An Introduction to Learning

Lecture 12/13

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Agenda for Today

- Talk about final... what format should it have?
- Questions from last time
- Social learning, observation, immitation
What age are these kids?... 4-year-olds
Is it pre-existing knowledge?

Another potential concern is that in our experiments we used only relatively familiar categories. It is possible that children had already acquired the superordinate- or subordinate-level terms and simply translated those words into our nonsense labels during the experiments. This is unlikely, because Waxman (1990) found that only about half of her 4-year-old children knew the superordinate term *animal*, and both *vegetable* and *vehicle* are less commonly known to preschoolers. In our sample, the 3-year-olds (who presumably were less likely to know these words) and the 4-year-olds did not behave differently on our task. Some of the subordinate-level concepts we used had an existing label (e.g., *basset hound* or *Dalmatian*), whereas others did not (e.g., *yellow truck* or *green pepper*). Thus, it is unlikely that the children simply translated the new words into words they already knew. Still, future work using a broader range of categories and novel categories could help to clarify the generality of our findings. Xu and Tenenbaum (2007)
How do people learn (in the “real world”)?
$r = -1$

S T H e C l i f f G

$r = -100$

safe path

optimal path

Sarsa

Q-learning

Reward per episode

Episodes

-100

-75

-50

-25

0 100 200 300 400 500
Q: How many times can you walk off a cliff before you learn to not walk off a cliff?

A: 0
Imitation and Observation

Fig. 1. Examples of transitive and intransitive actions performed by the experimenter in front of the recorded monkey (right column); same gestures made by the monkey (left column). Intransitive monkey actions, although rarely evoked during recording sessions, are shown here to outline their similarity with the same actions performed by the experimenter. From top to bottom: grasping of a piece of food; sucking juice from a syringe; lips protruded face.
Why imitate? What advantages might be conveyed to imitators?

- Imitators benefit by copying because it is a short-cut to acquiring adaptive information, saving the costs of asocial learning (Laland, 2004)

- In human groups, cultural identity determined by the propagation of concepts, beliefs, artifacts, and behaviors

- “Standing on the shoulders of giants” -> cumulative build up of knowledge impossible if each individual learns de-novo from their own experience
... *but is copying ALWAYS adaptive?* (Laland, 2004)

- Copying bad or ineffective behaviors no good... learners may have to make decision about how and when to imitate.

- Imitators (compared to asocial learners) don’t know the source and history of experience that is guiding their model’s behavior, thus hard to evaluate it’s effectiveness.

- At extreme ends, if everyone copies everyone else no information about the environment is coded into adaptive behavior!!
When and who to copy (Laland, 2004)

<table>
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<tr>
<th><strong>Table 1</strong></th>
<th><strong>Social Learning Strategies</strong></th>
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<td><strong>“When” Strategies</strong></td>
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<td>Copy when established behavior is unproductive</td>
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<td>Copy when asocial learning is costly</td>
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<td>Copy when uncertain</td>
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<td><strong>“Who” Strategies</strong></td>
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<td>Copy the majority</td>
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<td>Copy if rare</td>
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<td>Copy successful individuals</td>
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<td>Copy if better</td>
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<td>Copy if dissatisfied</td>
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<td>Copy good social learners</td>
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<td>Copy kin</td>
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<td>Copy “friends”</td>
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<td>Copy older individuals</td>
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Note—“When” strategies specify the circumstances under which individuals copy others, and “who” strategies identify from whom individuals learn. Here, the term *copy* refers to any form of social learning.
When to copy (Laland, 2004)

- **When established behavior is unproductive** - copying behavior in pigeons increased in a flock when food was plentiful (they would steal food from other pigeons) but switch to self-directed food finding behaviors in resource limited environments (Lefebvre & Palameta, 1988)

- **When asocial learning is costly** - when collecting ones own information through self-directed learning is costly then there are advantages to imitate/copy. e.g., starlings use public information about foraging success of other animals only when accurate information was difficult to obtain for ones self (Templeton & Giraldeau, 1996)

- **When uncertain** - when uncertainty goes up animals may prefer to copy to avoid costs of being wrong (Boyd & Richerson, 1988). However, may be subsumed by the previous bullet
Who to copy (Laland, 2004)

- **Copy the majority** - the frequency with which a behavior is adopted in a group of conspecifics often influences the likelihood it is copied. Can lead to pathological situations in environments where exploration are favored (guppy experiments, Day et al., 2001)

- **Copy if rare** - happens in birdsong when animals favor large repertoires (basically copy novel sounds which is adaptive in this group) (Catchpole & Slater, 1995)

- **Copy successful people** - certain animals will acquire food preference through social learning but only if the model remains well (if it gets stuck the behavior isn’t copied (Mason, 1988).

- **Copy if better (and variants)** - compare individual to group and copy if the other person is doing better (related to the cultural ratchet of Tomasello, 1994)

- **Copy the best immitators** - Blackmore’s memetic evolution theory, good social learner get advantages so recognizing this in others is a cue for when to copy (evidence mixed)

- **Copy the best immitators** - Blackmore’s memetic evolution theory, good social learner get advantages so recognizing this in others is a cue for when to copy (evidence mixed)

- **Copy kin, copy older individuals, copy friends** - other good strategies
When and who to copy (Laland, 2004)

Are unlearned strategies (e.g., scrounging) productive?

- **YES**: Unlearned strategies
- **NO**: Is asocial learning productive?
  - **YES**: Asocial learning
  - **NO**: Is social learning productive?
    - **YES**: Social learning
    - **NO**: Innovation
Ok, so that’s some “normative” arguments for when, why, and who to imitate. Let’s look at some patterns of imitation
1. Pairs of rats are fed rat chow.

2. The observer rat is removed to another cage: both rats are deprived of food.

3. The demonstrator is given a novel food (cinnamon!).

4. Briefly together again; the observer rat smells the novel food on the demonstrator rat's breath.

5. Later, the observer rat chooses the food that the demonstrator rat ate.
LETTERS

De novo establishment of wild-type song culture in the zebra finch

Olga Fehér¹, Haibin Wang², Sigal Saar¹, Partha P. Mitra² & Ofer Tchernichovski¹
In visible scores condition 79% of imitation events were of the highest-scoring player (copy the best), while in invisible-scores condition, all players were approximately equally likely to be imitated.
Participants solve simple problem, taking advantage of neighbors’ solutions

- Numeric guesses mapped to scores according to fitness function
- Attempt to maximize earned points

Network Types

- Lattice: Ring of neighbors with only local connections
- Fully connected: Everybody sees everybody else’s solutions
- Random: Neighbors randomly chosen
- Small world: Lattice with a few long-range connections
  • Based on Newman and Watts (1999), not Watts and Strogatz (1998)

Fitness Functions

- Unimodal - a single, gradually increasing peak
- Trimodal - two local maxima and one global maxima
Network Types

- Regular Lattice
- Fully Connected
- Random
- Small World
Small World Networks

Constructing a small world network (Watts, 1999)
Start with regular graph
Rewire each edge with probability p

Benefits for information distribution (Kleinberg, 2000; Wilhite, 2000)
Systematic search because regular structure
Rapid dissemination because short path lengths

Prevalence of small world networks (Barabási & Albert, 1999)
Experiment Interface

http://groups.psych.indiana.edu/

Time remaining: 13

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<thead>
<tr>
<th>ID</th>
<th>Guess</th>
<th>Score</th>
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<tbody>
<tr>
<td>YOU</td>
<td>45</td>
<td>36.1</td>
</tr>
<tr>
<td>Player 1</td>
<td>39</td>
<td>45.7</td>
</tr>
<tr>
<td>Player 2</td>
<td>95</td>
<td>4.2</td>
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<tr>
<td>Player 3</td>
<td>52</td>
<td>29.0</td>
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Experimental Details

• 56 groups with 5-18 participants per group
  – 679 total participants
  – Mean group size = 12

• Within-group design: each group solved 15 rounds of 8 problems (4 network types X 2 Fitness functions)

• For Trimodal function, global maximum had average score of 50, local maxima had average scores of 40

• Normally distributed noise added to scores, with variance of 25.

• Average number of network neighbors for random, small world, and lattice graphs = 1.3 * N

• Characteristic path lengths: Full =1, Random = 2.57, Small world = 2.61, Lattice = 3.08
For unimodal function, lattice network performs worst because good solution is slow to be exploited by group.

For trimodal function, small-world network performs best because group explores search space, but also exploits best solution quickly when it is found.
Neural mechanisms of observational learning

Christopher J. Burke\textsuperscript{a,1,2}, Philippe N. Tobler\textsuperscript{a}, Michelle Baddeley\textsuperscript{b}, and Wolfram Schultz\textsuperscript{a}

Fig. 1. Experimental design and behavioral results. (A) After a variable ITI, participants were first given the opportunity to observe the confederate player being presented with two abstract fractal stimuli to choose from. After another variable ITI, participants were then presented with the same stimuli, and the trial proceeded in the same manner. When the fixation cross was circled, participants made their choice using the index finger (for left stimulus) and middle finger (for right stimulus) on the response pad. (B) The proportion of correct choices increased with increasing amounts of social information. (C) There was a monotonic increase in the proportion of correct choices as a function of the observability of the other player's behavior and outcomes. Learning from the actions and outcomes of the other player resulted in significantly more correct choices than action only observable and individual learning conditions.
Neural mechanisms of observational learning

Christopher J. Burke, Philippe N. Tobler, Michelle Baddeley, and Wolfram Schultz

\[ \delta^S = r^S_{(a,t)} - Qa(t) \]

\[ Qa_{(t+0.5)} = Qa(t) + \alpha^S \times \delta^S \]

\[ P(a)_{(t)} = \frac{\exp(Qa(t)/\beta)}{\exp(Qa(t)/\beta) + \exp(Qb(t)/\beta)} \]

\[ \delta^i = r^i_{(a,t)} - Qa(t) \]

\[ Qa_{(t+1)} = Qa(t) + \alpha^i \times \delta^i \]
Neural mechanisms of observational learning

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Ventral striatum underlies individual outcome predictions

DLPFC underlying this “observational” prediction error (when the model chooses in a way unexpected by the individual)
VMPFC matches again in “full information condition”

**Is vicarious social learning just consistent with reward learning?

However, prediction error on observing the feedback for the other learner is inverted!
Mirror neurons! A neural substrate for action modeling
What about learning from others when you are being taught (pedagogical learning)?

Figure 1: Possible rectangle game scenarios. The top row shows a possible rectangle concept, and two possible pairs of examples that a teacher might choose to communicate to a learner. The bottom row shows possible examples a learner may observe, and two possible guesses about what rectangle the teacher had in mind. The middle column shows better choices than the right column.

Figure 2: Distributions of examples in the teaching task for (a) positive examples and (b) negative examples. Pictured from left to right in each panel are the predictions of strong and weak sampling, the observed human data, and the predictions of pedagogical sampling. For the models, figures display the probability of an example in each block. For human data, the proportion of positive examples in each location is plotted. People strongly preferred to give positive examples in the corners of the rectangle and negative examples near the boundaries, as predicted by pedagogical sampling.

Figure 4: Results from the learning task. Plots show the positions of the teacher’s examples, relative to the rectangles drawn by learners for positive (left) and negative (right) examples. The results show that learners clearly understand that teachers are sampling data pedagogically – positive examples indicate corners of the correct rectangle, and negative examples indicate the boundaries.
What about learning from others when you are being taught (pedagogical learning)?

Figure 2: Performance of three concept learning algorithms on the rectangle task.
What about learning from others when you are being taught (pedagogical learning)?

Figure 2  Percentages of generalization responses at the subordinate and basic levels, for adults and children in both teacher-driven (a) and learner-driven (b) conditions. Corresponding posterior probabilities for subordinate and basic-level hypotheses are shown for the Bayesian model.
Discussion point: How to give unique support to imitative behaviors/learning that is distinct from classical/instrumental conditioning?