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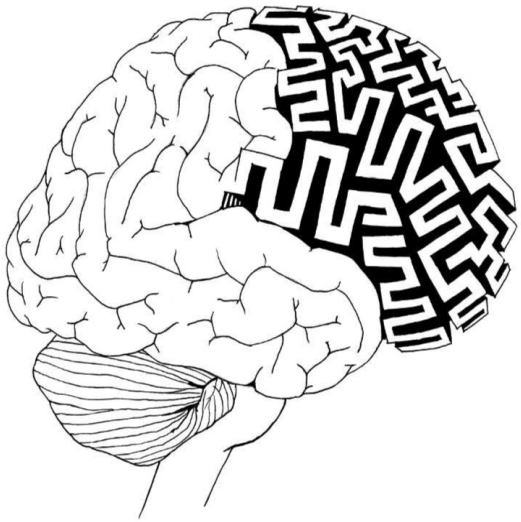

HOW DO DISTINCT NEURONAL SUBPOPULATIONS IN THE CENTRAL AMYGDALA SHAPE THE FEAR RESPONSE? — A COMPUTATIONAL MODEL

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During a typical fear conditioning experiment a neutral stimulus is paired with a fearful one and after several trials the former acquires aversive properties. Such learning can be suppressed by repeated presentations of the initially neutral stimulus alone (fear extinction). The critical brain structures involved in these fear related processes are the lateral (LA), the basal (BA) and the central (CeA) nuclei of the amygdaloid complex. The CeA is a striatum-like structure containing almost exclusively GABAergic neurons [1]. It is known to be the major output nucleus of the amygdala and to control the fear response by its projections to the brainstem and hypothalamus.

To understand the interactions between the lateral (CeL) and medial (CeM) subdivisions of the CeA during fear conditioning and fear extinction, we built a spiking neuron network model of the CeA using the NEST simulator [2]. We modeled the CeA as a feedforward dis-inhibitory circuit, based on known anatomical and electrophysiological data. The input to the CeA was controlled by two distinct, fear and extinction specific neuronal subpopulations within the BA [3,4]. These inputs were crucial, as they altered the states of different subgroups within the CeA.

With our model we provide first insights about possible computations performed by the CeA. In particular, we show how CeL and CeM neurons might process fear and extinction related activity of the BA in order to shape the fear response.

Acknowledgements

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AN ONLINE BRAIN-MACHINE INTERFACE USING DECODING OF MOVEMENT DIRECTION FROM THE HUMAN ELECTROCORTICOGRAM

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Brain-machine interfaces (BMIs) can be characterized by the approach used to translate brain signals into effector movements. Here we use a “direct motor” BMI approach where movements of an artificial effector (e.g. movement of an arm prosthesis to the right) are controlled by motor cortical signals that control the equivalent movements of the corresponding body part (e.g. arm movement to the right). This approach has been successfully applied in monkeys and humans by accurately extracting parameters of movements from the spiking activity of multiple single-units. Here we show that the same approach can be realized using brain activity measured directly at the surface of the human cortex (electrocorticogram, ECoG).

Three subjects suffering from intractable pharmaco-resistant epilepsy voluntarily participated in the study after having given their informed consent (study approved by the Freiburg University Hospital's Ethics Committee). As a part of pre-surgical diagnosis all subjects had 8x8 ECoG grid implants (4 mm electrode diameter, 10 mm inter-electrode distance, Ad-Tech Medical Instruments, USA) over the hand and arm motor cortex. Subjects interacted with an experimental paradigm shown on a computer screen. Each trial consisted of a pause phase (1-2 sec) followed by a preparatory informative cue (1-2 sec) which informed the subject to prepare for executing or imagining a hand/arm movement to the left or to the right using the hand contralateral to the implantation site. After a delay of 2-3 sec, a go cue was presented and subjects had to perform the movement execution or imagination within the next two seconds. Subsequently, a cursor on the screen was moved according to the movement direction decoded from the subjects’ ECoG signals.

Closed loop BMI control of movement direction was realized using low-pass filtered (symmetric Savitzky-Golay filter, 2nd order, between 0.25 and 1 sec window length) ECoG signals during movement execution or movement imagination. For movement execution significant BMI control was achieved for all three subjects in all 7 sessions with correct directional decoding in 69%-86% of the trials (79% on average across all sessions). Movement imagination was carried out with only one subject where 3 out of 4 sessions showed significant BMI control with correct decoding in 66%-72% of the trials (69% on average).

In summary, our results demonstrate the principle feasibility of an online direct motor BMI using ECoG signals. Thus, for a direct motor BMI, ECoG might be used in conjunction or as an alternative to the intra-cortical neural signals, with possible advantages due to reduced invasiveness.

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