Defining and Measuring Drowsiness

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Definition of Drowsiness

- Assume that drowsiness is related to the chance of the occurrence of a slow response or non-response to a stimulus.

$$D(t) = P(\tau(t + \epsilon) > \tau_{thr})$$

τ: response time (RT)

τ_{thr}: a set threshold that determines a long RT

ϵ: the duration from the current time to the upcoming stimulus

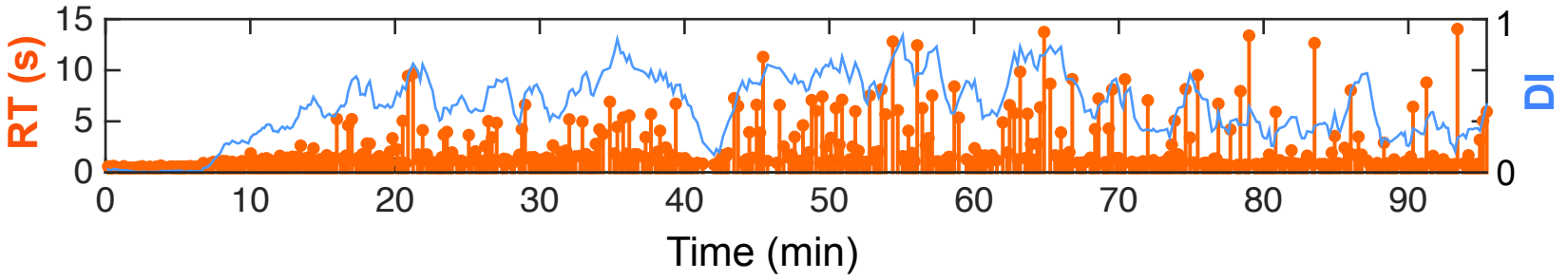
Drowsiness Index

- In a sustained attention task (e.g. lane-keeping task), RT is measured discretely across time. The discrete form of drowsiness is expressed as:

$$D[n] = P(\tau[n+1] > \tau_{thr})$$

- A drowsiness index (DI) is designed for tracking the slow-response probability.

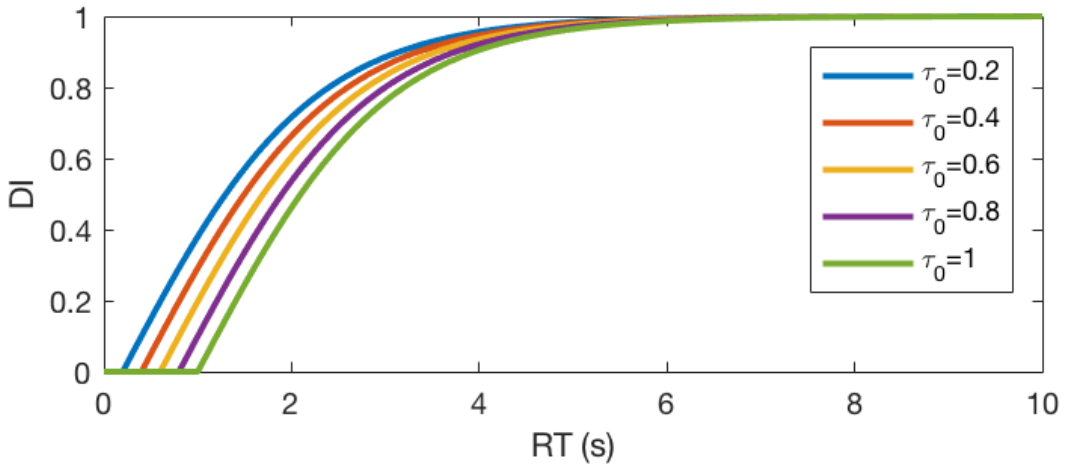
$$x[n] \approx P(\tau[n+1] > \tau_{thr} \mid x[n])$$



Extracting DI from RT data

- Normalization $x[n] = max\left(0, \frac{1 - e^{-a(\tau[n]-\tau_0)}}{1 + e^{-a(\tau[n]-\tau_0)}}\right)$

  τ_0 is the RT in the alert state



- Smoothing $\bar{x}[n] = \frac{1}{M}\sum_m x[m]$

  m belongs to the trials occurs within the time window [-*w*, 0] of the current trial *n*.

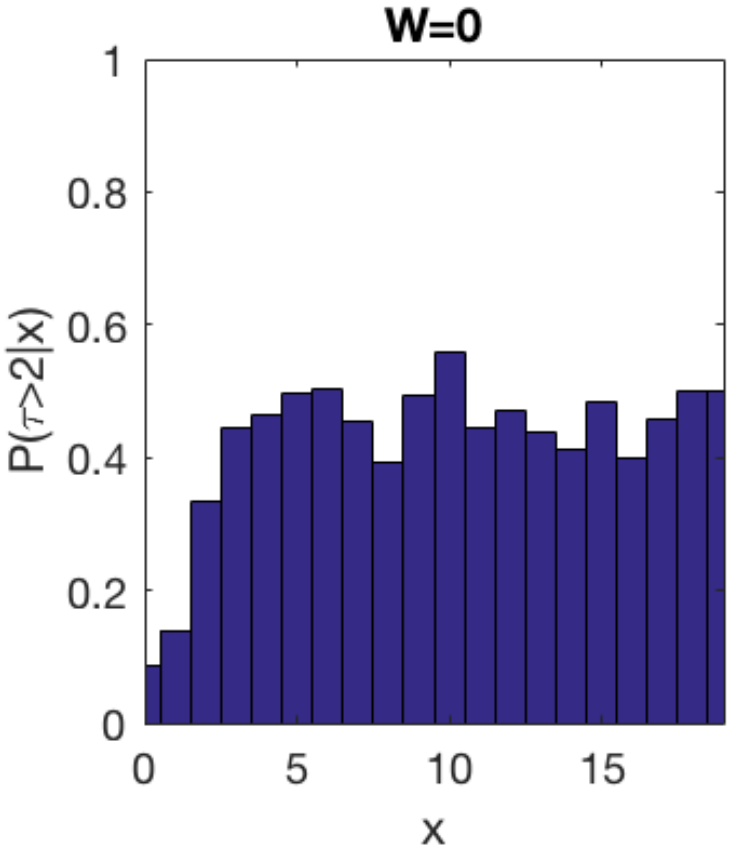
Validating the DI

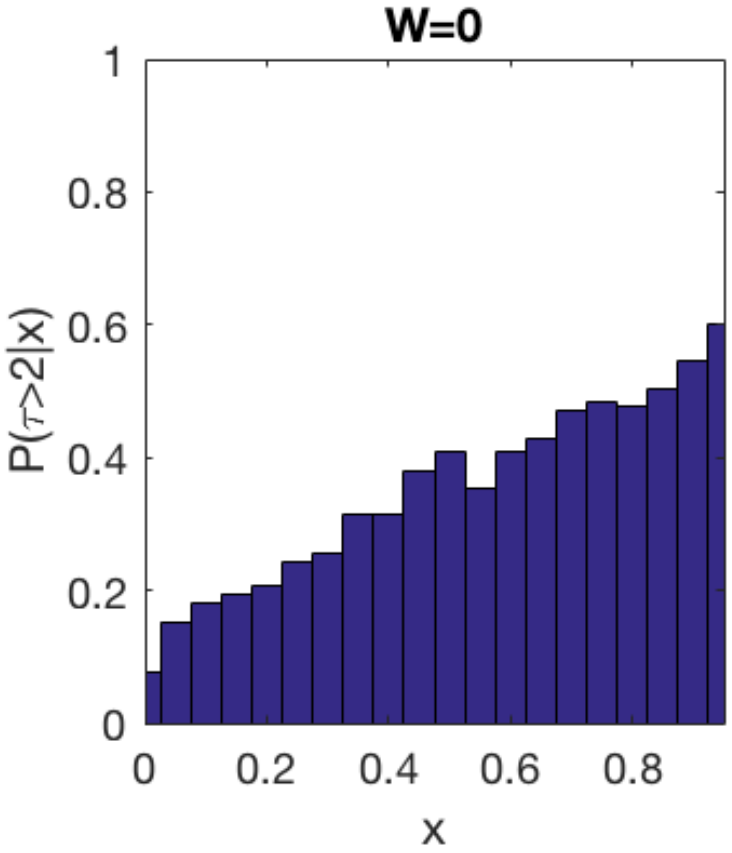
- Estimating the slow-response probability

$$P(\tau[n+1] > \tau_{thr} \mid 0 \le x[n] < 0.1)$$

$$= \frac{number\ of\ trials\ at\ [n+1]\ with\ \tau > \tau_{thr}\ given\ 0 \le x[n] < 0.1}{number\ of\ trials\ at\ [n+1]\ given\ 0 \le x[n] < 0.1}$$

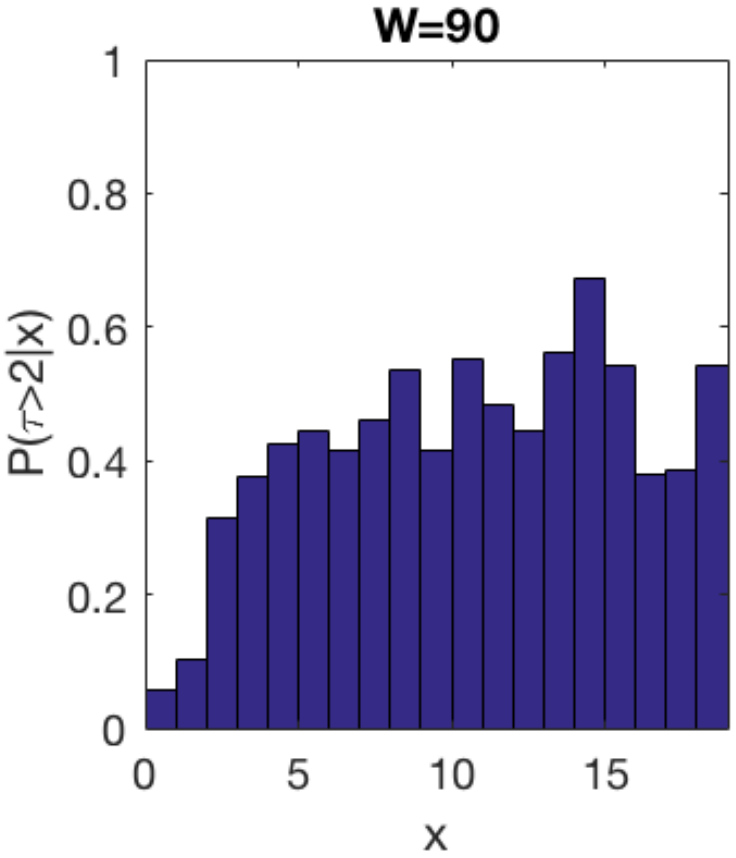
- Data: NCTU LKT Dataset (79 session)

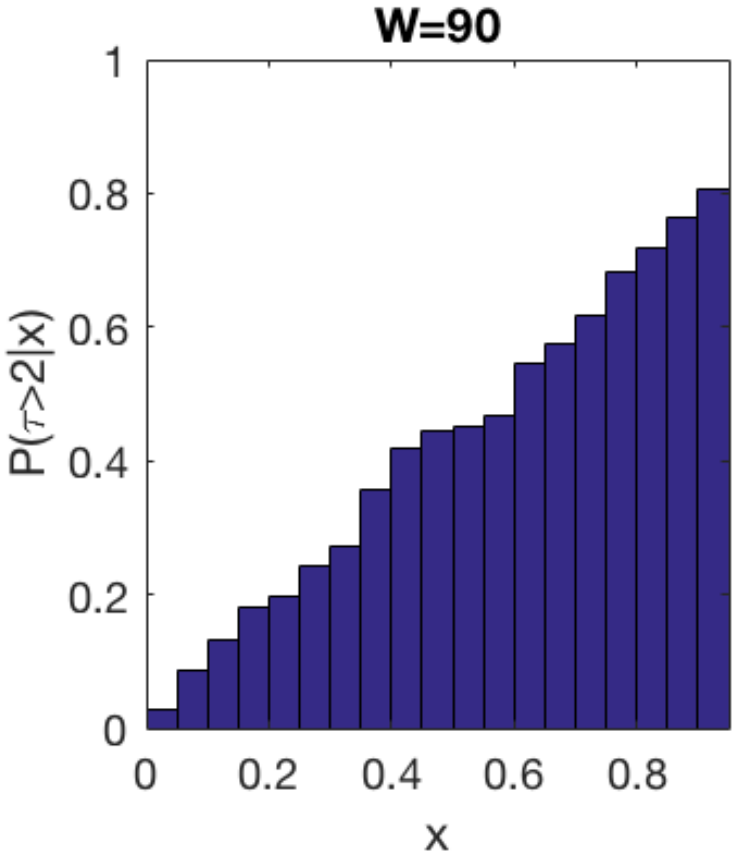




$$x[n] = \tau[n]/\tau_0$$

$$x[n] = max\left(0, \frac{1 - e^{-a(\tau[n]-\tau_0)}}{1 + e^{-a(\tau[n]-\tau_0)}}\right)$$





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