Perceptual Learning, Roving, and Synaptic Drift

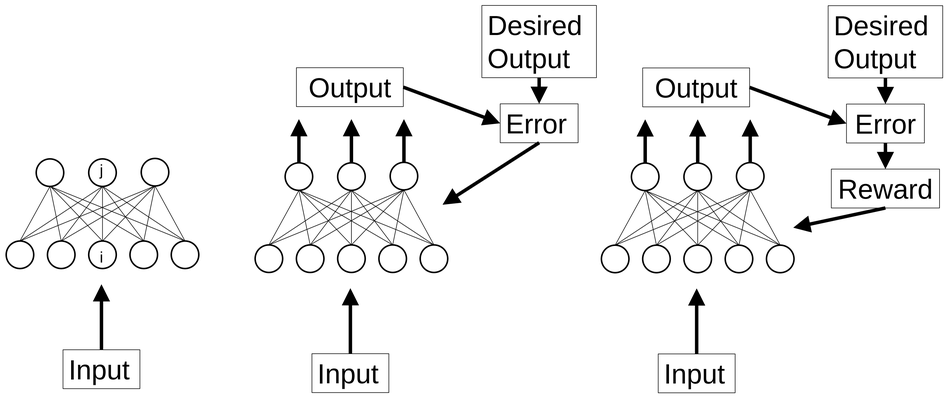
Michael H. Herzog and Aaron Clarke

Laboratory of Psychophysics, Brain Mind Institute, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Introduction:

- Roving is when two different stimulus types are randomly interleaved during training.
- Roving can impair learning.
- Prior studies have speculated that roving is related to disruption of memory-traces (Yu et al., 2004), diminishment of stimulus predictability (Adini et al., 2004), or prevention of conceptual tagging (Zhang et al., 2008).
- Here we show that roving has a much more parsimonious, mathematical explanation.

Unsupervised	Supervised	Reward-Based
$\Delta w_{ij} = pre_i \times post_j$	$\Delta w_{ij} = pre_i \times e_{ij}$	$\Delta w_{ij} = Cov(R,w_{ij}) + \langle R \rangle \langle w_{ij} \rangle$



- No feedback
- Trial by trial feedback
  - Error feedback
  - Teacher signal
- Feedback after many trials
  - Error feedback
  - Teacher signal

Figure 1. Unsupervised models fail because feedback facilitates learning. Supervised models fail because learning is possible without feedback. **Hence, only reward-based learning can explain perceptual learning.**

Unsupervised Bias Hypothesis:

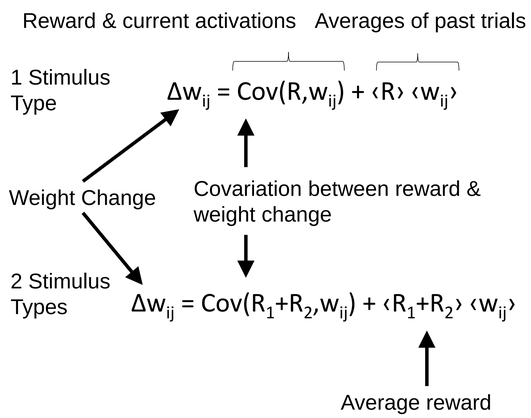


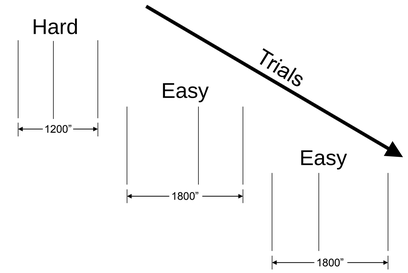
Figure 2. Perceptual learning can occur only if $\langle R \rangle = 0$ or $\langle R_1+R_2 \rangle = 0$, respectively otherwise synaptic drift occurs.

Predictions:

- The unsupervised bias hypothesis predicts that perceptual learning fails when an easy and a hard task are roved because of their different rewards.

Experiment:

- Bisection task
- We first measure pre-training thresholds for a 1200” and an 1800” bisection stimulus.
- During training, participants are presented with both the 1200” and the 1800” stimuli randomly interleaved.



Results:

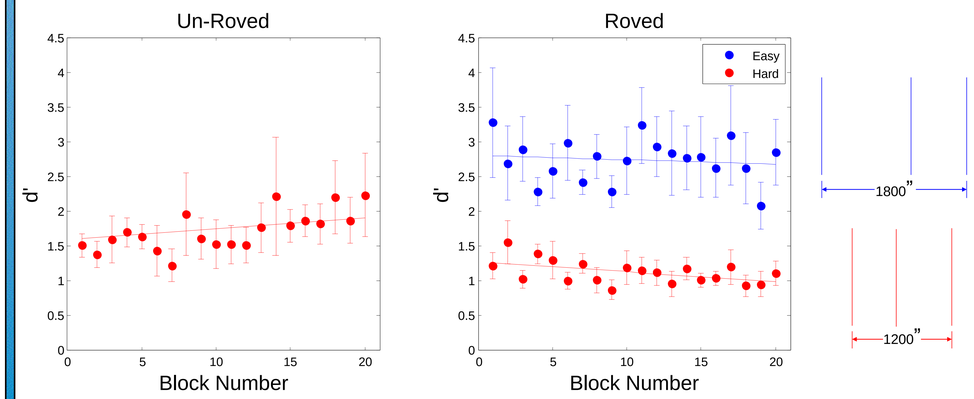


Figure 3. While learning is possible for a difficult, un-roved task (left), no learning occurs when the same task is roved with an easy task (right).

Summary:

- A parsimonious mathematical analysis shows why roving can impair learning.
- Our experiment provides evidence for the unsupervised bias hypothesis..

This work was supported by the Sinergia of the Swiss National Science Foundation (SNF)

Corresponding author: michael.herzog@epfl.ch