

Monday Meeting

06.10.25 Meeting

Paper on efficient coding in sensory pathway

- Barlow, H. B. "Possible Principles Underlying the Transformations of Sensory Messages", 2012.
- Study the efficient coding performed in the sensory pathway.
- Formulate three hypotheses to answer the question "What are sensory relays for?".

Paper on efficient coding in sensory pathway

Key takeways :

- Sensory relays are for detecting, in the incoming messages, certain "passwords" that have a particular key significance for the animal.
- They are filters, or recoding filters, whose "pass characteristics" can be controlled in accordance with the requirements of other parts of the nervous system.
- They recode sensory messages, extracting signals of high relative entropy from the highly redundant sensory input.

Password hypothesis

- Sensory messages (signals from the retina, cochlea, or skin receptors) travel through successive processing layers of neurons before higher centers (cortex).
- The transformations at each stage shape the neural representation of the world => reflect how the organism typically reacts to those stimuli.

Password hypothesis

- A neural unit or single neuron wouldn't be capable of deciding a complex behavior like whether performing an action or not in a low-level sensory area, because that area doesn't have access to all the relevant information to take a decision.
- The password hypothesis would suggest that some neurons are tuned to detect **specific combinations of features**, being the neural equivalent of recognizing a password that releases a specific behavioral response.

Controlled Pass-Characteristic Hypothesis

- Sensory pathway is not purely passive => signals from higher centers can modulate how lower sensory relays respond.
- Control of the sensory relays close to gain modulation. Not global but rather selective and specific (≠ turning the whole system on or off).
- Sensory control can increase the sensitivity to one type of stimulus or decrease the sensitivity to another similarly to feature-specific attention.

Controlled Pass-Characteristic Hypothesis

- Require feedback from higher centers to points early in the sensory pathway.
- The basic idea would be to have elements in the pathway that can change their transmission characteristics.

Redundancy-Reducing Hypothesis

- Sensory relays recode sensory messages to decrease their redundancy.
- Redundancy is reduced but comparatively little information is lost.
- Redundancy reduction in the nervous system cuts down the impulse traffic from expected messages, whereas unexpected inputs on the basis of previous experience require more impulses to stand out from the background.

Paper on Active Efficient Coding for Active Motion

- Lelais, A. et al. "Autonomous Development of Active Binocular and Motion Vision Through Active Efficient Coding", (2019).
- Autonomous model learning of active motion vision using AEC framework.
- AEC postulates that biological sensory systems do not just seek to encode the sensory input efficiently, but that they also utilize motor behaviors, such as eye movements, to further improve their coding efficiency.

Paper on Active Efficient Coding for Active Motion

- AEC studies efficient coding in the context of behavior and considers the full perception-action cycle and how the organism's behavior shapes the statistics of the sensory signals.
- AEC works by combining a sparse coding model with a reinforcement learner, which is responsible for generating actions.

Future experiment with piezo-sensor and tactile chip

- Perform finger sweep on ≠ texture patterns.
- Fixed texture, material and force but ≠ sweep velocities.
- Record tactile data for texture recognition.

TO-DO List

- Read more about Active Efficient Coding.
- Understand Christian's paper and toolbox.
- Structure PhD plan.