

Purkinje cells (PCs) exhibit increased firing rates with STP, suggesting facilitation enhances their excitability. Basket cells and Deep Cerebellar Nuclei neurons (DCN, both *\_P* (projecting) and *\_I* (inhibitory)) exhibit reduced firing rates when STP is present, indicating synaptic depression reduces activity over time. Also the Inferior Olive neurons (IO) show a significant increase in their mean firing rate of IO stimulus when introducing STP.

## Discussion

The results show the significant impact of STP in terms of signal propagation. Future work will explore the combination of STP-LTP which operate on two different time scales and their interactions in sensorimotor loops during motor learning protocols [6, 7]. Specifically, LTP plasticity rules have been introduced on synapses at parallel fibers to Purkinje cells and parallel fibers to Molecular Layer Interneurons [6], utilizing awake version of the canonical cerebellar circuit.

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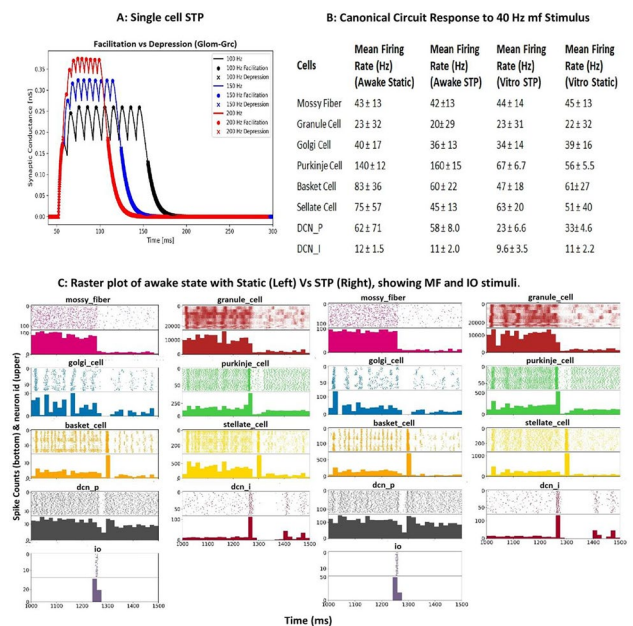
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**Figure 1:** A) Single-synapse STP dynamics, B) Canonical circuit in-vitro and awake (with STP vs static), response at step-like mf stimulus. C) Raster plot of the awake circuit (with STP vs static) with mf-IO stimulus paradigm

## P031 Adaptive Cerebellar Networks in Sensorimotor Loops

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## Introduction

Humans can generate accurate and appropriate motor behavior under many different environmental conditions [1]. Robotics is compatible for modelling this behavior, controlled by embodied human-like brain networks, along with monitorable and adjustable parameters [2] [3] [4]. To link cellular-level phenomena to brain architecture, we develop an efficient neuro-inspired controller for sensorimotor learning and control, based on specific brain neural structures and dynamics, employing a tandem configuration of forward and inverse internal models represented by cerebellar networks. Possible fall-out is simulating pathological states of patients with cerebellar-related movement disorders and predicting outcomes of neuro-rehabilitative treatments.

## Methods

The system (Fig.1A) is made of two main components, the BRAIN, represented as a system of spiking neural networks (SNNs), and the BODY, represented in Pybullet, with proper interfaces (MUSIC or NRP). The cerebellar SNNs (Fig.1B) [5], using population-specific EGLIF neuron model [6], present a structure with “agonist-antagonist” functional subsections and include proper tuned long-term plasticity rules, to achieve an adaptive and physiologically accurate cerebellar model. The computational software is the Brain Scaffold Builder (BSB) [7], interfacing with NEST.

## Results

The Long-Term Plasticities (Depression and Potentiation - LTD and LTP) have been implemented at: parallel fibers to Purkinje Cells and parallel fibers to Molecular Layer Interneurons. A Classical Eye Blinking Conditioning (CEBC) paradigm with 15 consecutive trials has been carried out to generate the learning curves in temporal association. Proper modulation of population firing rates along trials emerges (Fig.1C). The extension to an upper limb reaching task is under testing.

## Discussion

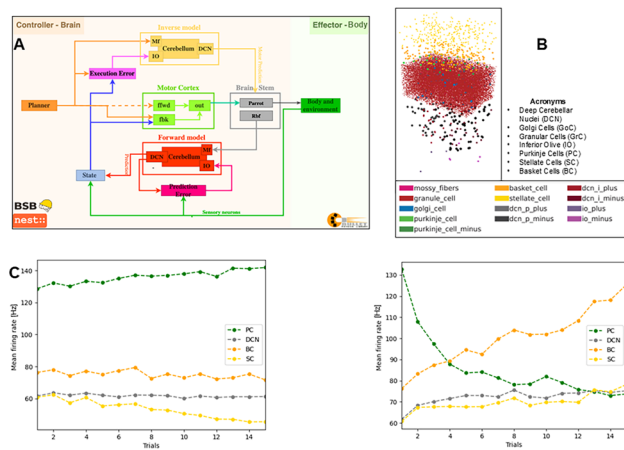
Ongoing steps include the integration of short-term plasticity synaptic models with the long-term rules, and an optimal balance between forward and inverse cerebellar blocks, for stable and effective learning. Moreover, task complexity will be increased, simulating a reaching-grasping task with object-based action. Also, an integration of more

physiological blocks (cortex and premotor cortex) is under development. Lastly, modification of the structural and functional parameters of the cerebellar modules to mimic cerebellar patients’ alterations is planned.

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**Figure 1:** A) System block diagram, divided into BRAIN and BODY sections. B) Reconstruction of the cerebellar SNN, with the different populations ("plus" and "minus" only for differentiation between agonist and antagonist, respectively). C) Firing modulation driven by long-term plasticity rules, without (left) and with (right) complex spike (teaching) stimulus.

### P032 Universal coarse-to-fine transition across the developing neocortex

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### Introduction

How cortical representations emerge in development is an unresolved problem in neuroscience. Recent work in ferret shows that during early development, spontaneous activity exhibits a modular organization that is highly similar across diverse cortical areas, from sensory cortices to higher-order association areas [1]. Moreover, this modular organization persists in all areas after eye and ear-canal opening (approx. postnatal day 30), but the organization also changes, suggesting a considerable refinement over development, part of which may be area-specific [2]. It is currently unclear how this refinement unfolds on the level of local neural circuits and what mechanisms might guide this maturation.

### Methods

We examine the development of network organization across diverse cortical regions (V1, A1, S1, PPC, PFC), before (P21–24), around (P27–32) and after (P39–43) eye opening using both widefield and 2-photon in vivo calcium imaging of spontaneous activity in the ferret. To gain mechanistic insight, we employ Local Excitation/Lateral Inhibition (LELI) network models, following [3]. These models can both reproduce the modular structure of early cortical activity and account for the ability of developing cortical circuits to transform unstructured input into modular output.

### Results

We find that in both sensory and association areas, networks exhibit a highly similar pattern of changes over development: spontaneous activity is initially highly modular, i.e. strongly correlated and low-dimensional in local populations, becoming less correlated and higher-dimensional with age. These in vivo changes can be explained by a developmental increase in lateral inhibition strength in a LELI model. This allows feedforward inputs to engage a larger number of network states, consistent with the transition of cortical networks to external sensory activity during this period. Moreover, the increase in inhibition predicts a decrease in modular wavelength over this same developmental time, which we confirm in our experimental data.

### Discussion

Our findings indicate that the spontaneous activity in ferret cortex undergoes a developmental reorganization from coarser to finer-scaled organization, accompanied by a transition to more high-dimensional activity in both sensory and association areas. We propose that an increase in lateral inhibition serves as a common mechanism underlying cortical network refinement, and that this maturation leads to the expansion of representational capacity throughout the developing cortex.

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