CCN – Day 3 – Máté Lengyel
– (Probabilistic Internal Models) –

INTERNAL MODEL = Mental representation surrounding world

Perception | Action | Semantic knowledge | Navigation

Probabilistic perspective ⇒ $p_m(y) \rightarrow p_m(x \mid y) \rightarrow$ Interested in generative model: $p(x, y)$

↳ Central problem: Inversion ⇒ $p_m(y \mid x)$ → How to do best?

↳ Model in alignment with "true" generating process

↳ Flexibility (!!!) ⇒ Using same internal model in multiple tasks!

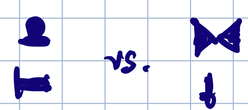
Three parts:
1. Env Adaptation
2. Task-Modality-Independence
3. Neural Substrates

ADAPTATION TO ENV

- Visual Pattern Learning (József Fiser) → requires generalization via model identific.

ATTENTION PHASE

Visual Familiarity



vs.

TEST PHASE

What is closer?

→ Associative Learning
↳ Rules / Correlations
↳ 1st / 2nd order statistics

→ Bayesian learning
↳ Latent state inference

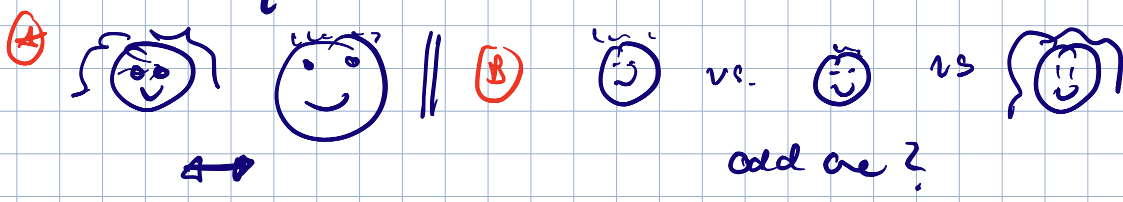
⇒ TAKE-AWAY: As complexity of env/task increases
→ Bayesian learner fits performance best! → Generalisation

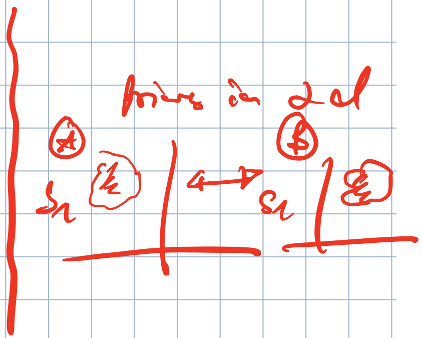
- Chunking → Haptic pull extension to prev. task

⇒ TAKE-AWAY: Zero-shot generalisation using extracted latent variables! ↳ to new haptic task!

TASK-MODALITY INDEPENDENCE

- Familiarity vs. Odd-one-out task





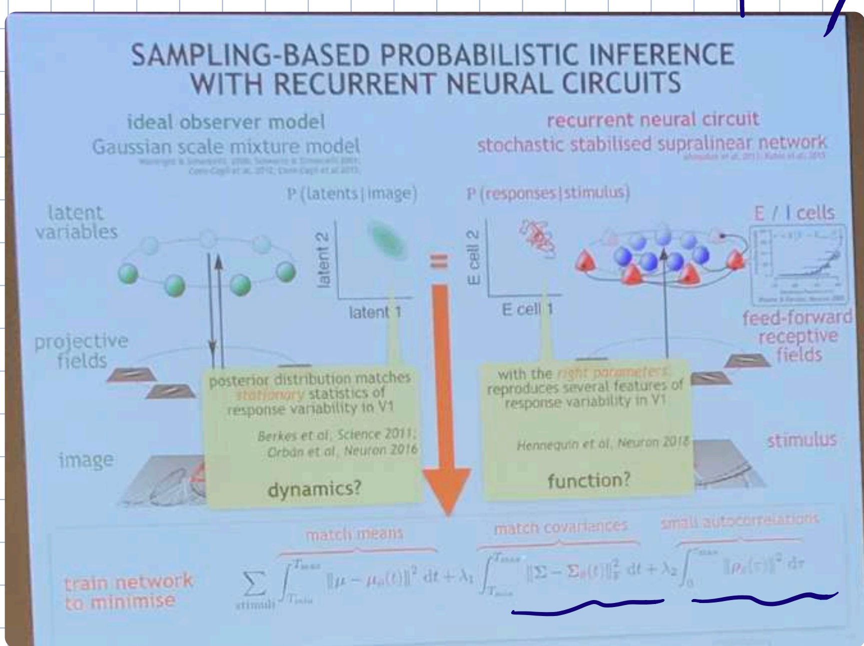
→ Natural prior identification for both tasks → behavior fitting!

⇒ TMG-study: Similar prior across task but different between objects

- Cross-Validation → behavior prediction + prior prediction (across tasks)

NATURAL SUBSTRATES (Variability, Oscillations, Transitions)

- Motivation → DL: Get biologically plausible dynamics!



Gaussian Scale Mixture Model

Stochastic Stabilized Supralinear Network

→ Noise neural activity "noise"

Co-variates with latent vars!

↳ Amortized Inference

→ Probabilistic samples → MC!

- Interested in resulting dynamics ⇒ hand-out matching objectives

↳ anti-correlations ⇒ MCMC

Nathaniel Daw — Population Codes and Prediction Errors

- Dopamine RPE Problems:

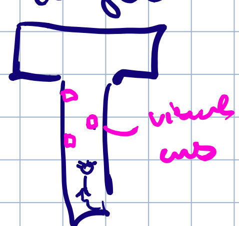
  (1) Conceptual → STATE / INPUT Representation
  ↳ often times oversimplified in simulation

  related!

  (2) Empirical → RESPONSE HETEROGENEITY
  ↳ challenges idea of scalar broadcast signal

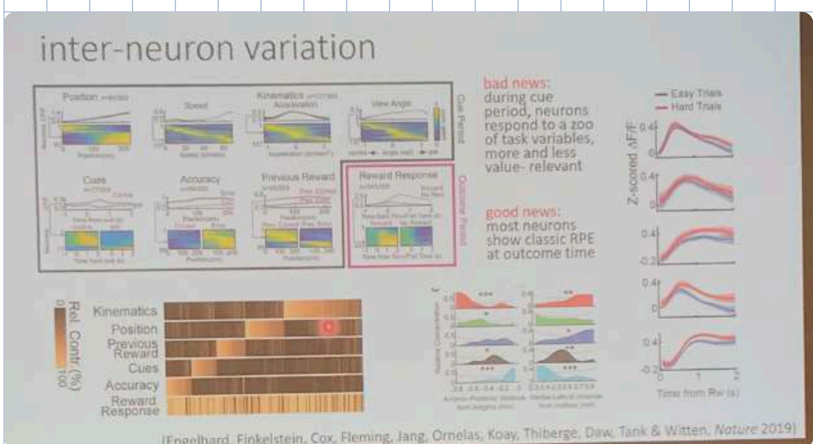
- Value / Reward ↔ Scalar
  → Utility / Decision Theory ⇒ project on line to compare!
  → Anatomical : Neuromodulators broadcast signals
  → Physiological : Averaged view ⇒ homogeneous

- Experiment T-Maze (Engelhard) ⇒ done in VR → has to integrate visual cues



  ↳ key task: Keep track on left vs. right cues!
  ⇒ Dopaminergic neurons "should be alert"!
  ↳ DA during cue period ⇒ Respond to many task variables
  DA at reward time ⇒ Classic RPE dynamics

  Problem!



$$\delta_t = r_t + \gamma V(s_{t+1}) - V(s_t)$$

changing w. cues?!

Reasons:
→ Many artifacts from VR ⇒ riders
→ Topography at each step

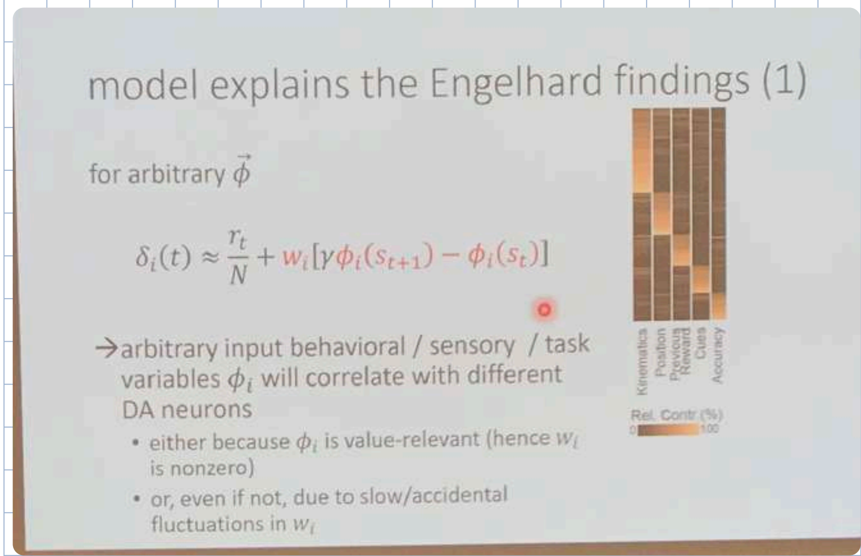
- Rewrite $V(s_t) = \phi(s_t) \cdot w$ → L. Rule: $w_i \leftarrow w_i + \alpha \phi_i(s_t) \delta_t$

↳ $\delta_t = r_t + \sum_i [\gamma V_i(s_{t+1}) - V_i(s_t)] \to \delta_{i,t}$

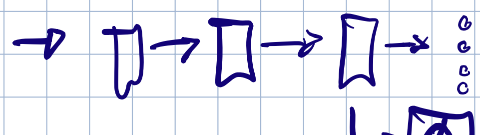
⇒ DOPAMINE NEURON PER VALUE CHANNEL

↳ Same model → different mapping!

$\boxed{\sum_i \delta_{i,t} = \delta_t}$



• Put into DQN Context:

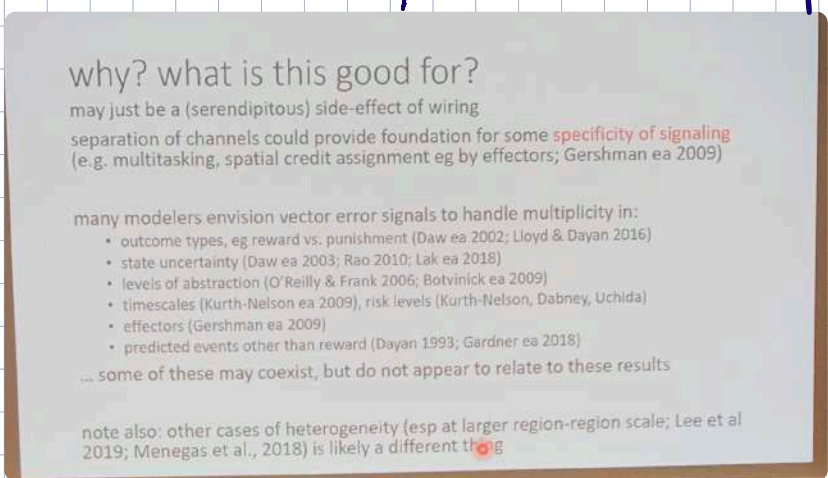


↳ $\boxed{\phi}$

→ Use to compute different "neuron"-specific RPEs

↳ RELATIONSHIP TO DISTRIBUTIONAL RL ?!

• Factorization $\sum_i \delta_{i,t}$ can lead/imply distortions



• Learning of multiple value fct.?