A Wireless System for Long-Term Biopotential Recording from Individual or Group-Housed Rats

Erik Naylor, David A. Johnson, Seth Gabbert, Hans Harmon, Eric L. Akers, Chris Jubic, Daniel V. Aillon, Donna A. Johnson, & Peter A. Petillo
Pinnacle Technology Inc., Lawrence, KS, USA

Abstract

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We have developed two wireless telemetry systems for use with rats. One is designed for long-term, wireless recording of electroencephalograph (EEG) and electromyograph (EMG) signals (EEG/EMG) while the second is capable of recording EEG, EMG, and simultaneous biosensor readings (EEG/EMG/BIO). Both systems are capable of recording individual animals or multiple rats within a group housed environment.

Several systems have been described that are capable of telemetry-based recording of EEG and EMG signals. However, none of these systems have been used to record EEG & EMG data simultaneously from multiple animals within a group housed environment, a condition which reduces related stress, nor are they capable of recording simultaneous biosensor measurements.

We have tested the ability of these systems to wirelessly record EEG and EMG signals under both single and group housed conditions. We further tested the second system by simultaneous recording EEG, EMG and extracellular lactate concentrations using a biosensor from a single rat.

Methods

• Three young (age 3-4 months) Sprague Dawley rats were surgically implanted with cortical EEG recording electrodes and EMG leads placed in the nuchal muscles. One rat was also implanted with a guide cannula designed for biosensor insertion positioned in the prefrontal cortex (AP=+3.2, M/L= -0.8, D/V = -4.5).

• All rats were fitted with a plastic recording enclosure which was secured on the head of the animal and designed to protect the electronics, battery and biosensor (Figure 1a).

• Rats were group housed and placed on a 12 hour light 12 hour dark cycle persisting throughout the experiment. After surgery, rats were individually housed for one week to allow for recovery.

• To test the EEG/EMG telemetry system, two rats were recorded in their home cages for 24 hours then both rats were placed within group housing and EEG/EMG data was continuously collected for an additional 24 hours.

• To test the EEG/EMG/BIO telemetry system, a lactate sensor was inserted into the single rat implanted with a biosensor cannula (Figure 1b). Biosensors use an active enzyme layer that reacts with a specific analyte, in this case lactate, to provide instantaneous, in vivo measurement of extracellular concentration changes.

• EEG, EMG and continuous extracellular lactate concentration were recorded in a single rat over a complete light/dark cycle.

Results

• Recordings using the EEG/EMG system demonstrated that, under group housing conditions, the sleep/wake cycles of both rats became more correlated (Figure 2).

• During group housing, similar wake epochs between rats increased 27% and the number of similar sleep epochs increased 3% (Table 1).

Table 1: Comparison of wake and sleep epoch scores at the same time marker between rats under differing housing conditions.

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<th>Single housed</th>
<th>Group housed</th>
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<tbody>
<tr>
<td>WAKE</td>
<td>2635</td>
<td>3358</td>
</tr>
<tr>
<td>SLEEP (SWS + REM)</td>
<td>2395</td>
<td>2470</td>
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Figure 3: Hypnogram depiction of sleep wake cycles of two rats under individually housed conditions (left) followed by group housing within the same home cage (right). W: Wake, S: slow wave sleep, R: REM sleep. The lower trace indicates light/dark cycles with each colored section representing 12 hours of light (yellow) or 12 hours of dark (black).

Figure 4: Rat in home cage with wireless EEG/EMG/BIO unit and attached battery.

Figure 5: Baseline sleep data and simultaneous lactate concentration changes wirelessly recorded from a rat during a complete light/dark cycle. Dots represent individual sleep epochs and color coding represents sleep state (RED=Wake, BLUE=slow wave sleep, GREY=REM sleep). The Y-axis indicates alterations in lactate concentration. The bar across the bottom indicates light/dark cycling with each colored section representing 12 hours of light (yellow) or 12 hours of dark (black).

Conclusions

• Recording EEG and EMG signals from multiple animals within a group housed environment can be accomplished within a home cage environment.

• Group housed rats demonstrate greater correspondence of time awake than individually housed rats.

• Lactate concentration changes in the rat prefrontal cortex during sleep/wake states resemble those recorded in a mouse model.

• Wireless data collection of simultaneous EEG/EMG and biosensor signals is a feasible mechanism for periods lasting 24 hours and beyond.

References


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