MSc in Computational Cognitive Neuroscience

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Modelling "free will" (or the lack thereof) in the cortex

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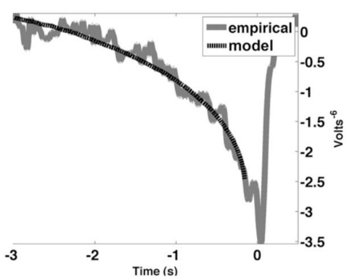
Introduction

The "Readiness Potential" (RP) or "Bereitschaftspotential" is a slow negative potential in EEG recordings preceding voluntary movement which has traditionally been interpreted as the preparation to perform an action (Kornhuber and Deecke ,1965).

An alternative proposal, termed "the stochastic account", is that the RP is the result of random noise accumulating within neural motor circuits, and that the full "ignition" of such circuits determines - as opposed to being the result of - a "free" decision to act (Schurger, Sitt, and Dehaene, 2012).



(Schurger, Sitt & Dehaene, 2012)

Prior research focused on where the RP emerges and under what conditions (Shibasaki and Hallett, 2006), but until Garagnani and Pulvermüller (2013) there had not been a focus on how or why it emerges in the areas that it does.

This approach found that random noise was required for the spontaneous emergence of voluntary action, manifesting as "ignition" of cortically distributed Cell Assembly (CA) circuits (Garagnani & Pulvermüller, 2013). This is inline with the stochastic account, and offers an opportunity to explore the RP profile and the activity that precedes its emergence which would not be possible in humans.

Aims

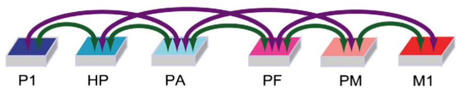
- Investigate variability in onset time and amplitude of the RP, as observed in humans
- Investigate subthreshold activity to look for partial activations of the learnt patterns and their effect on the emergence of a decision to act if any

Research Question

- What model parameters influence the emergence and behaviour of the decision to act and how exactly?
- Can the system exhibit a stable/steady state where subthreshold activity of CA circuits is consistently observed?

Materials

The model comprises 6 areas of neuronal pools: primary perceptual (P1), higher perceptual (HP), perceptual association (PA), prefrontal (PF), premotor (PM), primary motor (M1).

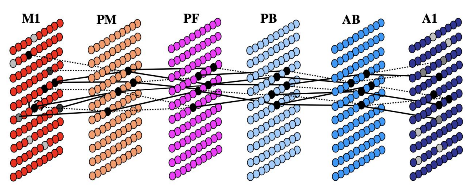


(Garagnani & Pulvermüller, 2013)

These contain both excitatory and inhibitory cells that represent cortical columns. Both lateral and area-specific inhibition are included to moderate excitatory behaviour, along with neuronal adaptation of the firing threshold. Firing rate is derived from the membrane potential.

Method

The model is trained via Hebbian learning with 12 patterns, which emerge as Cell Assemblies (CAs) spanning the entire network.

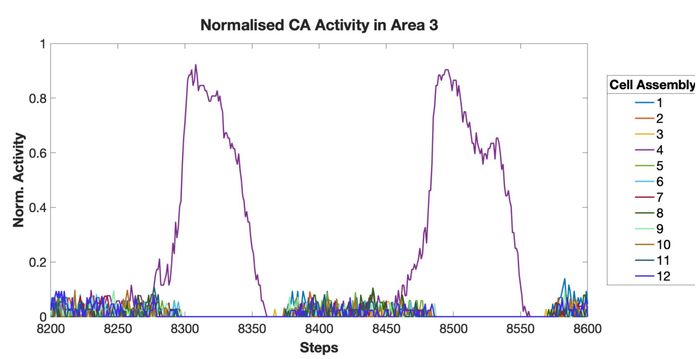


(Garagnani, Wennekers & Pulvermüller, 2009)

These CAs spontaneously ignite simply as a result of noise in the network (simulating baseline neuronal firing). Each CA ignition is taken as a model correlate of the RP.

The RP will be extrapolated from the membrane potentials of CA circuits that have reached an activity threshold. Subthreshold CA activity will be investigated across CAs in the build-up towards activation.

Initial Observations



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