

Combined use of the PhenoTyper® and accelerometer for activity and sleep pattern categorisation

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Rationale

Sleep pattern analysis requires the recording of both EEG and EMG in order to categorise different sleep stages; however the EMG recording has technical problems due to anatomical and physiological limits of the animals. Therefore, a more tailored alternative would be beneficial for an accurate categorisation of sleep stages. The PhenoTyper® system provides useful information of gross locomotor activity in a free moving animal in its home cage [1]. However, the software (EthoVision 3.0) only detects robust changes of the body point centre, and it does not record fine movements (such as small head accelerations) during the stationary phase. The knowledge of possible subtle movements is fundamental for sleep stages categorisation as it is a hallmark to distinguish the different sleep phases and during active and quiet awake. The use of an accelerometer would provide such information [2], however limitations would occur if for instance, an animal moves with a constant velocity, moreover it does not provide information on the animal spatial location. The combined use of the PhenoTyper and an accelerometer device would provide a more robust reading of the activity of the animal, which would allow a more reliable interpretation of EEG recordings during circadian rhythms.

Methods

Twelve month old female C57BL6/j mice were anesthetized with 3% isoflurane in medical grade oxygen. After full induction of the anaesthesia gold electrodes were placed in the prefrontal cortex and left and right hippocampi. Reference ground screws were placed in the parietal and occipital regions. Electrodes in form of gold skull-screws, soldered to pins, were lowered 1-1.5 mm below the skull to touch the dura mater. Finally, the electrode assembly of seven pins was anchored and fixed to the skull. Once mice recovered from surgery, (at least 7 days post surgery) behavioural experiments took place.

Mice were connected with a wireless EEG recorder data logger with a built-in accelerometer and their activity was synchronically recorded for 1 hour during the light phase by both the PhenoTyper® (EthoVision 3.0, Noldus Information

Technology, Wageningen, The Netherlands) and the built-in accelerometer. The device would also provide EEG recordings from selected brain areas, but this was not included in the present experiment. Animals were visually observed during the test to combine the software and visually recorded data. “Active awake” and “quiet awake” status was defined by the experimenter as active awake status with high activity and quiet awake with little or no movements.

Results

During both active and quiet awake assessed by visual observation and the use of the PhenoTyper®, a correlation between the locomotor activity recorded by EthoVision and the acceleration recorded by the data logger was found (see Figure 1 and 2). Correlations was obtained during both active ($P < 0.001$, $R^2 = 0.01912$, slope = 0.5584 ± 0.09) and quiet awake phases ($P < 0.001$, $R^2 = 0.1584$, slope = 15.66 ± 0.9799). However, during the active phase, the accelerometer reached the maximal measurable acceleration as it becomes saturated whereas EthoVision continually provides linear information about the activity. During the quiet wakefulness the animal stays still but sometimes grooms, moves the head or sleeps so in this case the accelerometer is able to provide useful information in order to discriminate between different stages of quiet activity.

Conclusions

In the active phase (see figure 1), the accelerometer saturates rapidly whereas EthoVision provides complete information about the animal activity. In the quiet phase (see figure 2) there is a wide distribution of the parameters, therefore for a small range of movements the accelerometer gives a more detailed reading of small changes in activity typical of pre-sleep phases. This is fundamental for the automatic scoring analysis of sleep stages. In conclusion, the PhenoTyper® (EthoVision 3.0) allowed a gross analysis of the locomotor activity, whereas the accelerometer provided an index of fine accelerations of the head. Together the two devices offer an enriched reading of the animal’s activity allowing a more robust interpretation of the automatic recognition of the behavioural parameters and possibly sleep stages.

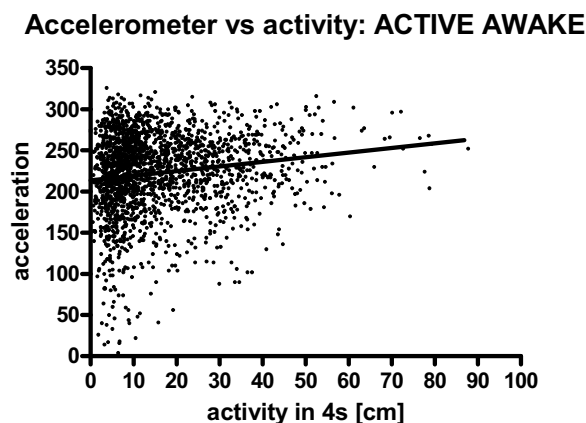


Figure 1. Linear interpolation between active activity and acceleration

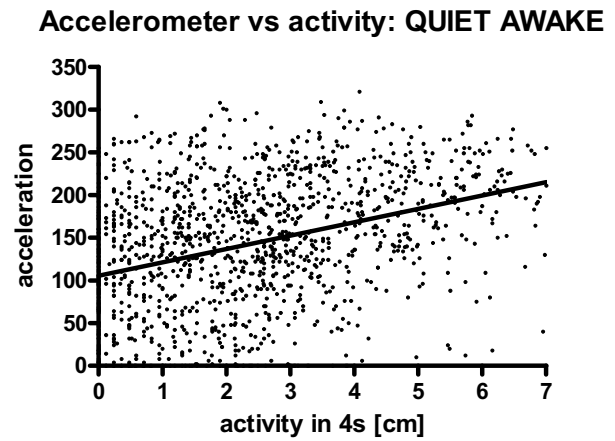
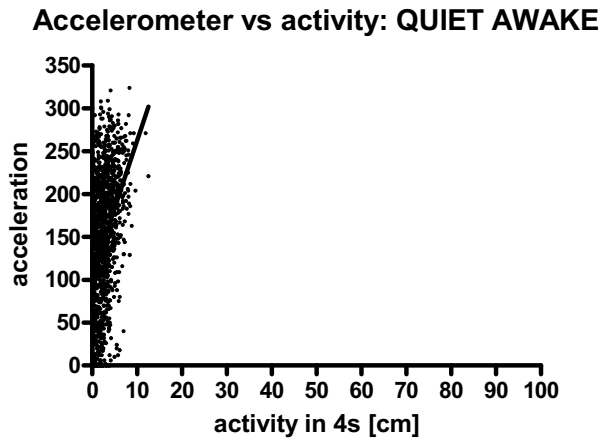


Figure 2. Linear interpolation in different scales between quiet activity and acceleration

References

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2. Sunderam S., Chernyy N., Peixoto N., Masona J.P., Weinstein S.L., Schiff S.J., Gluckmana B.J.. (2007). Improved sleep-wake and behavior discrimination using MEMS accelerometers. *Journal of Neuroscience Methods* **163**, 373-383.