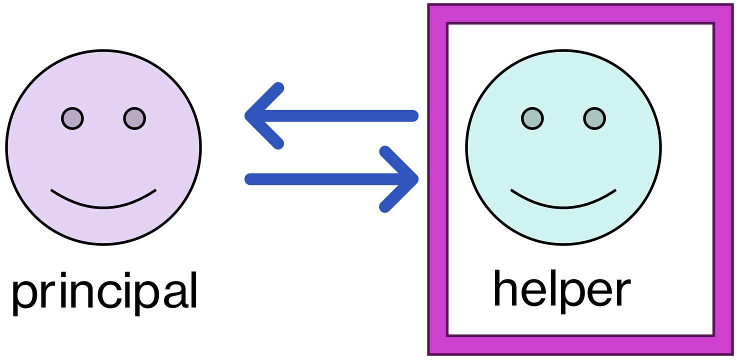


unknown goal: move all blue blocks to room C



Kumar & Steyvers (2023, *CogSci Proceedings*

move-a-block



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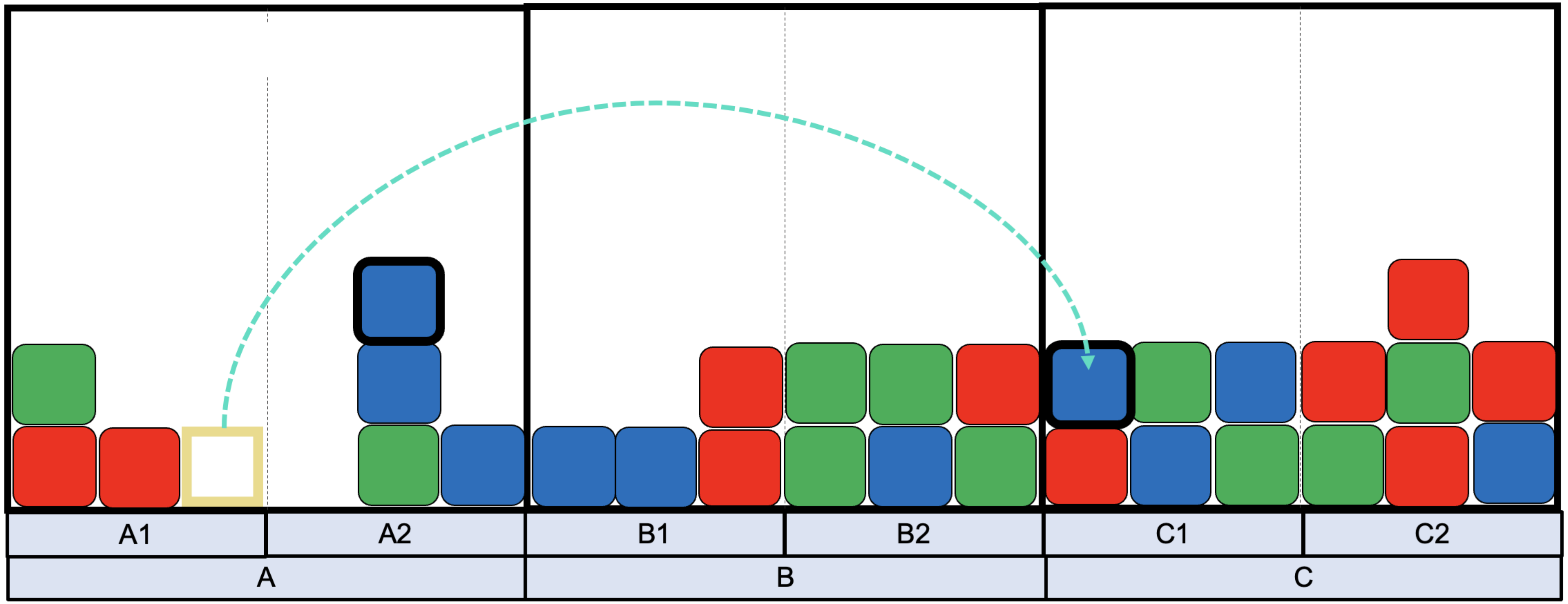
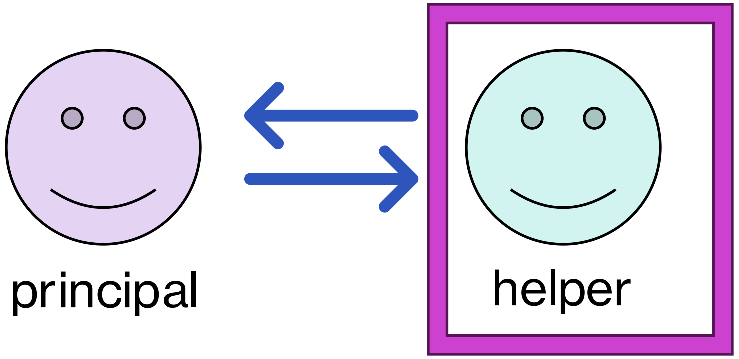


Kumar & Steyvers (2023, *CogSci Proceedings*

move-a-block



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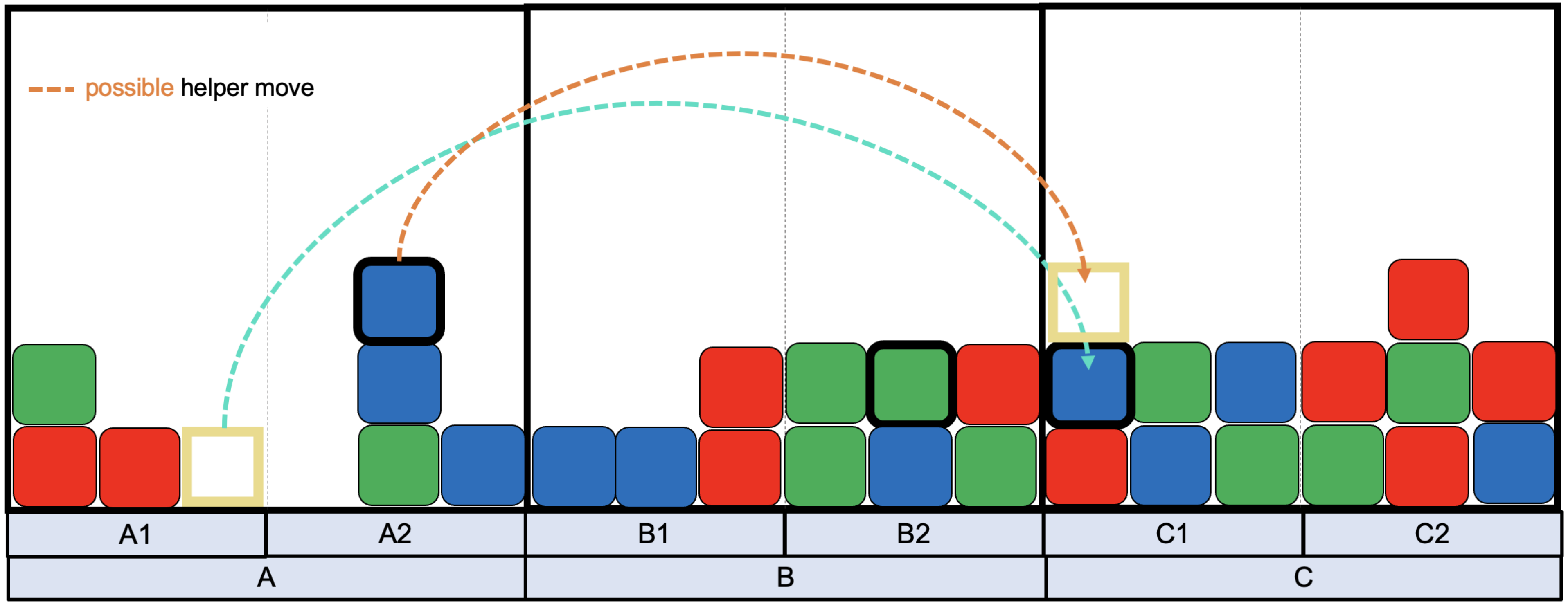
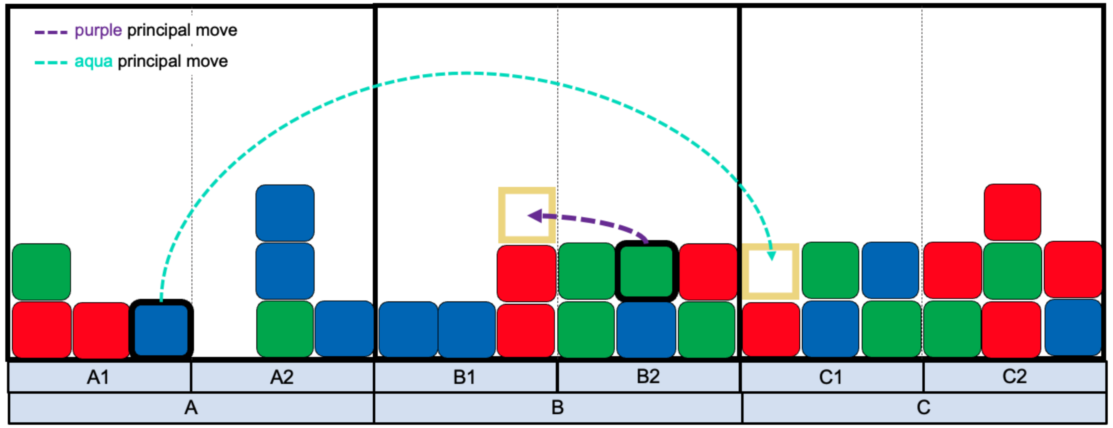
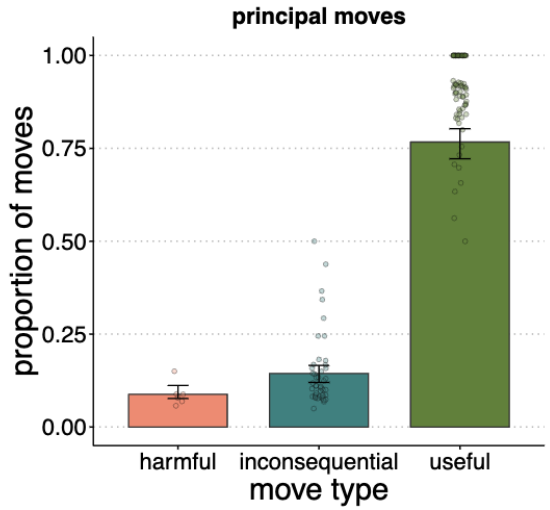


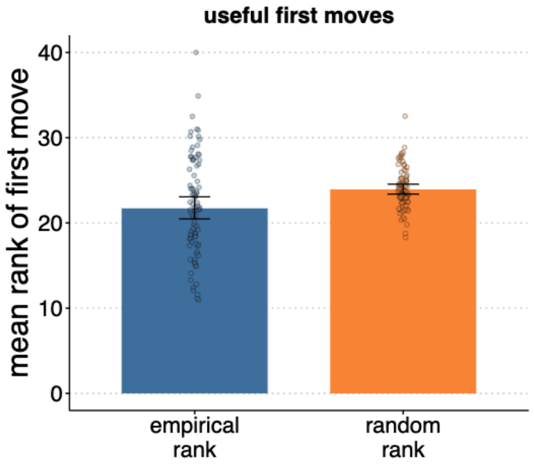
Kumar & Steyvers (2023, *CogSci Proceedings*

principals make useful and pragmatic moves



$$u(m|g,c) = \textsc{MinimumMoves}(g,c) - \textsc{MinimumMoves}(g,s(m,c))$$



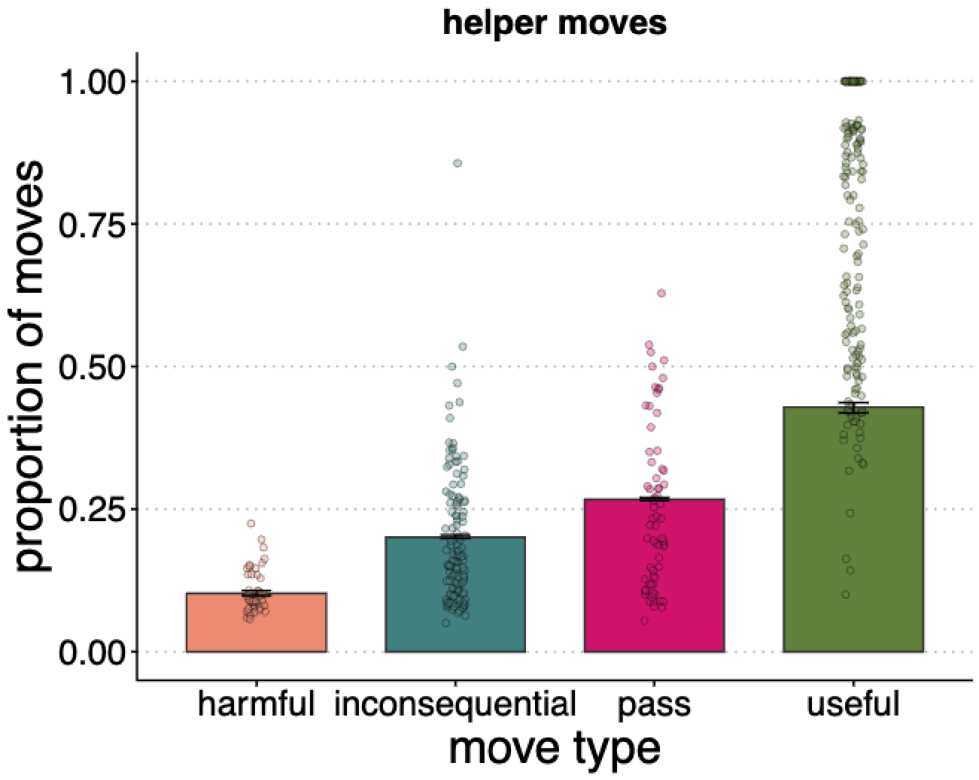


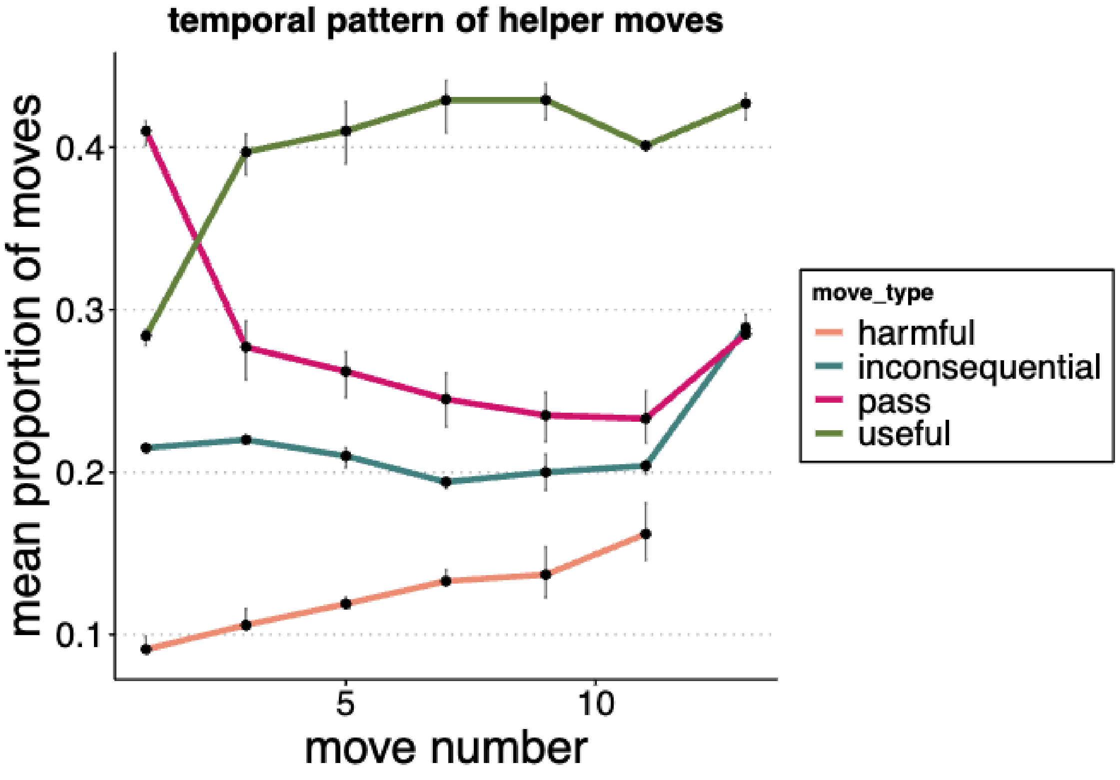
purple move
- moving green blocks to B1
- moving blue blocks to A
- moving blue blocks to A1
- moving blue blocks to A2
- moving blue blocks to C
- moving blue blocks to C1
- moving blue blocks to C2
- moving blue blocks to B1
- uncovering all blue blocks
- covering all red blocks
- clearing B2
- filling B1

aqua move
- moving blue blocks to C
- move blue blocks to C1
- filling C1
- covering all red blocks
- clearing A
- clearing A1

Kumar & Steyvers (2023, *CogSci Proceedings*

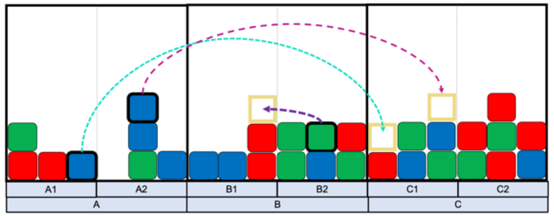
helpers tend to pass their turn (initially)

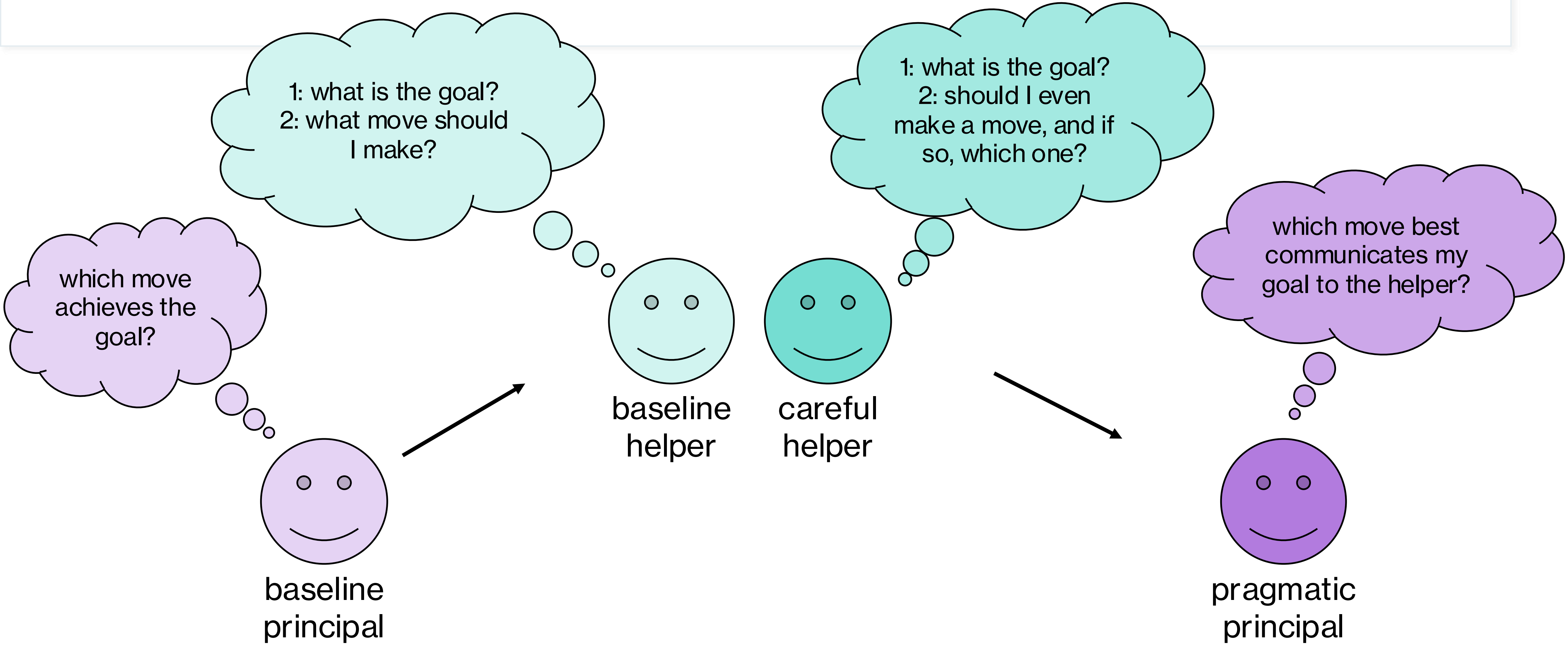




Kumar & Steyvers (2023, *CogSci Proceedings*

modeling cooperative behavior

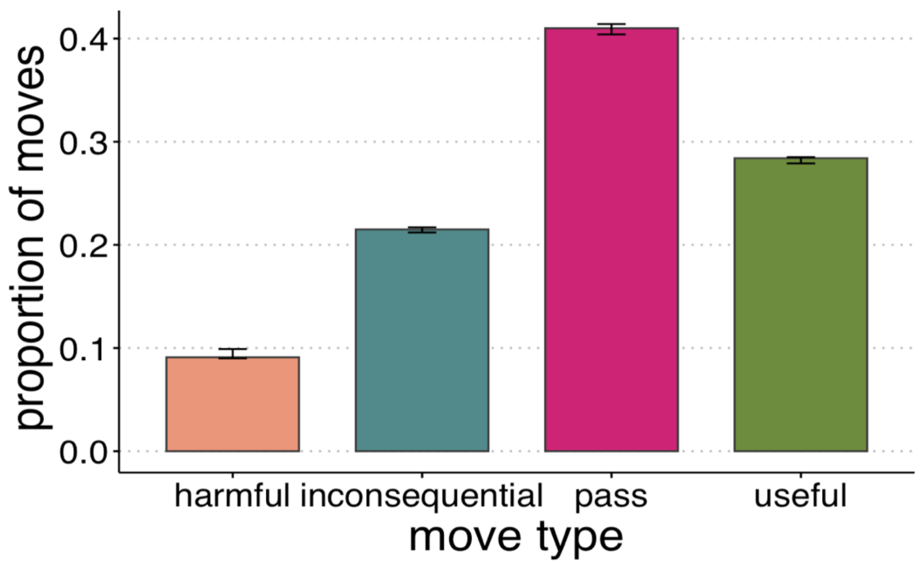




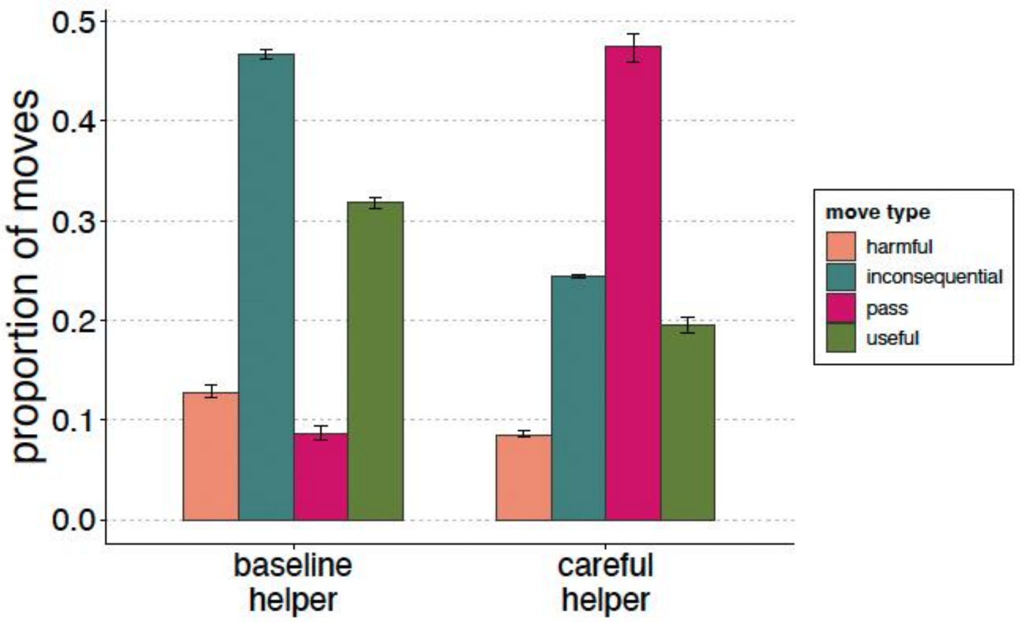
Kumar & Steyvers (2023), *CogSci 2023*

modeling helper performance

actual **participant** data

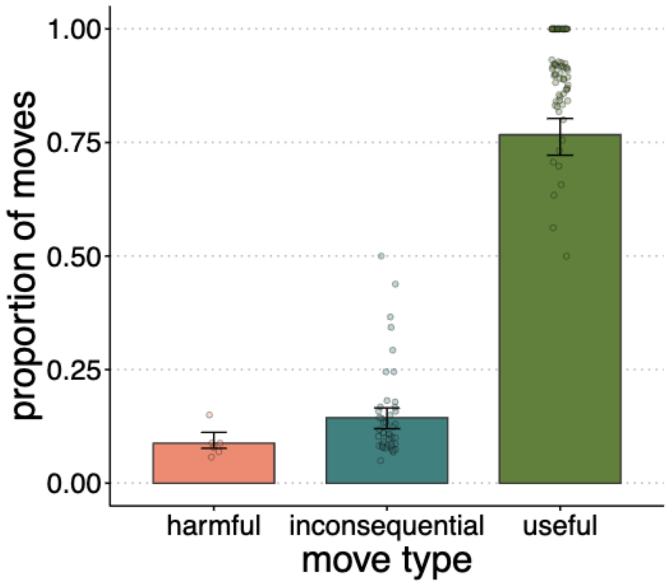


model predictions

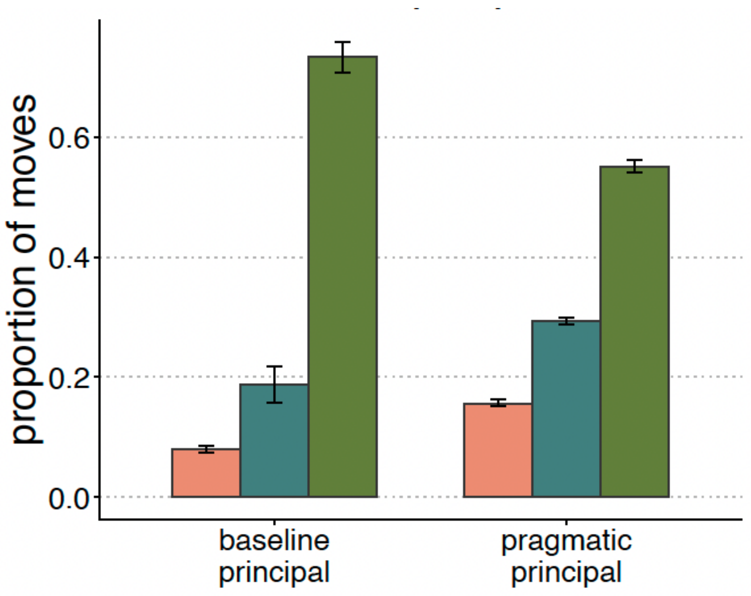


modeling principal performance

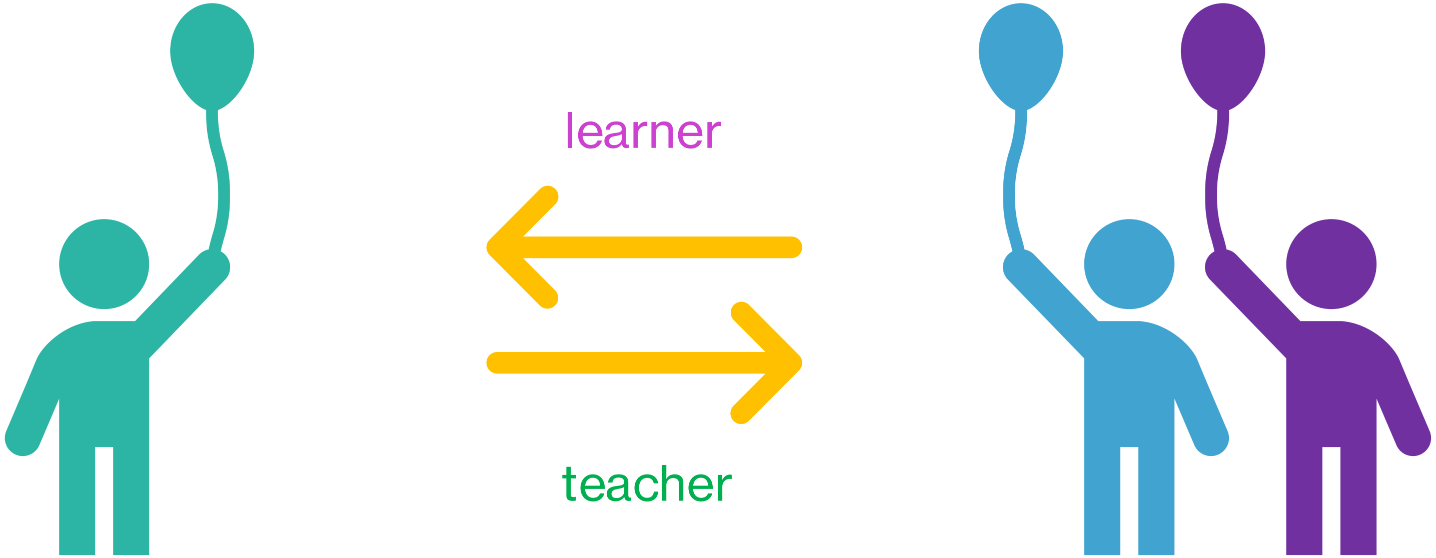
actual **participant** data



model performance

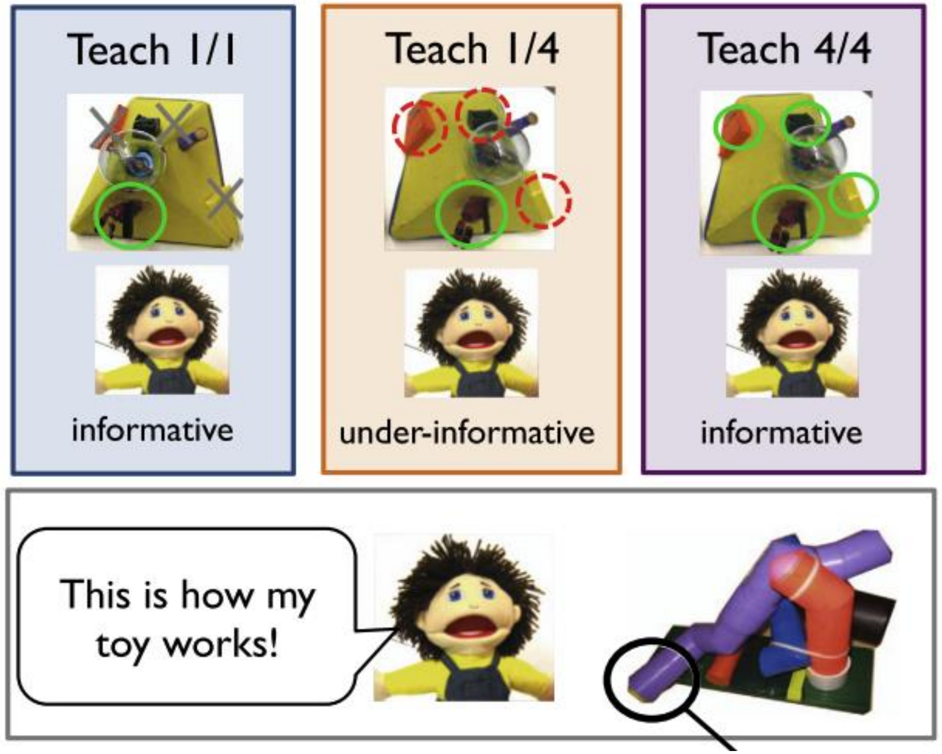


social learning as inference



child as learner: evaluating evidence

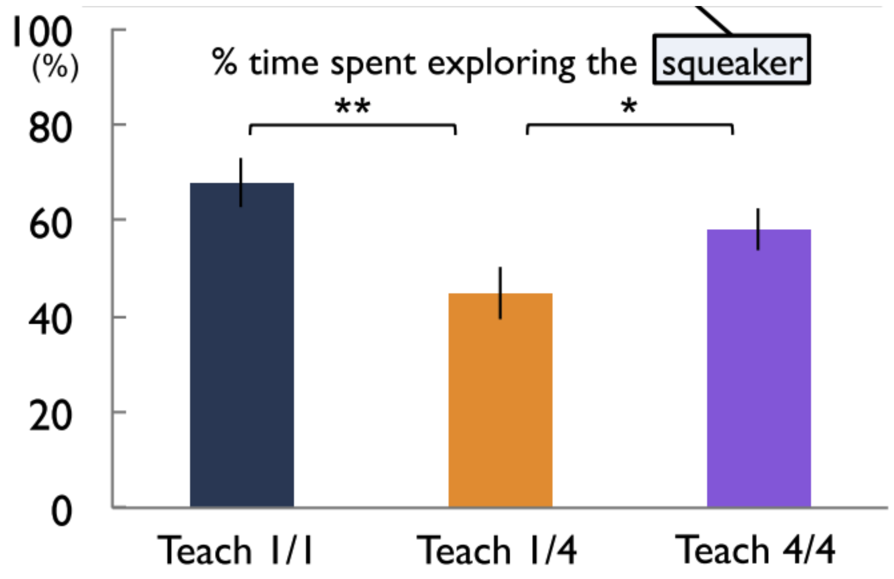
- Gweon et al. (2014) evaluated whether children (6-7yo) can evaluate and compensate for under-informative teaching
- teacher first provided under-informative or fully-informative demonstrations of a toy, and then demonstrated one function of a new toy
- recorded time spent exploring the squeaker part of the toy



paper

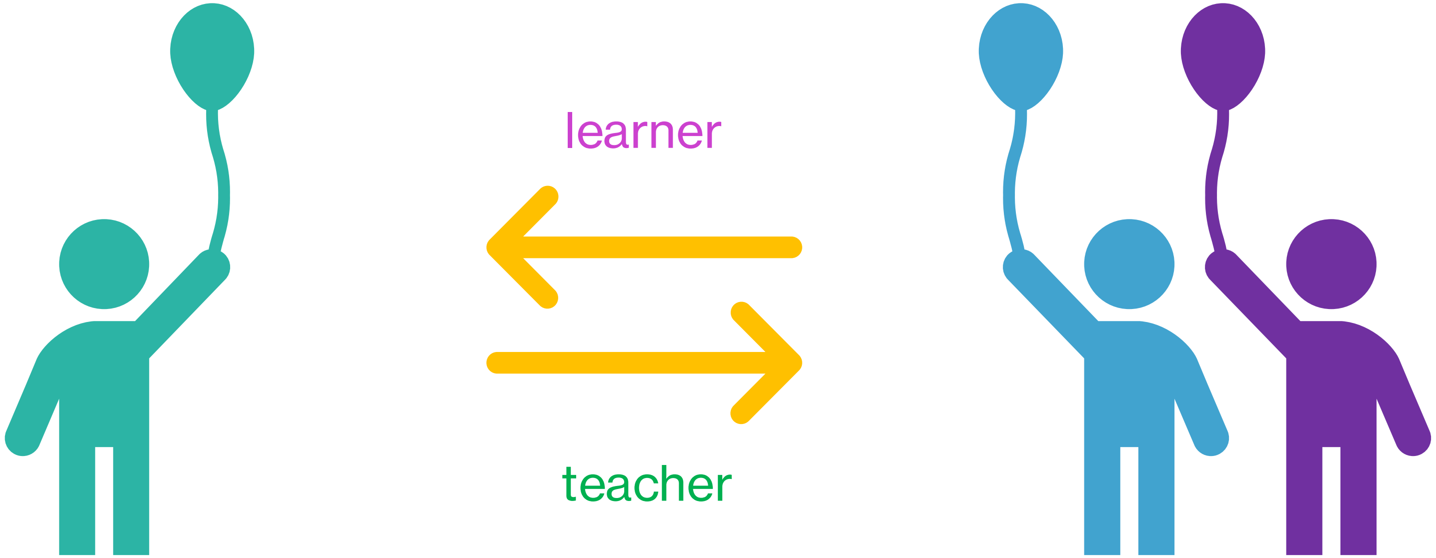
child as learner: evaluating evidence

- children spent less time on the squeaker and more time on other parts when the teacher was under-informative, vs. when the teacher was fully-informative



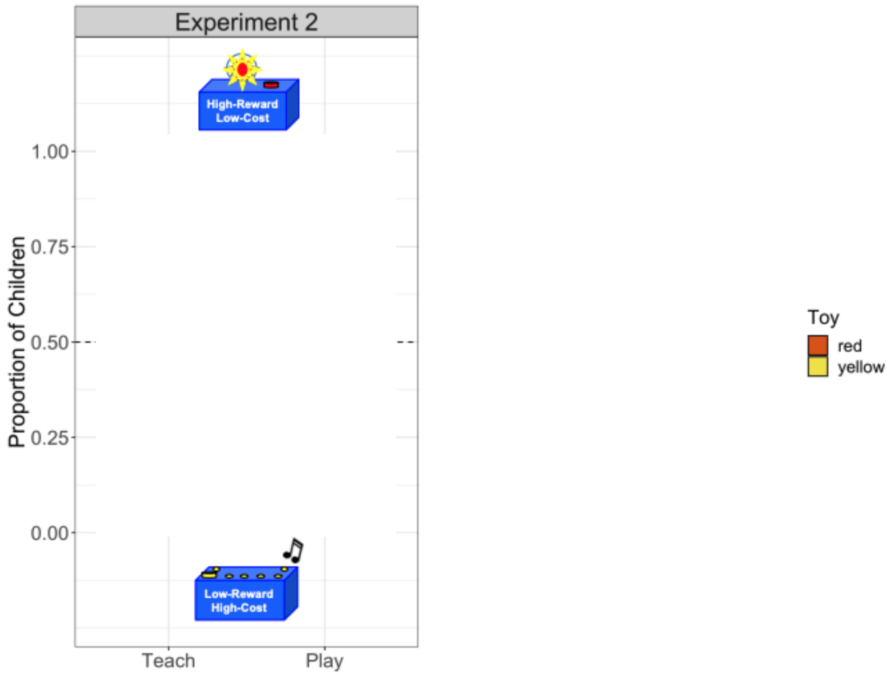
paper

social learning as inference



child as teacher: inferring utilities

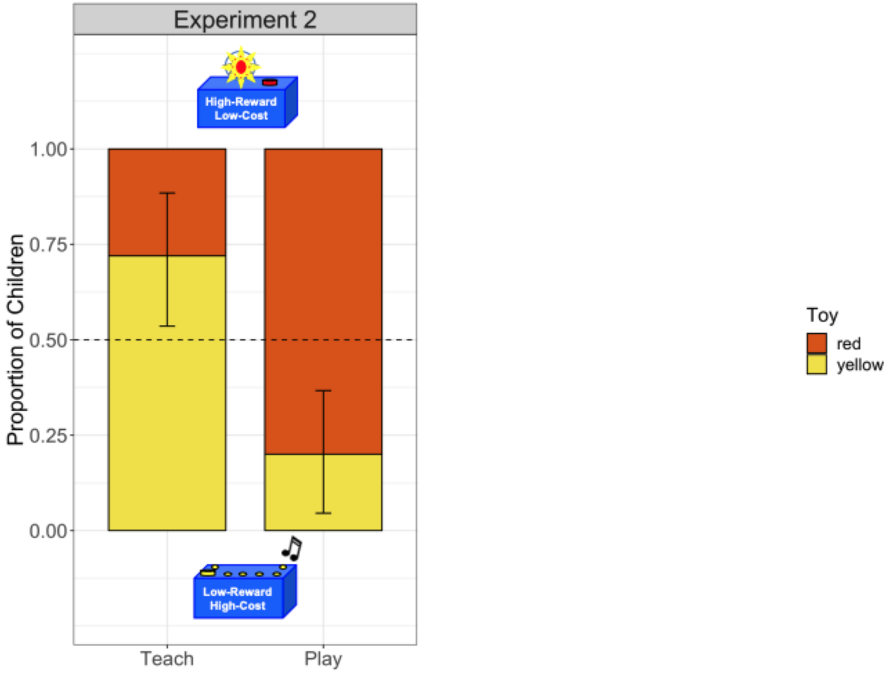
- Bridgers, Jara-Ettinger, and Gweon (2020) tested 5–7-year-olds with toys
    - low/high cost
    - low/high reward
- experiment 2: choose a toy to teach or play



paper

child as teacher: inferring utilities

- Bridgers, Jara-Ettinger, and Gweon (2020) tested 5–7-year-olds with toys
  - low/high cost
  - low/high reward
- experiment 2: choose a toy to teach or play
- children chose low-reward/high-cost toys to teach and high-reward/low-cost toys to play with
- children prioritized the learner's utilities over their own when deciding what to teach



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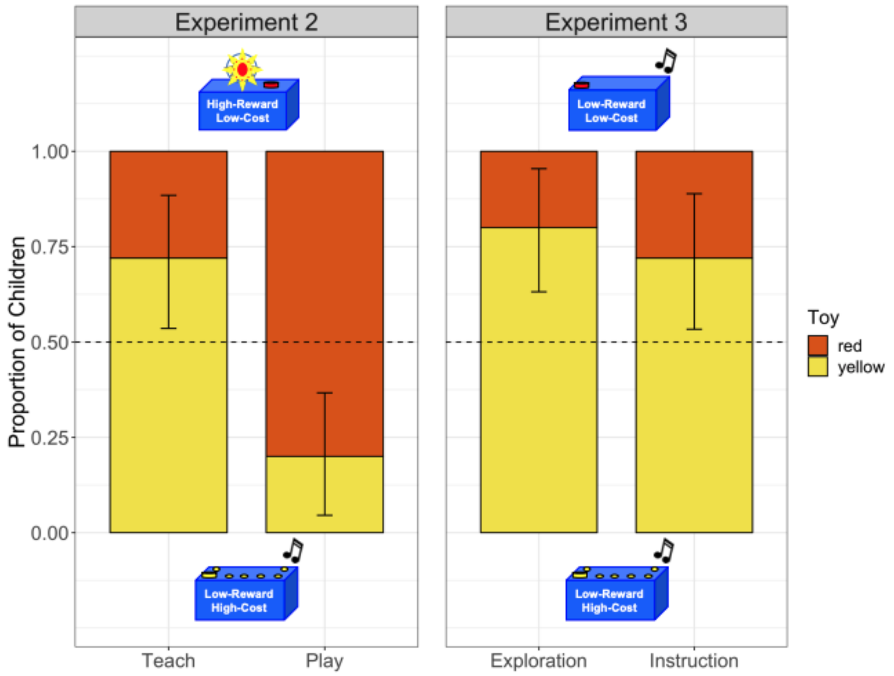
child as teacher: inferring utilities

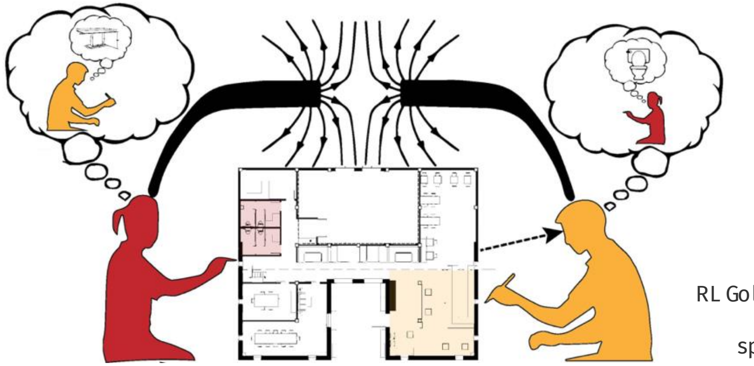
- experiment 3: choose a toy to teach after exploration or instruction
- children chose low-reward/high-cost toys regardless of whether or not they explored the toys themselves or not
- children can infer the costs for others' learnings even in the absence of direct experience



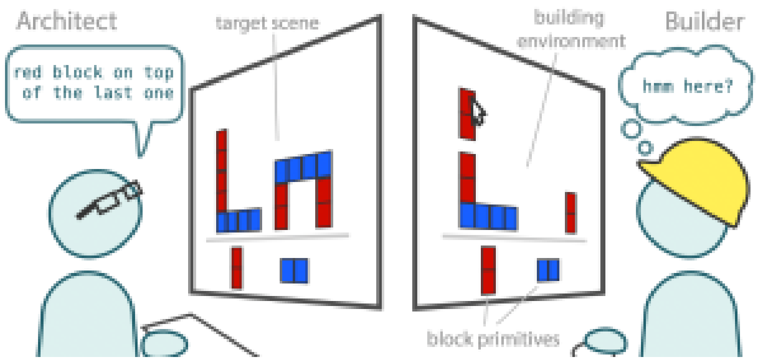
paper

social cognition

- researchers combine developmental + adult human studies with explicit mathematical models to account for a wide variety of cognitive phenomena
  - communication
  - helping
  - collaboration
  - cooperation
  - competition
  - teaching
  - …



RL Goldstone, E Andrade-Lotero, RD Hawkins, ME Roberts (2023). The emergence of specialized roles within groups. *Topics in Cognitive Science*.



W McCarthy*, RD Hawkins*, C Holdaway, H Wang, J Fan (2021). Learning to communicate about shared procedural abstractions. *Proceedings of the 43rd Annual Conference of the Cognitive Science Society*.

next class

- culture and cognition