Automated Algorithm for Synchronized Quantification of LFP Recordings and Individual Behavioural Parameters in an Animal Model for OCD

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1 OBJECTIVES

The knowledge on the origin of local field potential (LFP) signals is making progress (Buzsaki et al., 2012). To prove the clinical relevance of recording LFP signals, synchronous comparison with pathological behavioural parameters in animal models for diseases is essential. This work describes an algorithm, which is developed for automated analyses of LFP recordings and behavioural parameters in freely moving rats. Several studies showed the advantages of behaviour monitoring with video recordings (e.g. Zarringhalam et al., 2012), but there are limited studies describing correlations between neural and behavioural recordings for freely moving rodents (Venkatraman et al., 2010; Fan et al., 2011). Here, we present the algorithm applied on a rat model for OCD (schedule-induced polydipsia, SIP; Falk, 1961; Moreno and Flores, 2012). The algorithm allows to extract detailed behavioural parameters based on images of a top view camera. Changes during the disease conditioning period can be tracked and correlated with synchronously measured changes in the LFP recordings. We believe that such automated algorithms can highly contribute to a deeper understanding of recorded LFPs and their link with pathological behaviour of individual animals.

2 MATERIALS AND METHODS

2.1 Animal Conditioning

Electrodes (twisted bipolar platinum electrode, single strand diameter: 0.203mm, part number E363/8-2TW, PlasticsOne) were implanted in the bed nucleus of the stria terminalis (BNST) bilaterally in one Wistar rat before SIP conditioning. After three days of recovery the conditioning commenced. During SIP conditioning, the rat received food pellets under a fixed-time schedule each day, and gradually developed compulsive drinking behaviour (Moreno and Flores, 2012). A sampling rate of 10000 samples/s was used for all LFP recordings during conditioning.

2.2 Image Analysis

A webcam (Logitech HD Webcam Pro C910) was fixed on top of the conditioning cage to record the rat behaviour during conditioning (sampling rate: 15 images/s). The processing of the images consisted of three main steps: (i) *Cage detection*: Based on colour properties of the cage floor (dark brown-black), the shape of the cage and the exact locations of drinking and feeding tube were first extracted. (ii) *Rat detection:* Rats could be recognised using a specific threshold for (approximately) white pixel values, which represent the rat. After fixing the threshold to distinguish between rat and background, a binary image was obtained. For each video sample, the threshold was automatically recalculated based on the expected size of the rat to deal with changes of recorded light intensities. (iii) *Quantification of behavioural parameters:* Based on the rat detection, four behavioural parameters were determined: rat location in cage (in x- and y direction), drinking behaviour (0 or 1), eating behaviour (0 or 1), and walking patterns (i.e. correlation of changes in x- and y- direction). All image processing steps were executed in Matlab using the Image Processing Toolbox.

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2.3 LFP Analysis

After band-pass filtering (0.1-300 Hz), detrending and noise cancellation, the power of specific bandwidths was calculated using the fast Fourier transform algorithm of Matlab. To create a direct link between brain signal and the individual animal in the graphical interface, these power calculations were afterwards used for replacing the white colour of the rat with a colour on a cold-hot scale: for high powers, the rat was represented in dark red and for low powers the rat was represented in dark blue.

3 RESULTS

The developed algorithm required two inputs: a top view video of the cage in .avi format and a simultaneously recorded LFP signal. The average time (+-standard deviation) needed by the algorithm to analyse the video- and LFP recordings is 0.14s (+-0.015s), which implies that the developed algorithm could be used for real-time monitoring. The accuracy of the rat detection was tested based on a video of 20 minutes, which was not used for algorithm training. In all samples of the test video the rat could be correctly detected. Figure 1 shows the output of the algorithm. The feeding tube and the drinking tube are marked. The colour of the rat corresponds to the power of the LFP in a specific bandwidth, which can be selected by the user (e.g. the delta band in figure 1).Using this graphical representation, one can easily visualize correlations between behaviour (image at time t) and LFP recordings (signal of a one second time interval [t-1, t]).

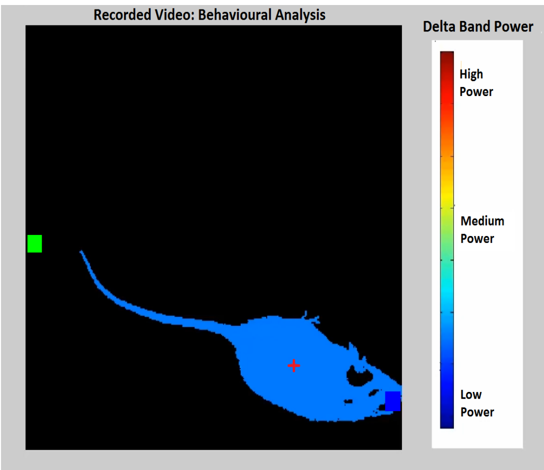

Figure 1: Output of the automated LFP-video algorithm. Location of food magazine (green) and water bottle (blue) are shown by rectangular. The rat is represented in a colour, which corresponds to the power of a specified frequency band (e.g. delta band power of the left hemisphere).

4 DISCUSSION

The developed algorithm presents an attractive way to synchronize, visualize and analyse LFP data with simultaneously recorded behavioural video data. The algorithm allows to gain insight in neuronal recordings, to assess animal model validity (e.g. Nestler and Hyman, 2010) and to quantify severity of disease in individual animals (e.g. Hooks et al., 1994). It is expected that such automated comparison of synchronised video- and LFP-recordings could substantially contribute to finding potential neurological biomarkers of psychiatric disorders.

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