Dynamic cortical and nucleus accumbens networks in humans: Combining intracranial and EEG recordings

ABSTRACT:

Background
Deep-brain stimulation (DBS) is being increasingly used to treat medication resistant neurological and psychiatric diseases. However, the cognitive effects of DBS are not well understood.

Aim of the study
To determine the effects of DBS to the human nucleus accumbens (NAc) on cognitive function.

Method
During the project period, 11 patients (10 with obsessive-compulsive disorder and 1 with major depression) underwent bilateral implantation of DBS electrodes. Intra-operatively, we recorded single-unit activity from the NAc during an auditory oddball task. Post-operatively, patients performed 3 behavioural tasks, with NAc DBS (130Hz, 3.5V, 60μs pulse-width) applied at 2 intervals during the task (On/Off design). In the third study, we simultaneously acquired scalp electroencephalography (EEG) recordings.

Results & Conclusion
Intra-operative recordings - Different forms of salience evoke a change in human NAc single neuron firing rate, at a latency ~200 ms. *Risky decision-making* - We found that NAc DBS disrupts the normal relation between probability of reward and choice in 4 patients, resulting in a shift towards more risk seeking behaviour. *Memory encoding* - In all 6 patients tested, we found that NAc DBS during encoding of images increases the probability that these images will be later recognised. The magnitude of this memory enhancement predicts memory improvement in a neuropsychological test of verbal memory after 2 months of chronic DBS. *Target detection during sustained attention* - In 6 patients tested with the AX-type continuous performance task (AX-CPT), NAc DBS evoked a reduction of total numbers of errors in the ON relative to OFF state. In the EEG, NAc DBS produced an increase in the distribution of sources generating the P3 potential during Go trials. NAc DBs has profound effects on cognitive function.

Keywords
Deep-brain stimulation, Intracranial recordings, Nucleus accumbens, Electroencephalogram (EEG)

Published Work:

Méndez-Bértolo, C., Moratti, S., Toledano, R., Lopez-Sosa, F., Martínez-Alvarez, R., … Strange, B. (2016). A fast pathway for fear in human amygdala. *Nature Neuroscience, 19*(8), 1041-1049. doi:10.1038/nn.4324

Nachev, P., Lopez-Sosa, F., Gonzalez-Rosa, J., Galarza, A., Avecillas, J., ..., Strange, B. (2015). Dynamic risk control by human nucleus accumbens. *Brain, 138*(12), 3496-3502. doi: 10.1093/brain/awv285

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