

Defining, Measuring, and Predicting Fatigue

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Fatigue Operationally Defined ...

- Fatigue is operationally defined ...
 - Subjectively by self-report, e.g., “I am tired.”
 - Karolinska Sleepiness Scale (KSS)
 - Samn-Perelli Fatigue Scale
 - Objectively by degraded performance, for instance
 - Psychomotor Vigilance Task (PVT)
 - FOQA-derived metric
- Fatigue is unmasked by increasing time on task
- Qantas simulator-based fatigue study
 - When fatigued better at detecting errors
 - When fatigued worse at managing errors

Fatigue a function of....

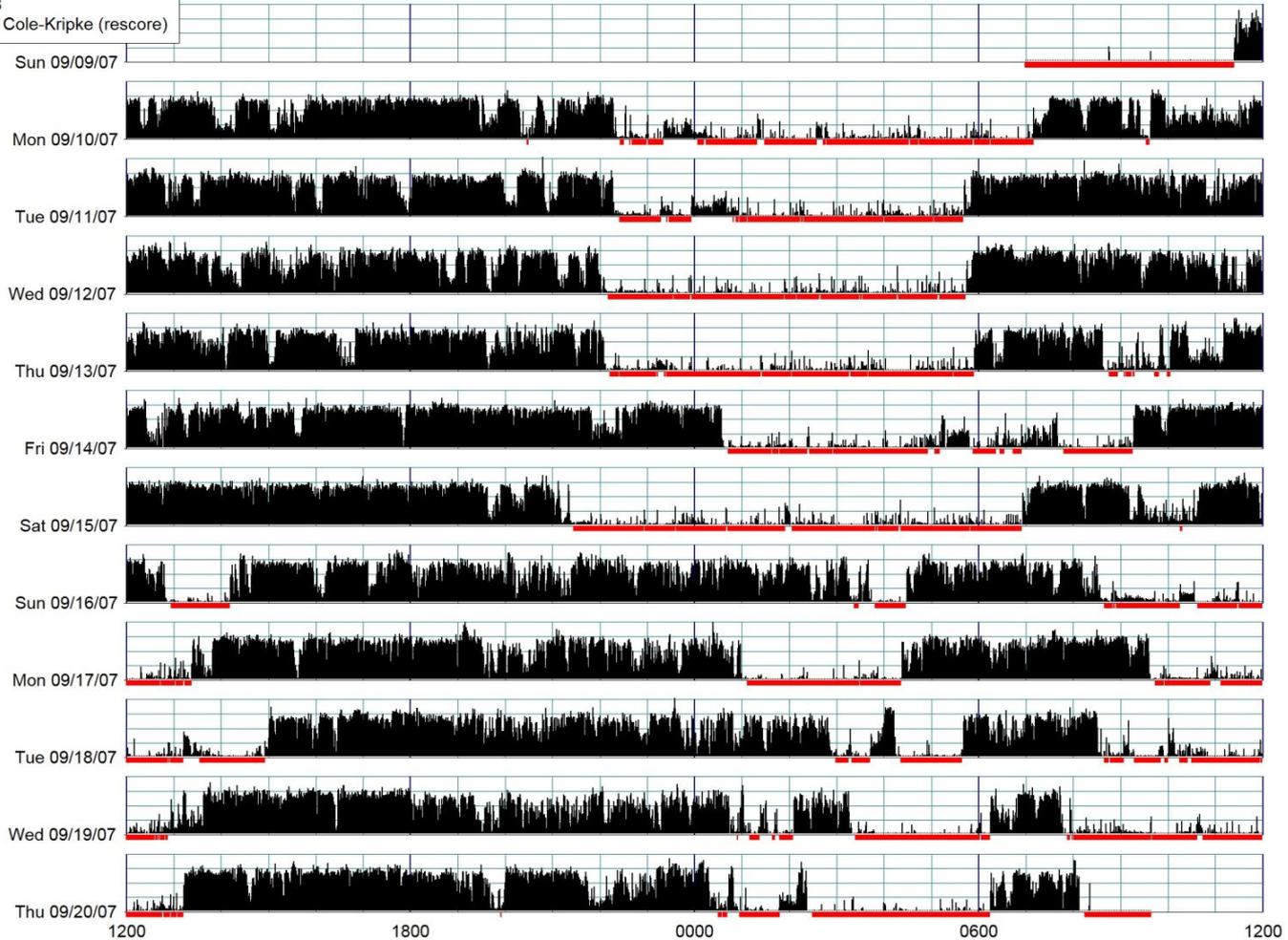
- Fatigue is function of three factors ...
 - Time awake (sleep/wake history) – in use
 - Time of day (circadian rhythm phase) – in use
 - Time on task (workload) – under development
 - All three are modulated by individual differences
- At a minimum to study fatigue we need
 - Objective measures of sleep
 - Objective measures of performance

Actigraph and Hand Held Psychomotor Vigilance Task (PVT)



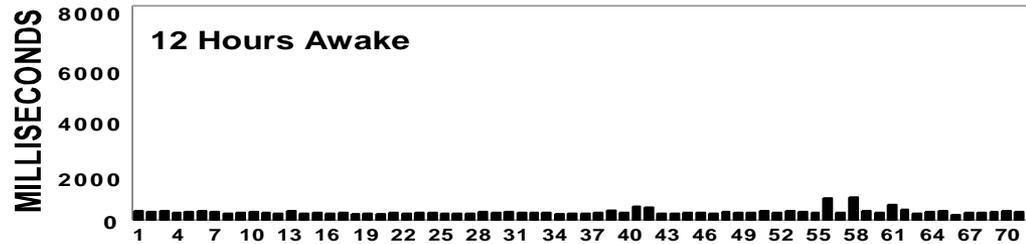
Measuring Sleep with the Actigraph...

File: jenhosp6.amf[ZCM]
Scale: 418
Algorithm: Cole-Kripke (rescore)

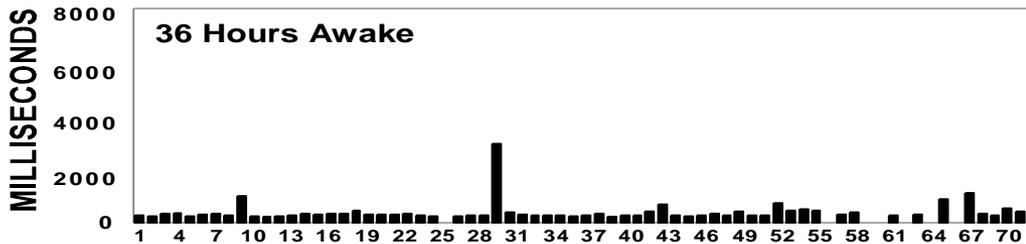


Measuring Performance with the PVT ...

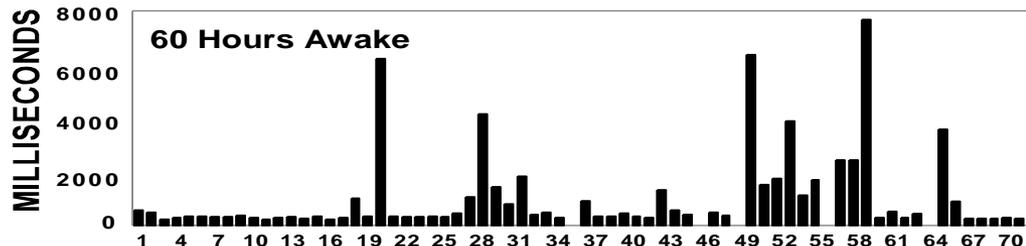
12 Hours
Awake



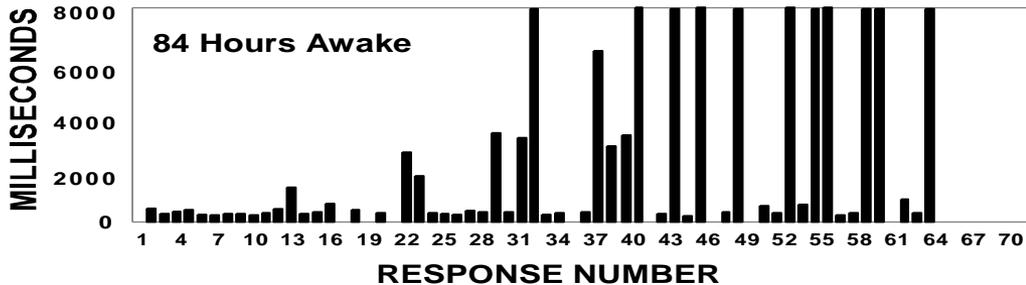
36 Hours
Awake



60 Hours
Awake

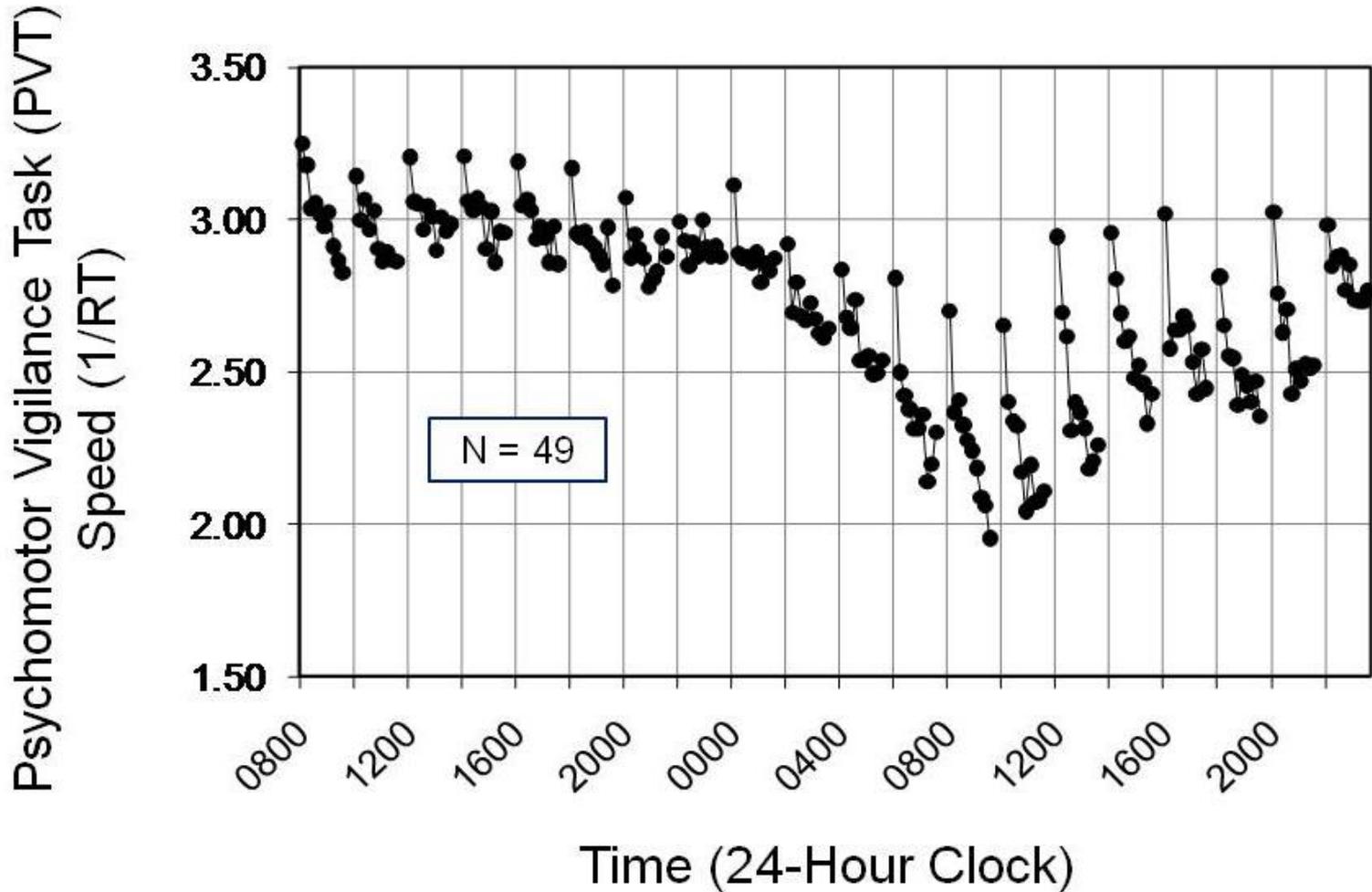


84 Hours
Awake

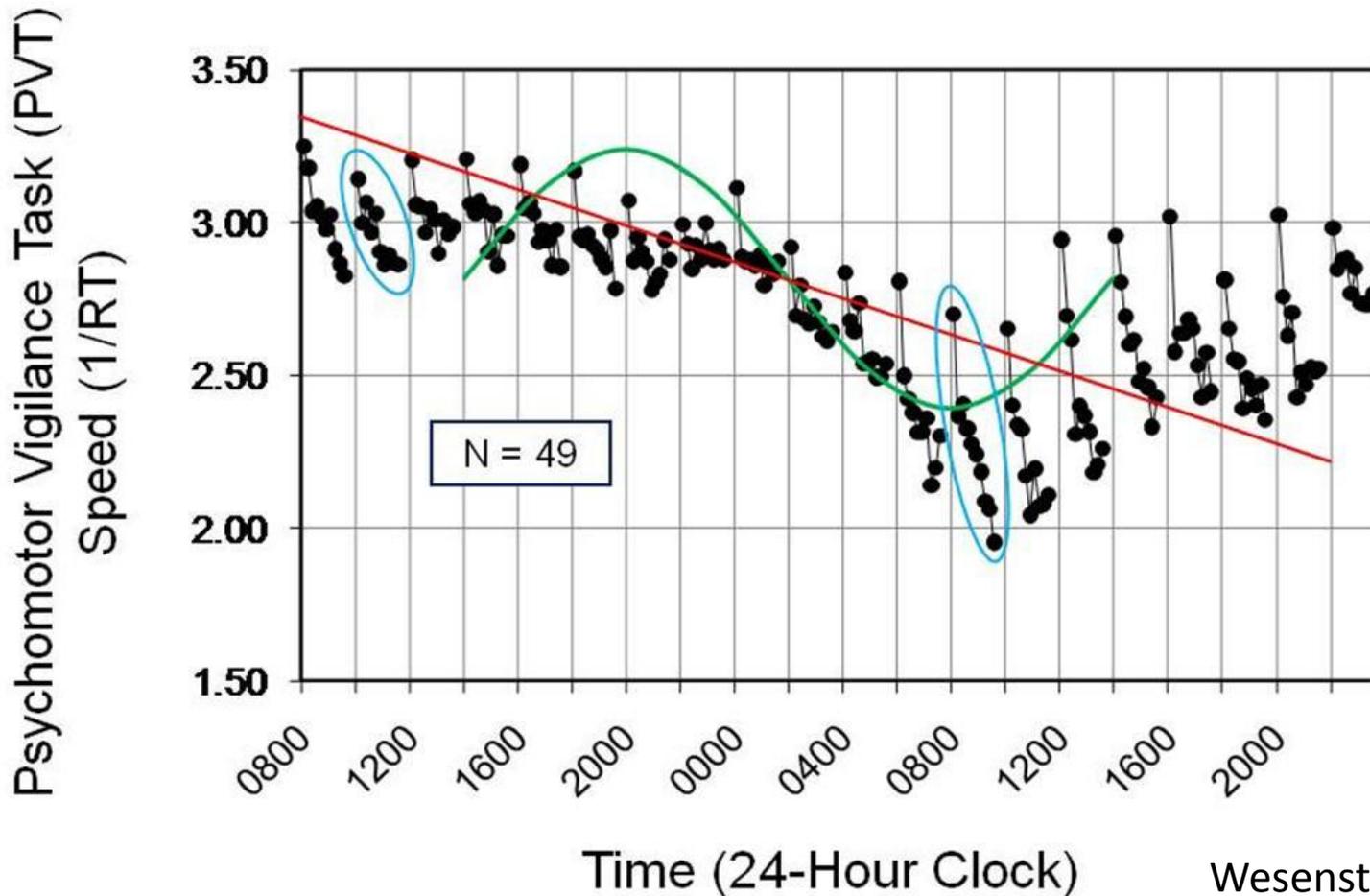


Van Dongen and
Hursh, 2011

An experiment...

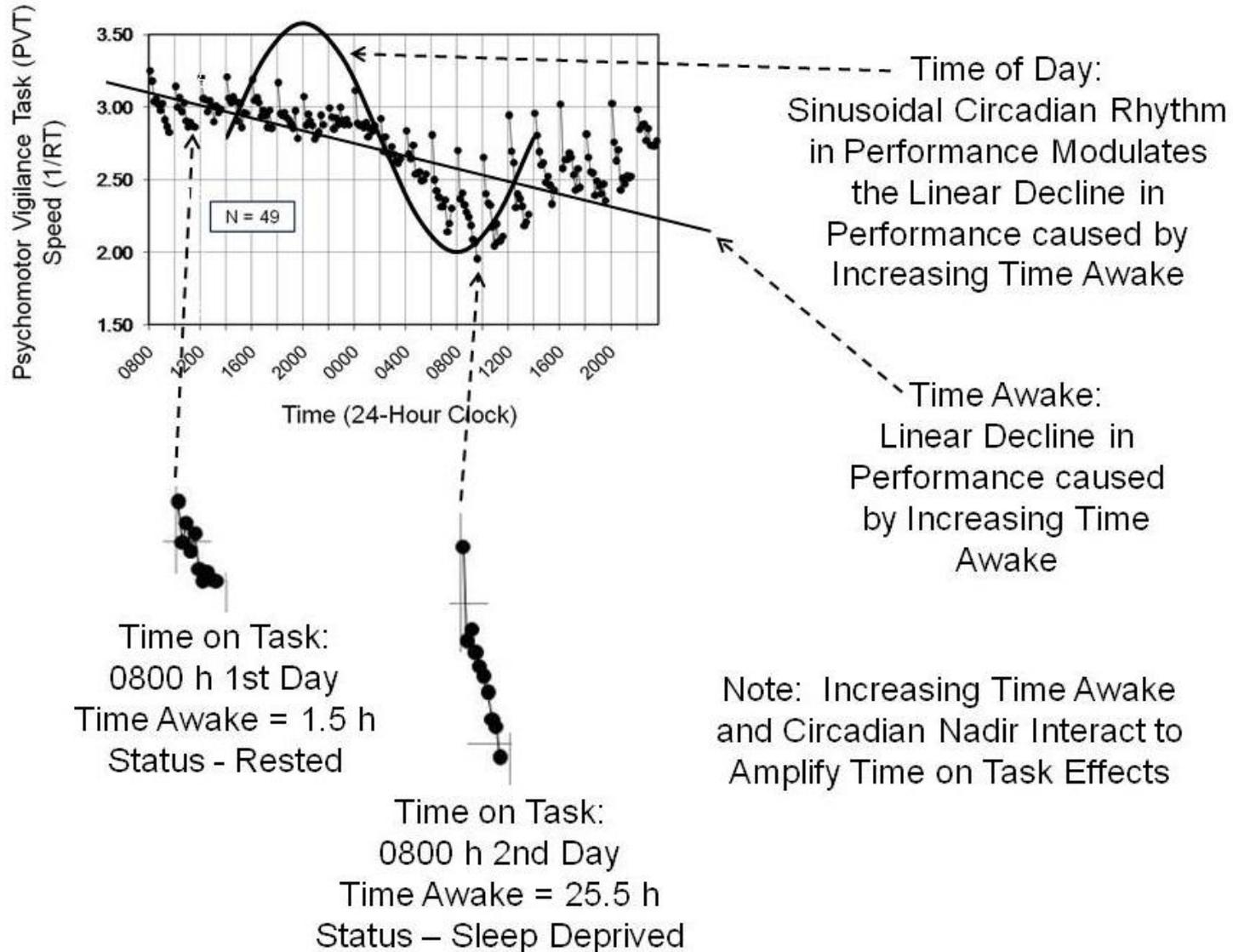


Fatigue as the Integration of Sleep Loss, Circadian Rhythm, and Workload



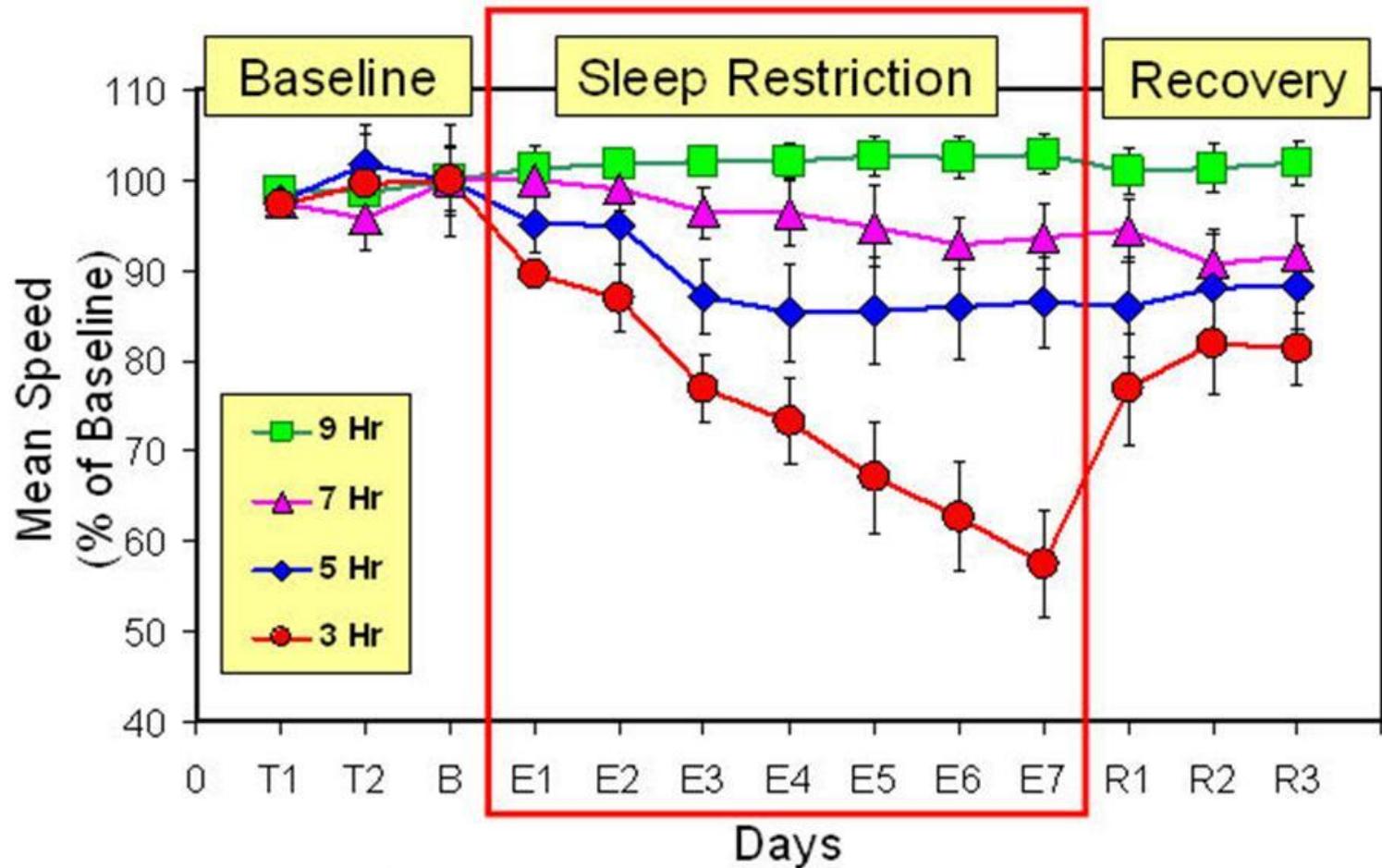
Wesensten, et al.,
2004

Time Awake, Time of Day, and Time on Task



Another Experiment ...

Sleep Restriction and Performance



Belenky, et al.,
2003

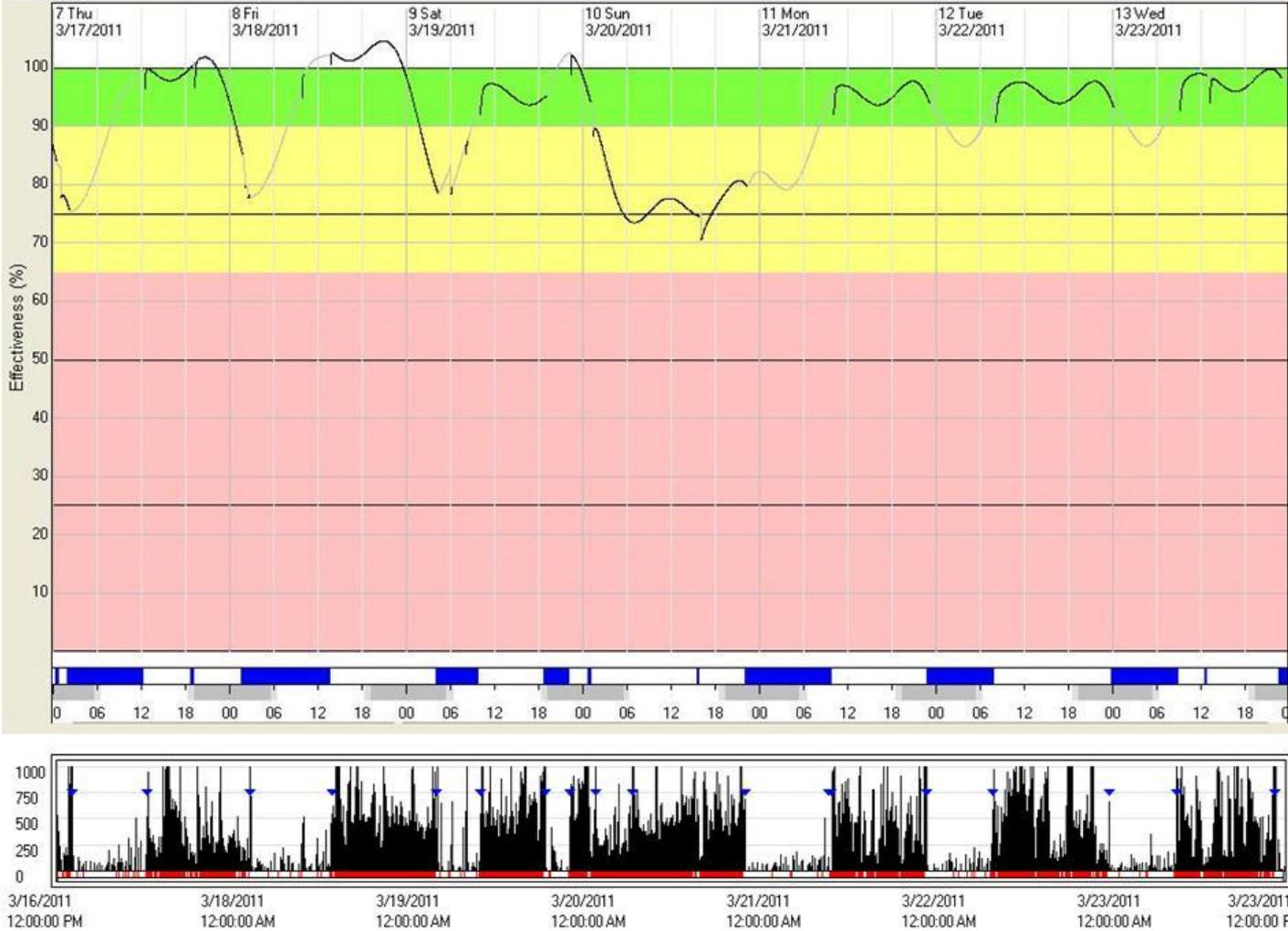
n = 16-18/group

Mathematical Models ...

- Mathematical models integrate ...
 - Homeostatic sleep drive (time awake/sleep/wake history)
 - Circadian rhythm phase (time of day)
 - Workload (time on task)

 - ... and individual differences
- Mathematical models combine sleep/wake history, circadian rhythm phase, and workload in order to predict performance

Activity, Sleep Scoring, Performance Prediction...



Integration of Fatigue Risk Management into Rostering and Scheduling

- Personal biomedical status monitoring
 - Sleep/wake history (by sleep watch)
 - Circadian rhythm phase (by technology TBD)
 - Predict performance in real time person by person (by biomathematical performance prediction model)
 - Validate with embedded performance metrics
 - Lane deviation (trucking)
 - Metrics derived from FOQA (commercial aviation)
- Integrate performance prediction into rostering and scheduling
 - Integrate into objective function of rostering and scheduling software
 - Optimize along with other constraints

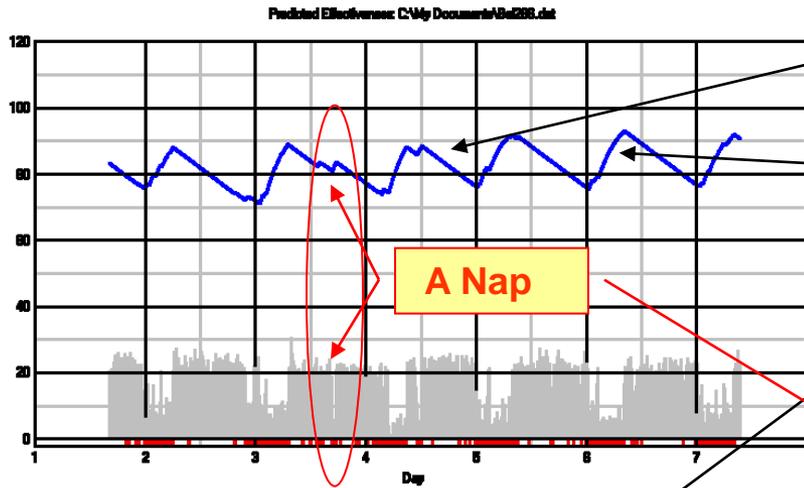
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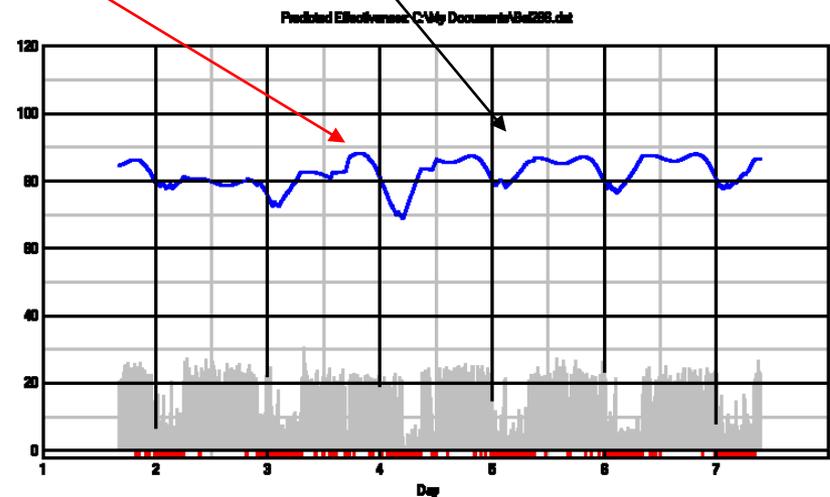
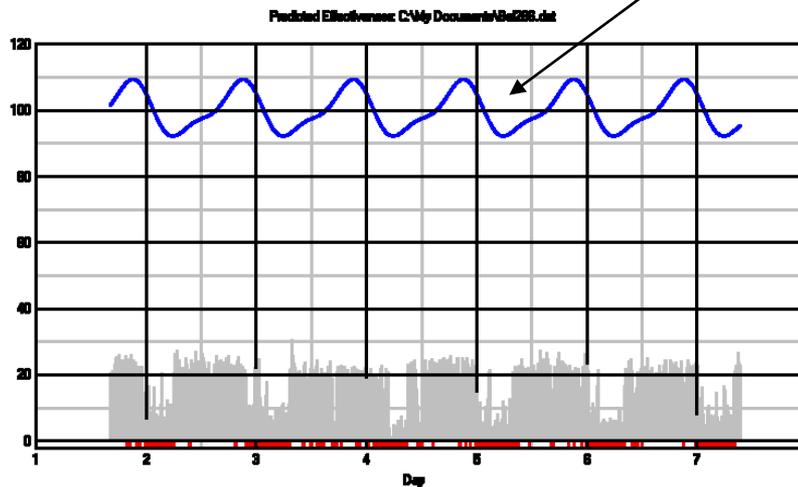
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Predicting Performance from Sleep/Wake History and Circadian Phase



- Linear Decline during Waking
- Charging Function during Sleep
- Circadian Rhythm
- Combined (decline, charge, circadian)



Predicting Performance from Actigraphically-Derived Sleep Wake History

