IMITATION LEARNING IN PROBLEM SOLVING TASKS: MEMORIZING OR UNDERSTANDING?

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Problem solving

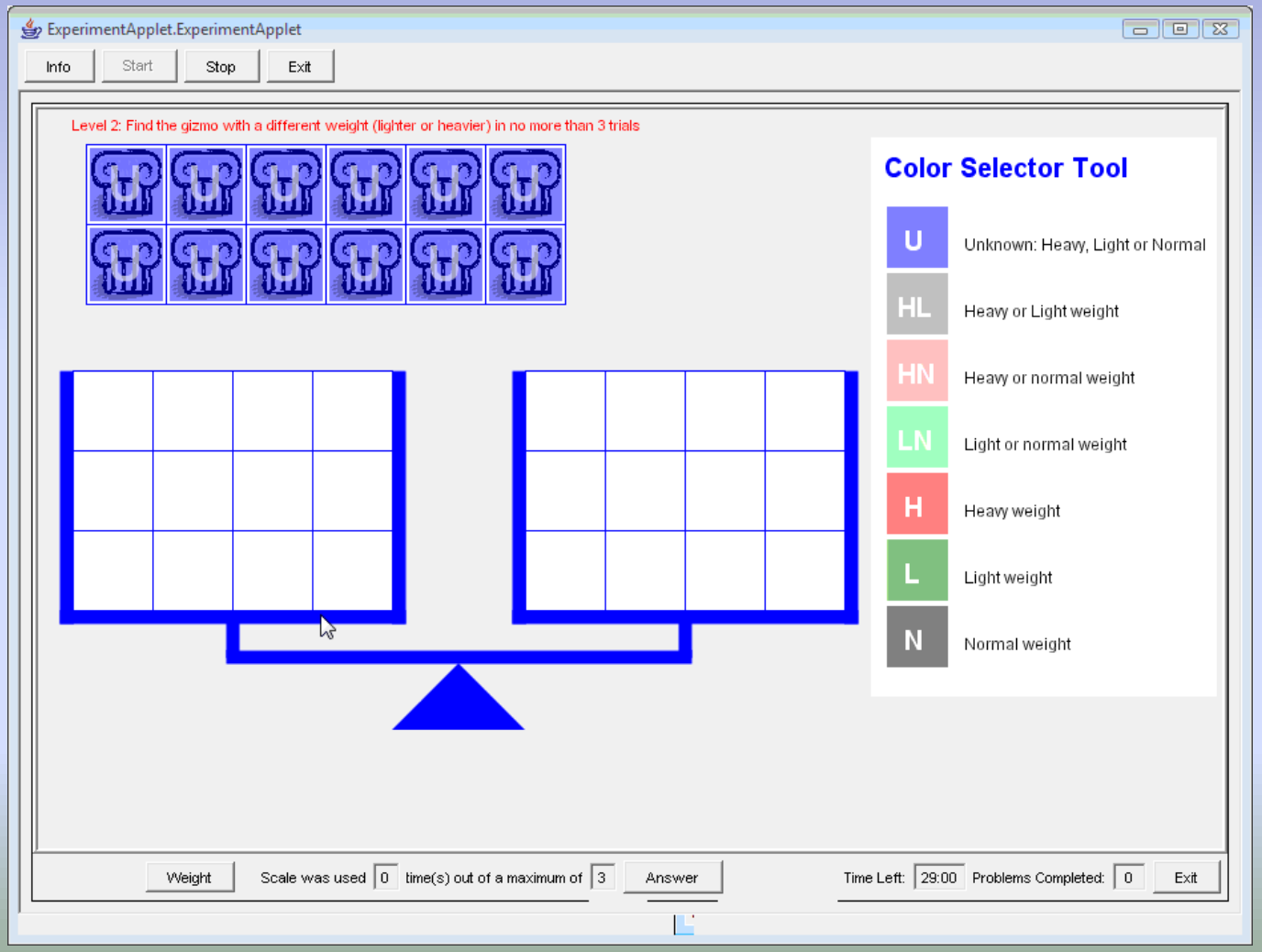
- Many activities in life involve planning and solving problems
- People learn to solve problems
  - By trial-and-error
  - Social learning
    - By teaching
    - By observation of skilled people (e.g., experts)

Gizmo problem solving task

- Previous experiment: Manipulated learning
  - Trial-and-error learning (reinforcement)
  - Learning by observation (imitation)
- Task
  - Find, with **three uses of a scale**, the one gizmo that is either **heavier** or **lighter** than the rest of a set of 12 gizmos
  - Variant used in psychology experiments (Simmel, 1953)
  - Well-defined problem
  - Complex enough to avoid ceiling effects

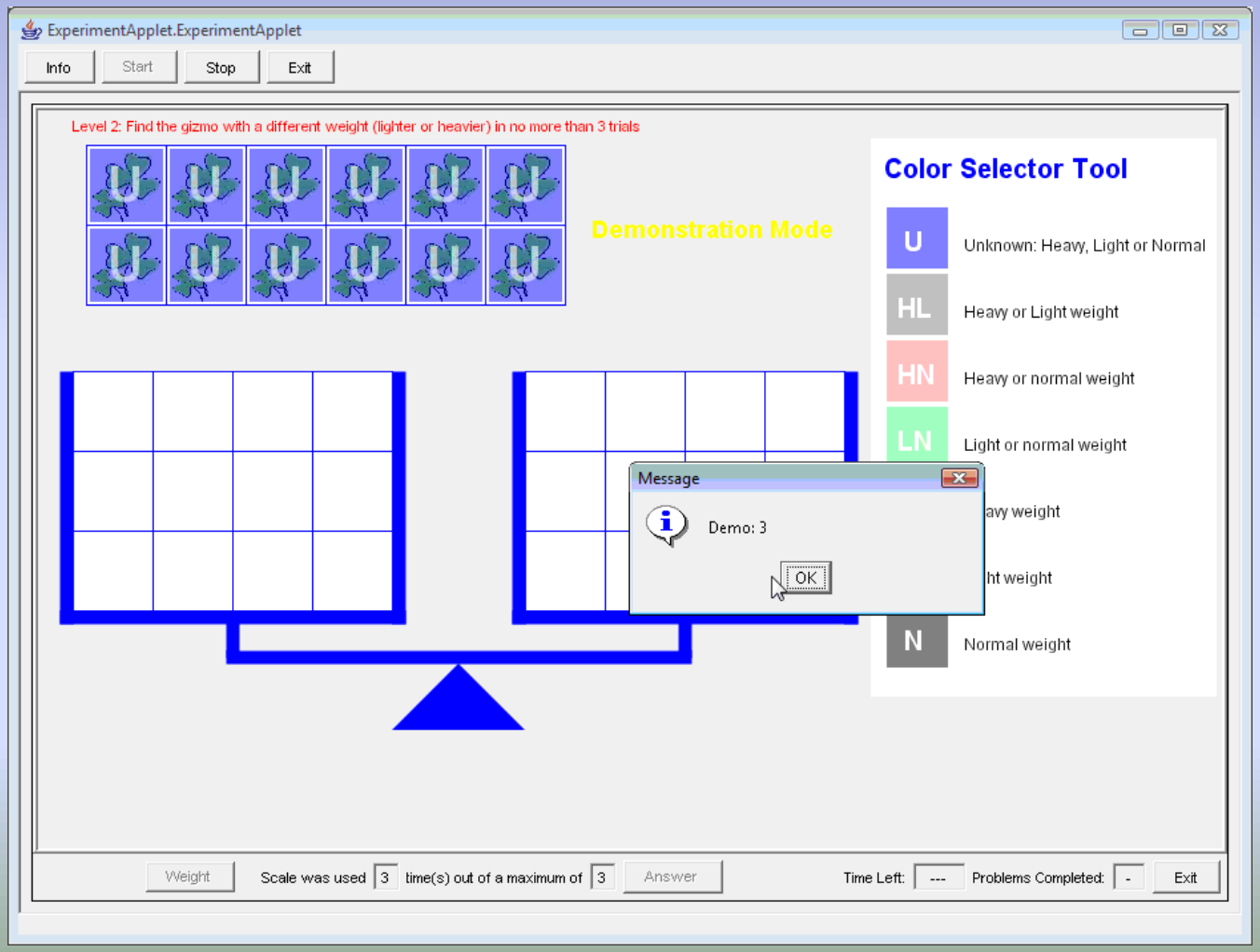
Reinforcement learning

Learning: told if answers are correct or not



Imitation learning

Learning: shown five demonstrations



Results

- Imitation learning group was more accurate (more correct answers) than reinforcement learning group

Dandurand, F., Bowen, M., & Shultz, T. R. (2004). *Learning by Imitation, Reinforcement and Verbal Rules in Problem Solving Tasks.* Paper presented at the Third International Conference on Development and Learning (ICDL'04) Developing Social Brains, La Jolla, California, USA.

Open research questions

- Is explicit feedback better than nothing?
  - Task can be solved using pen and paper
    - Explicit feedback not available
    - Uses reasoning only

- Why did imitation outperform reinforcement?
  - Does imitation involve understanding?
  - Or is memorizing sufficient?

- Does familiarization with task prior to demonstrations improve accuracy?

Is imitation about memorizing or understanding?

- Contradiction in the literature
- **Problem solving → memorizing**
  - Classical area of cognitive science (Newell, 1972)
    - Research interests: search, heuristics and hints
  - Imitation dismissed as rote memorizing (e.g., Katona, 1940)
- **Imitation learning → understanding**
  - Vast and active research area (human, animal, machine)
  - Understanding mentor's goals (Carpenter, Call, & Tomasello, 2002)
  - Complex, hierarchical problem representations (Byrne & Russon, 1998)

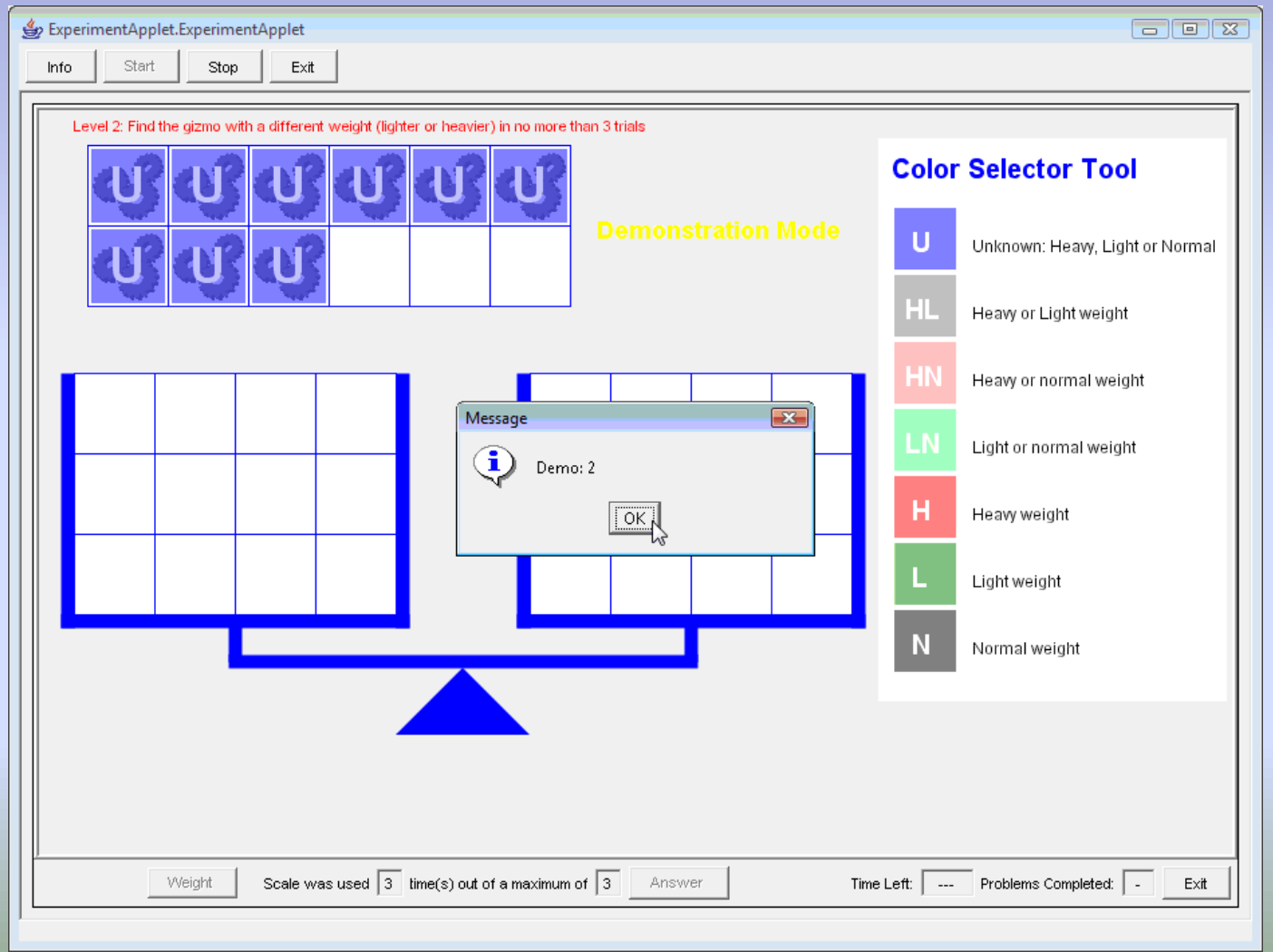
How to study understanding?

- Operational definition
  - Understanding = ability to generalize what was learned by observation to novel, more difficult problems

- Remove possibility of memorizing full solution
  - Use task in which demonstration problems are different from problems to-be-solved

Generalized imitation group

Watch 9 gizmo demos - solve 12 gizmo problems



General experimental setup

- Familiarization
  - 5 min. practice before watching demonstrations
- Demonstrations
  - Expert solves gizmo problem solving task
- Explicit feedback
  - Told if answers are correct or not

Experimental groups

- All participants solve 12 gizmo problems
- 5 Learning conditions

Learning condition:	Control	Reinforcement *	Imitation *	Generalized imitation	Delayed generalization
Familiarization	No	No	No	No	Yes
Demonstrations	None	None	12 gizmos	9 gizmos	9 gizmos
Explicit Feedback	No	Yes	No	No	No

** replication groups*

Design

- Two independent variables
  - *Learning condition*: 5 levels
  - *Quartile:* for each subject, 1/4 of trials went into each quartile
- Two dependent variables
  - *Elapsed time*: mean time to solve trials
  - *Accuracy*: proportion of correct answers out of total number of trials

Predictions

Elapsed Time

faster over quartiles (practice)

Accuracy

1. If explicit feedback is useful

   Reinforcement > Control

   Reinforcement will improve more with practice than other groups

2. If imitation involves understanding

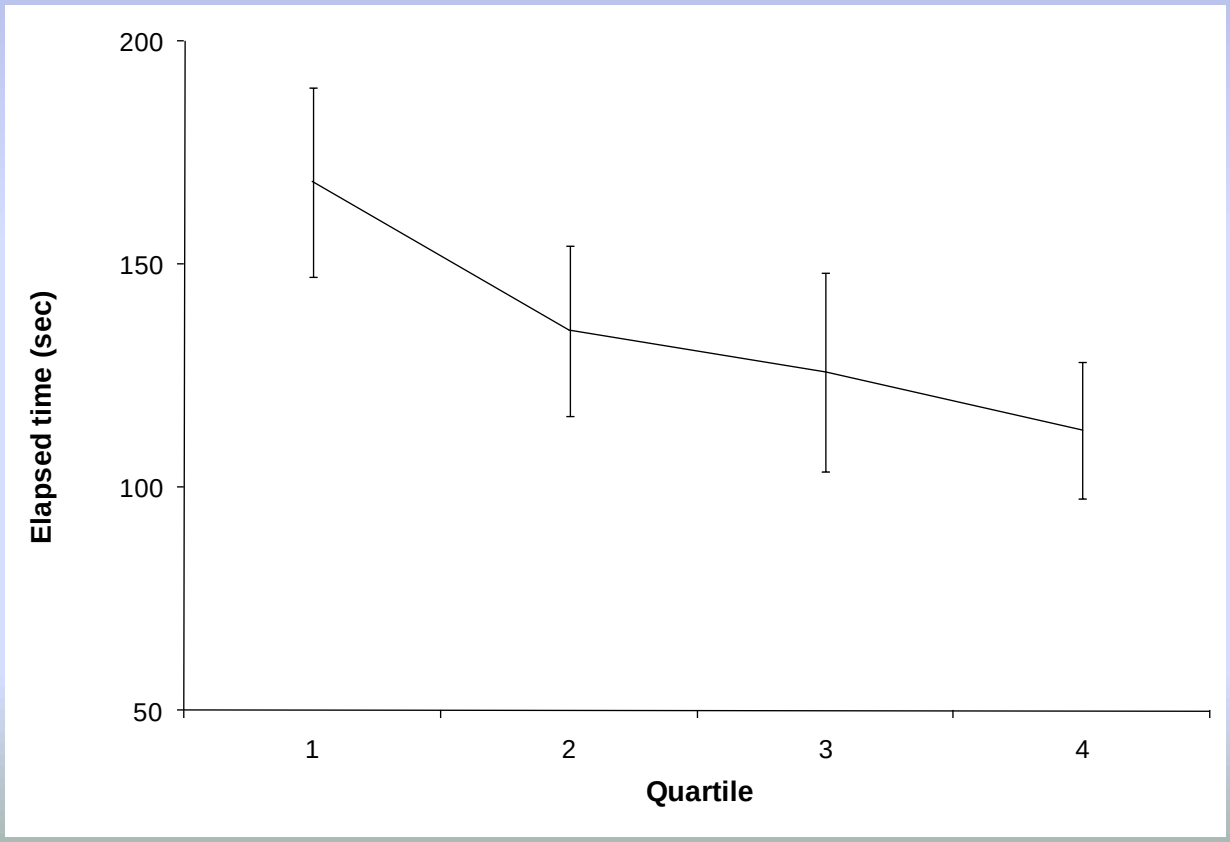
   Generalization groups > Control

3. If familiarization improves performance

   Delayed generalization > Generalized imitation

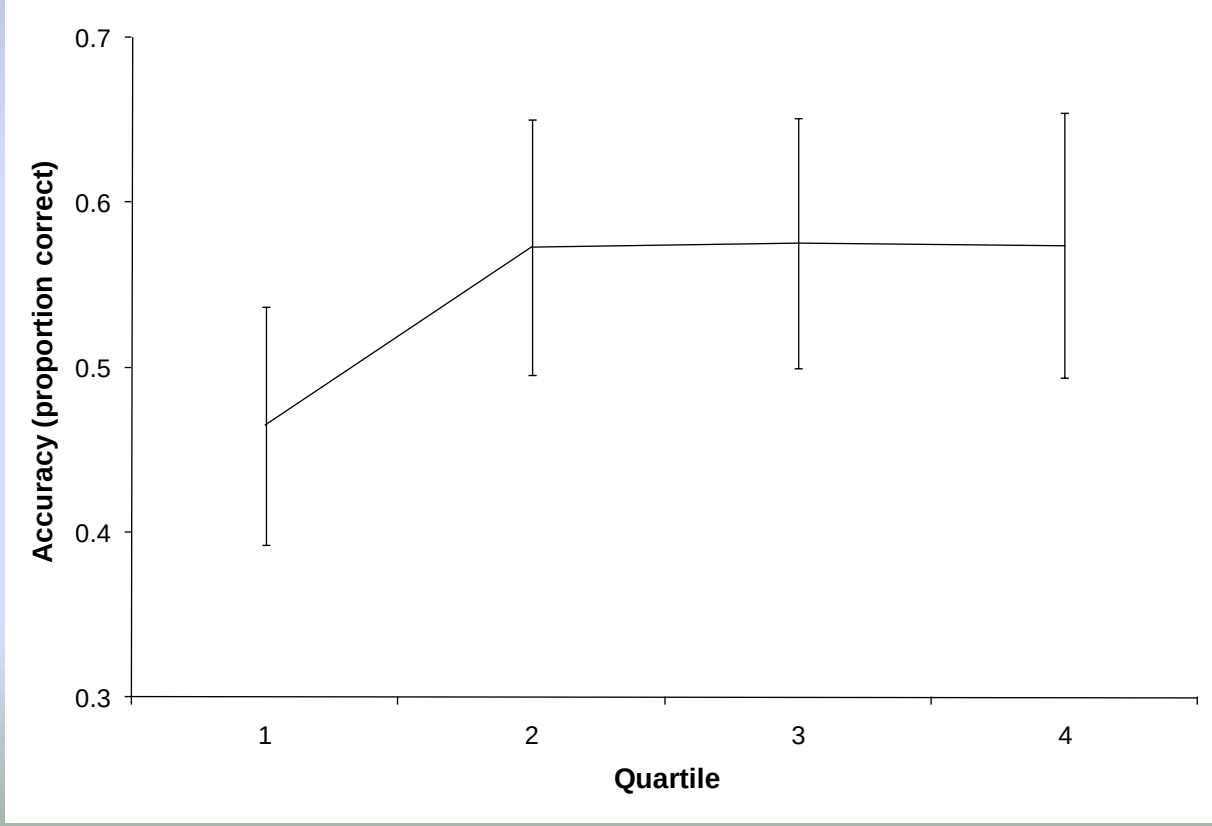
Results – Elapsed time

- Participants get faster with practice
  - Main effect of *Quartile* only $F(3, 285) = 41, p < 0.001$



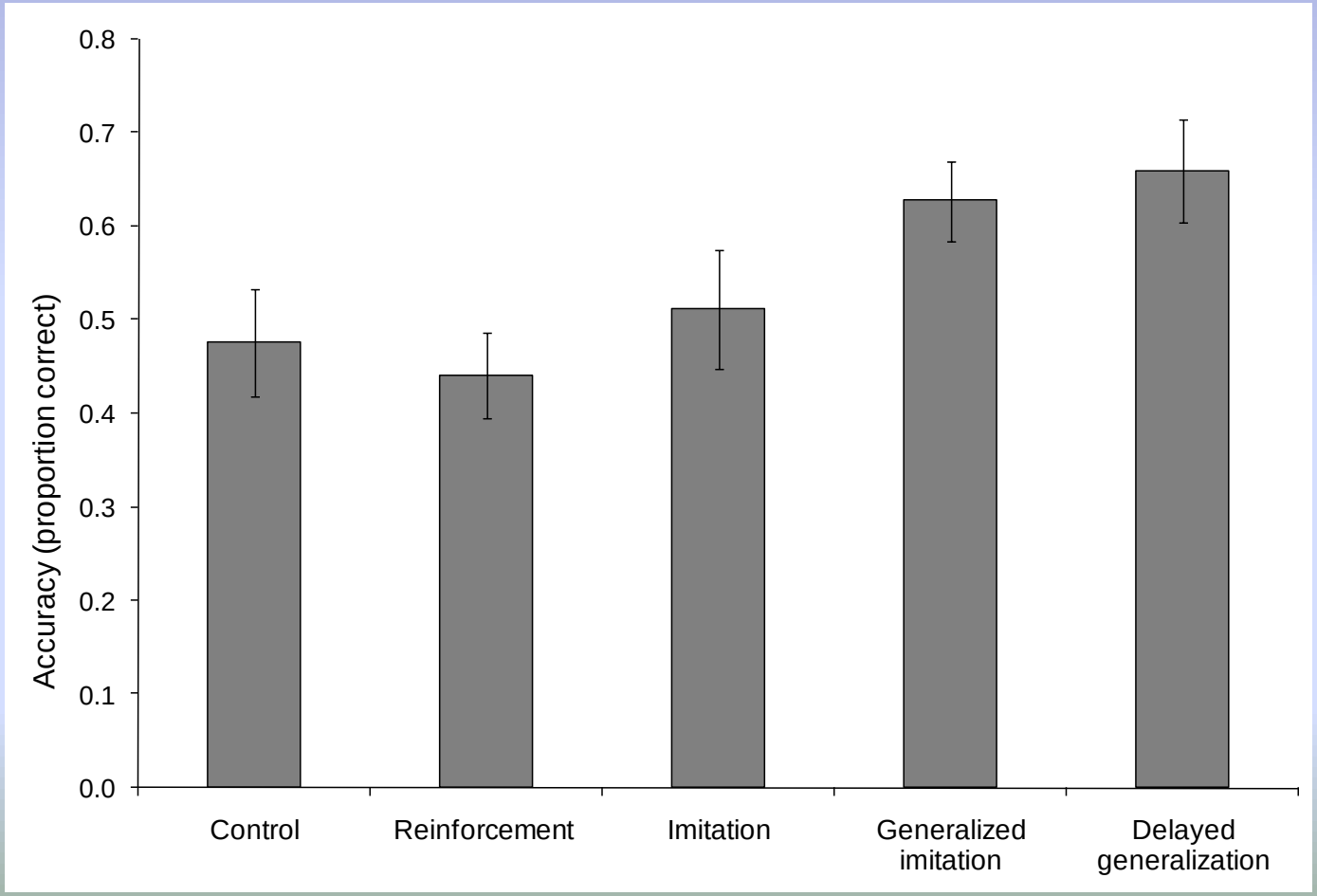
Results – Accuracy (1)

- Participants get more accurate with practice
  - Main effect of *Quartile* $F(3, 285) = 4.5, p < 0.01$



Results – Accuracy (2)

- Main effect of *Learning condition* $F(4, 95) = 3.4$, $p < 0.05$

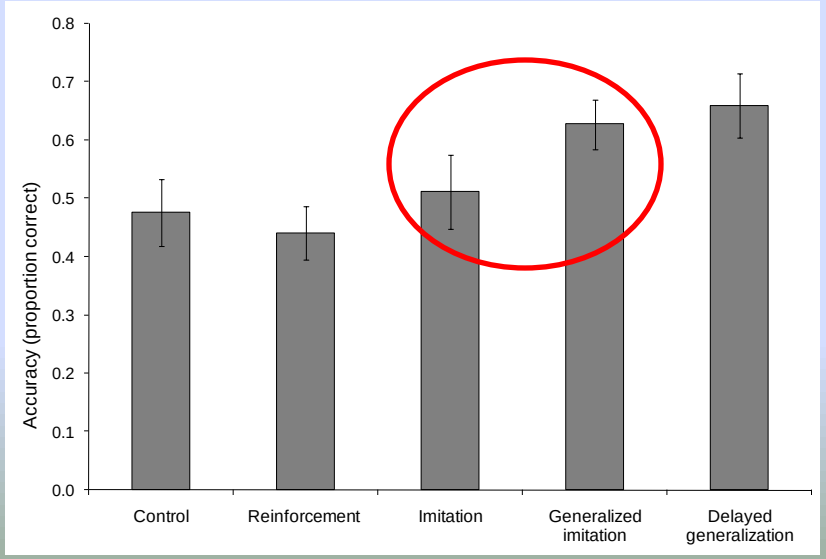


Q1: Is explicit feedback useful?

- No, feedback not required
- Reinforcement (44.1%) = Control (47.6%) (LSD post-hoc)
  - No *Group* x *Quartile* interaction

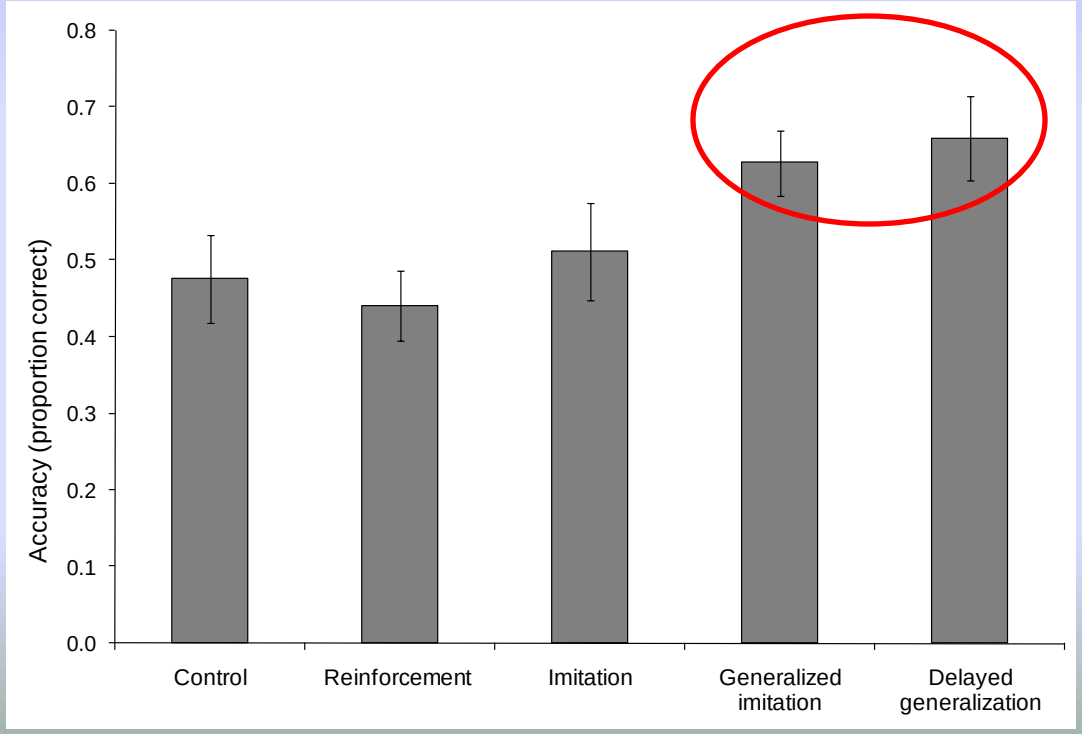
Q2: Does imitation involve understanding?

- Yes, Generalized imitation was at least as accurate as Imitation
  - Generalized imitation (62.7%) > Reinforcement (44.1%) (LSD post-hoc)
  - Generalized imitation (62.7%) = Imitation (51.1%)
  - *Generalized imitation (62.7%) = Control (47.6%) ?*
- *Why?*
  - More interesting?
  - More challenging?
  - More motivated?



Q3: Does familiarization improve performance?

- No, no evidence for a role of familiarization
  - Delayed generalization (65.9%) = Generalized imitation (62.7%)



Cognitive mechanisms of generalization

- Understanding = Ability to generalize to novel problems
- Generalization mechanisms: Understanding?
  - ☑ Problem-independent encoding of features

    Correct abstraction?
  - ☑ Insight

    Use think aloud protocols
  - X Priming of configurations or steps

    Humans prefer simple and symmetrical solution steps

    (Dandurand, Shultz and Onishi, 2007)

What did participants learn from the demonstrations?

- Investigate first-weighing strategies
  - Correct rule: use 1/3 of gizmos on each side
    - 9 gizmo problem → 3 vs. 3
    - 12 gizmo problem → 4 vs. 4

First-weighing strategies

Gizmos installed left /right	Experimental group				
	Control	Reinforcement learning	Imitation learning	Generalized imitation	Delayed generalization
1 / 1	13.6%	5.1%	7.5%	0.3%	0.0%
2 / 2	6.2%	12.2%	7.1%	1.0%	0.9%
3 / 3	19.9%	30.2%	17.8%	28.3%	26.9%
4 / 4	49.6%	30.5%	63.9%	67.2%	64.5%
5 / 5	2.7%	3.7%	2.5%	1.0%	6.0%
6 / 6	7.7%	18.3%	1.2%	2.0%	1.7%

- Generalization groups abstracted correct rule
- Control and reinforcement groups explore more

Next step

- Seek further evidence about cognitive processes involved in gizmo problem solving
- Use think aloud protocols
  - Transcribe and code
- Quantify – Count utterances
  - Understanding (e.g., insight)
  - Reasoning
  - Memorizing, priming

Take home messages

- Explicit feedback may be redundant
  - Reinforcement = Control
  - Correct self-evaluation of answers (reasoning)
- Participants generalized very well
  - Generalization groups were at least as accurate as imitation group
  - Correct abstractions -- 1/3 rule on 1st weighing
- Imitation learning of problem solving tasks: much more than rote memorizing

Thank you !

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- Comments, questions?

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