SUPPLEMENTARY ONLINE MATERIAL

Circadian Regulation of Sleep in *Drosophila*: Insights from a Two-Process Model

Lakshman Abhilash, Orie Thomas Shafer[#]

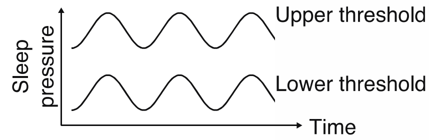
The Advanced Science Research Center, The City University of New York; The Graduate Center at the City University of New York

Running title: Drosophila two-process model

[#]Correspondence: oshafer@gc.cuny.edu

Step 1: Fix the amplitude of circadian oscillation of the thresholds and distance between them based on values reported in Daan et. al., 1984 which show bi-phasic sleep.

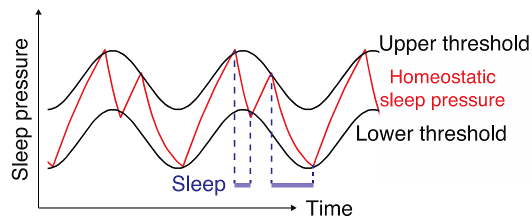
Step 2: Fix the τ of the circadian clock at 24-h.



Loop 1: Vary build-up of sleep pressure (from 0 to 0.4)

Loop 2: Vary release/decay of sleep pressure (from 0.5 to 1)

Step 3: For each combination of build-up and release of sleep pressure create the homeostatic component of the model.



Step 4: Perform periodogram analyses and calculate % time spent sleeping for each such model.

Step 5: Compare these values with behavioral data to get an estimate of fit (SSD).

end loop

end loop

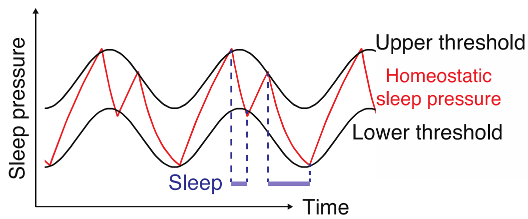
Step 6: Find out which combination of sleep pressure build-up and release have minimum SSD.

Suppl. Figure 1: Sketch of the algorithm used for generating a two-process model for fly sleep.

Step 1: Fix the amplitude of circadian oscillation of the thresholds and distance between them based on values reported in Daan et. al., 1984 which show bi-phasic sleep.

Step 2: Fix the rates of build-up and release of sleep pressure as identified from Fig. 2.

→ Loop 1: Vary free-running period of the clock (from 15 to 32-h)

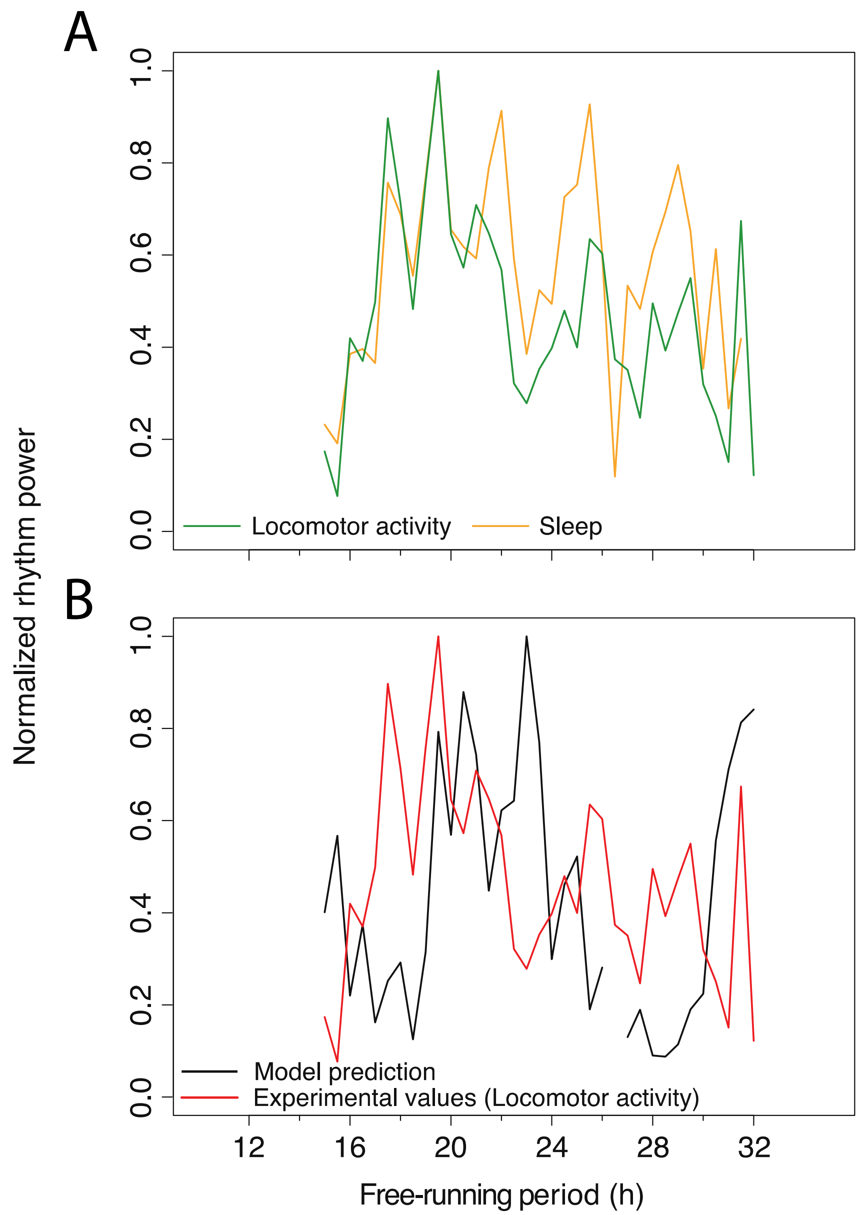


Step 3: In case of the model generated for each period value perform periodogram analyses and calculate % time spent sleeping.

end loop

Step 4: Generate plots to compare predictions from Step 3 and behavioral data for sleep.

Suppl. Figure 2: Sketch of the algorithm used for generating predictions from a two-process model with different free-running periods of the C-process.

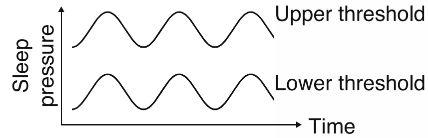


Suppl. Figure 3: (A) Median power of locomotor activity and sleep rhythms for flies with different free-running periods. (B) Median power of sleep rhythms across the entire range of free-running periods overlayed with the predictions of the two-process model when only the free-running period was altered in the model.

Step 1: Fix the amplitude of circadian oscillation of the thresholds and distance between them based on values reported in Daan et. al., 1984 which show bi-phasic sleep.

→ Loop 1: Vary τ of the circadian clock (from 15 to 32-h)

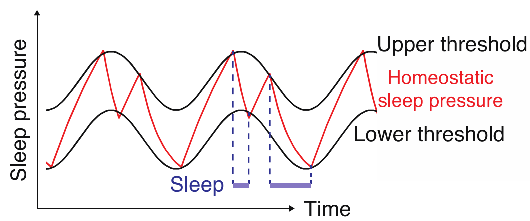
Step 2: Generate threshold oscillations for each free-running period.



→ Loop 2: Vary build-up of sleep pressure (from 0 to 0.4)

→ Loop 3: Vary release/decay of sleep pressure (from 0.5 to 1)

Step 3: For each combination of build-up and release of sleep pressure create the homeostatic component of the model.



Step 4: Perform periodogram analyses and calculate % time spent sleeping for each such model.

Step 5: Compare these values with behavioral data to get an estimate of fit (SSD).

Step 6: Find out which combination of sleep pressure build-up and release have minimum SSD.

end loop

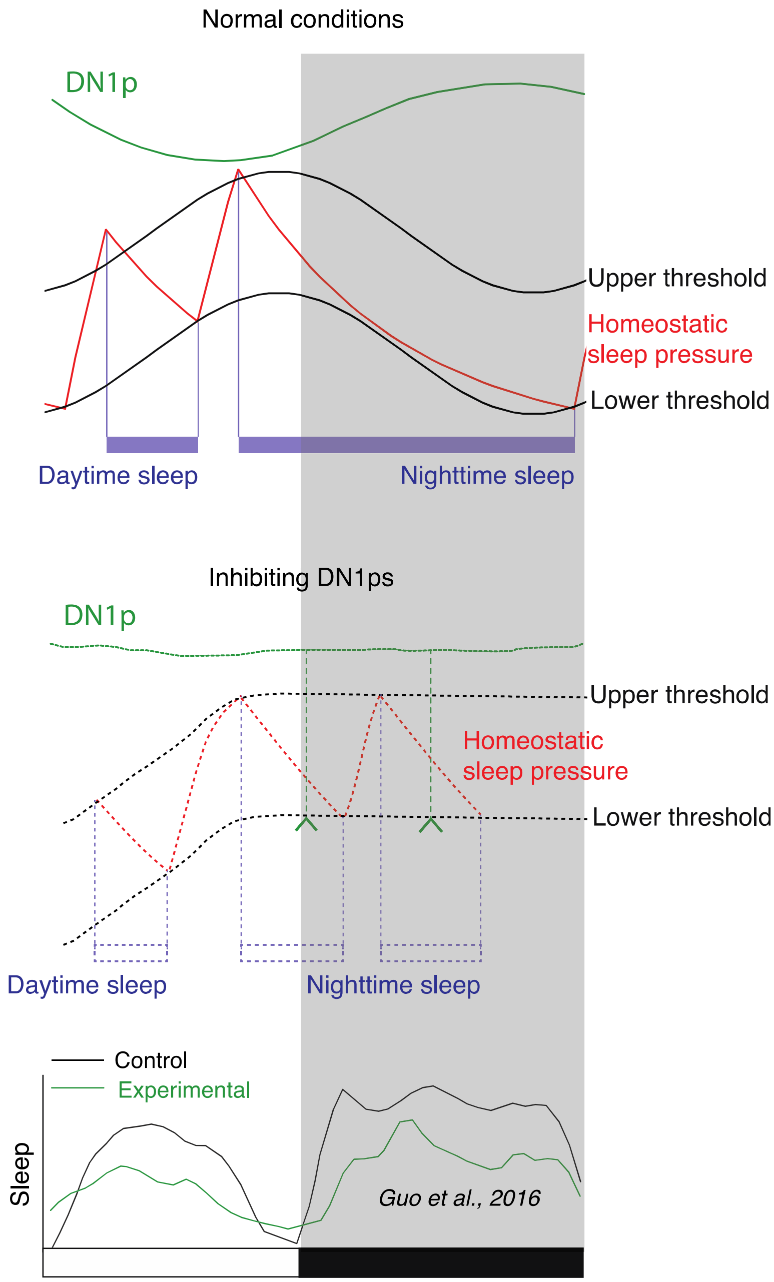
end loop

Step 7: Store the best-fitting sleep pressure parameters for each period value.

end loop

Step 8: Generate plots to compare predictions from Step 7 and behavioral data for sleep across different free-running periods.

Suppl. Figure 4: Sketch of the algorithm used for generating predictions from a two-process model with different free-running periods of the C-process when the S-process parameters were also allowed to change.



Suppl. Figure 5: A schematic representation of the effect of the inhibition of synaptic transmission from the DN-1ps on sleep. We assume that inhibiting synaptic transmission of the DN-1ps will mimic the inhibition of DN-1p activity. As a consequence, reduced DN-1p output during the day (dotted green line), the sleep thresholds of the two-process model will not fall throughout the night and would remain high (black dotted lines). Such a manipulation is predicted to lead to an altered pattern of sleep pressure changes (dotted red line) that would result in the reduction and fragmentation of sleep (dotted blue bounded boxes). Such effects of inhibiting synaptic transmission in the DN-1ps were indeed reported previously (bottom panel; Guo et al., 2016; [1]). The schematic of behavioral sleep data is redrawn from Guo et al. (2016) [1] – green line represents the experimental flies and black line represents control flies.

References

[1] Guo F, Yu J, Jung HJ, Abruzzi KC, Luo W, Griffith LC, et al. Circadian neuron feedback controls the Drosophila sleep-activity profile. Nature 2016;536. https://doi.org/10.1038/nature19097.