

Contribution ID: 295

Type: **Oral Presentation**

## Multiscale adaptive analysis of circadian rhythms in the study of acute insomnia

*Wednesday, 11 July 2018 11:10 (20 minutes)*

Circadian analysis is becoming increasingly important as a diagnostic tool to quantify deviations from regularity in circadian cycles. Circadian rhythms become less dominant and less regular with ageing and disease. It has been hypothesized that insomnia might be related to alterations, albeit small, in circadian and ultradian rhythms, but this topic remains an open problem. In this work, we propose a novel data-adaptive technique, singular spectrum analysis (SSA), to investigate in a model-free way quasiperiodic components and noise fluctuations in time series data. SSA was applied to one-week continuous actigraphy data in young adults with acute insomnia and healthy age-matched controls [1]. The findings suggest a small but significant delay in circadian components in the subjects with acute insomnia. The ultradian components follow a fractal  $1/f$  power law for controls, however for individuals with acute insomnia this power law breaks down due to an increased variability at the 90min time scale. This is reminiscent of Kleitman's basic rest-activity (BRAC) cycles. It indicates that for healthy sleepers attention and activity can be sustained at time scale required by circumstances, while for individuals with acute insomnia this capacity may be impaired and they need to rest or switch activities in order to stay focused. Traditional methods of circadian rhythm analysis are unable to detect the more subtle effects of day-to-day variability and ultradian rhythm fragmentation at the specific 90min time scale.

[1] R Fossion, AL Rivera, JC Toledo-Roy, J Ellis and M Angelova. Multiscale adaptive analysis of circadian rhythms and intradaily variability: Application to actigraphy time series in acute insomnia subjects. *PLOS One*, 12(7): e0181762 (2017).

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**Session Classification:** Human physiology

**Track Classification:** Human Physiology