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Speech biometric analysis can be used to detect performance impairments under conditions of sustained wakefulness.

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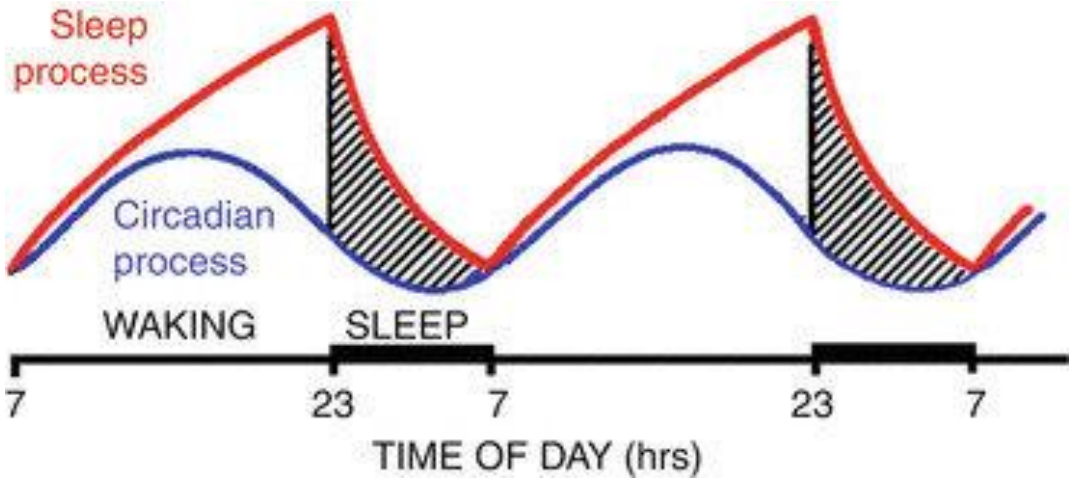
Introduction

- Sleepiness has widespread effects on core brain function and is known to induce changes in psychomotor functioning.

- Sleepiness is defined as a **state of tiredness due to prolonged wakefulness, extended work periods, and/or circadian misalignment** (Åkerstedt, 1995; Dinges, 1995).



Borbely et al 1982

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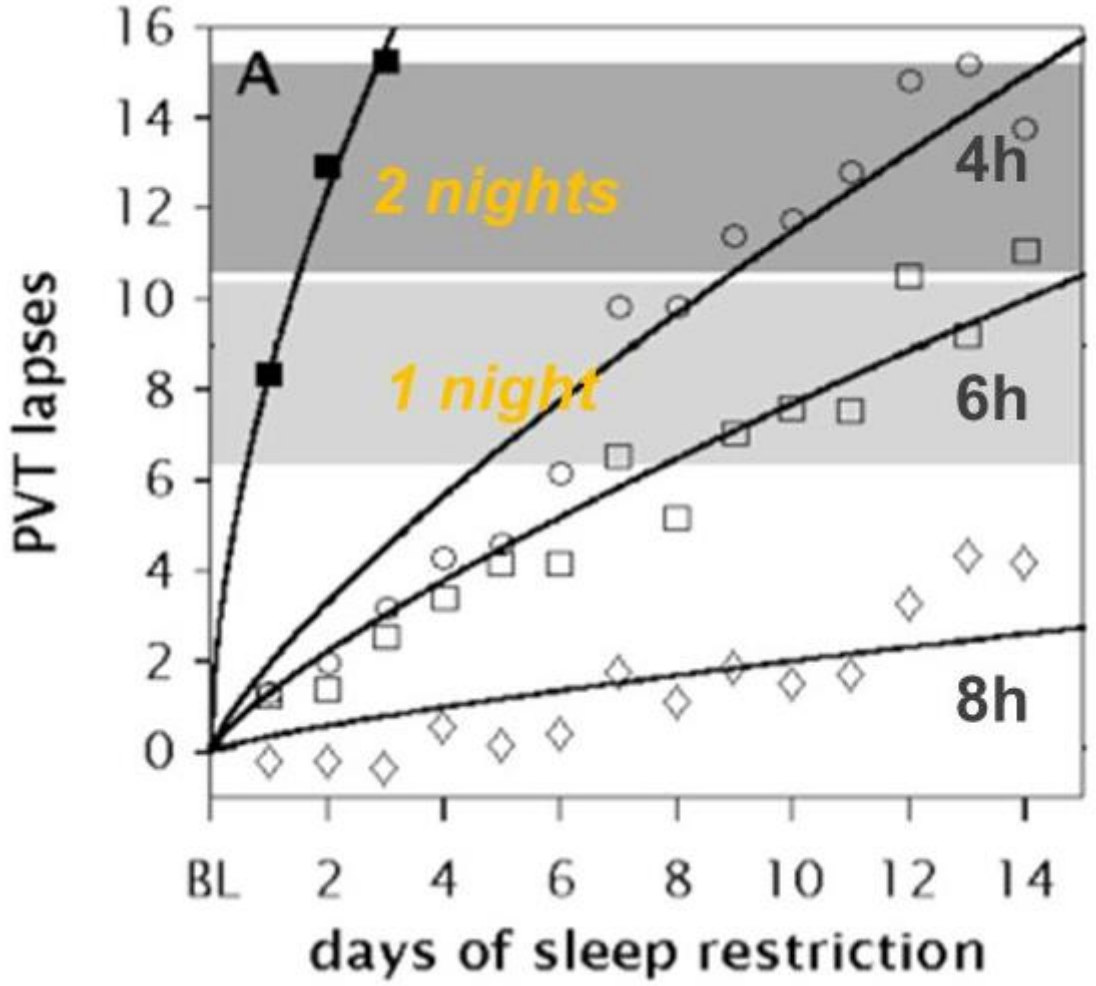
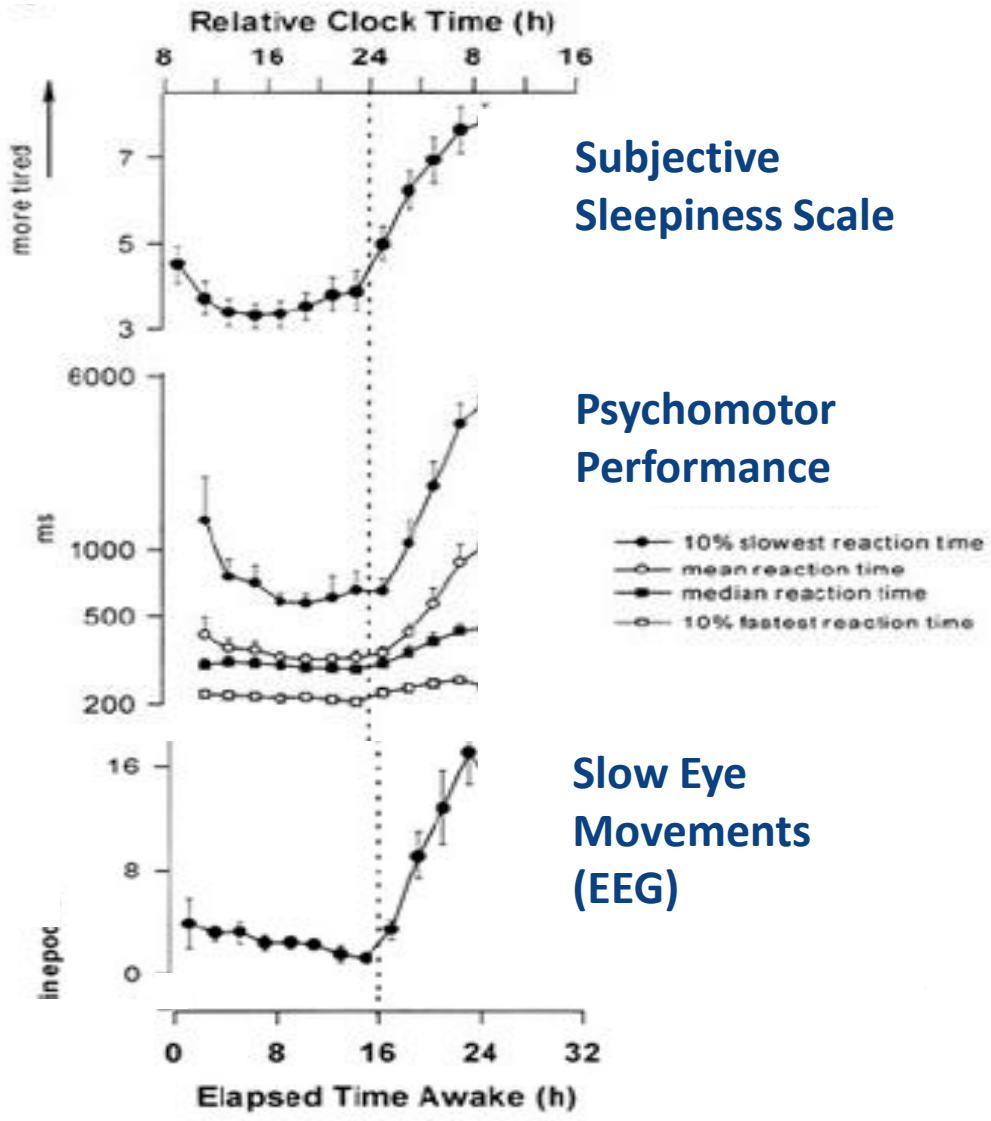
- In safety-critical environments, this can lead to human-error related accidents, incidents and injuries.



Van Dongen et al 2003

Correlates of sleepiness/alertness impairment

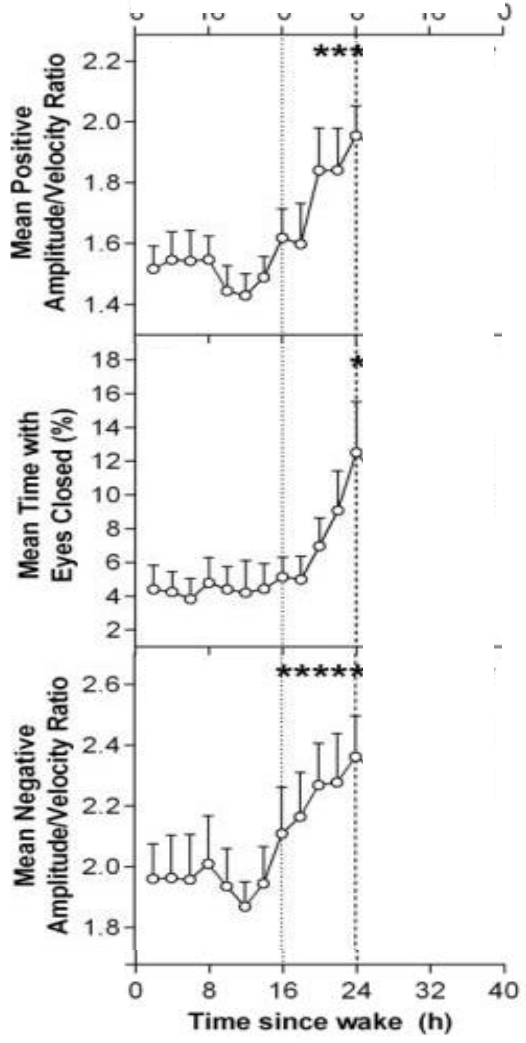


Subjective Sleepiness Scale

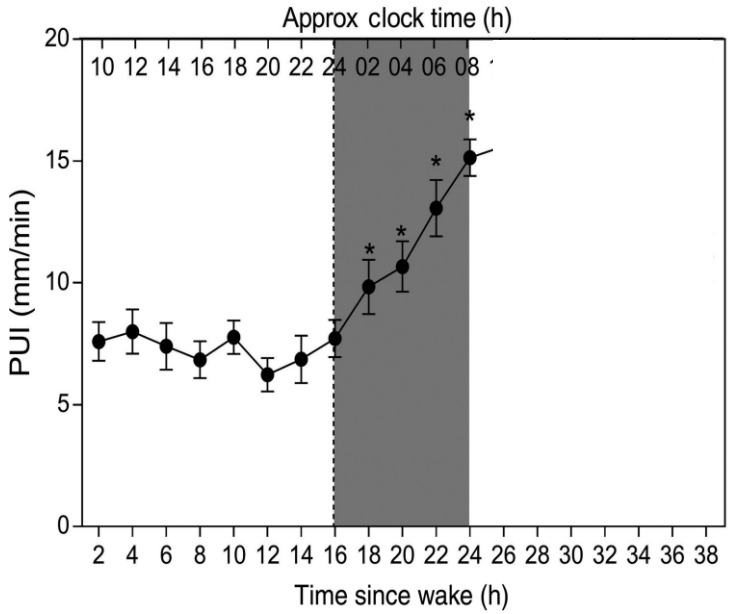
Psychomotor Performance

Slow Eye Movements (EEG)

Ocular Parameters



Pupillary Variability



Czeisler et al, 2007, Ftouni et al 2013, Maccora et al 2019

Pitfalls

- Translatability and applicability in occupational settings
- Invasive - use of a wearable
- Expensive and complex
- Addition of tasks in applied settings not practical
- Lengthily duration

What is needed?

A non-invasive, reliable, and valid method of objectively detecting alertness impairment in applied settings

Speech biometrics: potential marker of performance impairment

- changes in timing (Bard et al., 1996), pitch and vocal quality (Harrison and Horne, 1997)
- Monotonic or flatten voices

- Small sample size n = 2-10
- Gold standard comparison usually subjective
- Unable to detect changes until > 36 hours post wake
- no standardization of speech battery and Speech collection protocol

Construction of Corpus for Learning Fatigue Detection from Speech

Predicting fatigue and psychophysiological test performance from speech for safety-critical environments

Speech Analysis for Fatigue and Sleepiness Detection of a Pilot

Speech during sustained operations

An Acoustic Framework for Detecting Fatigue in Speech Based Human-Computer-Interaction

Acoustic analysis of the effects of sustained wakefulness on speech

Aims

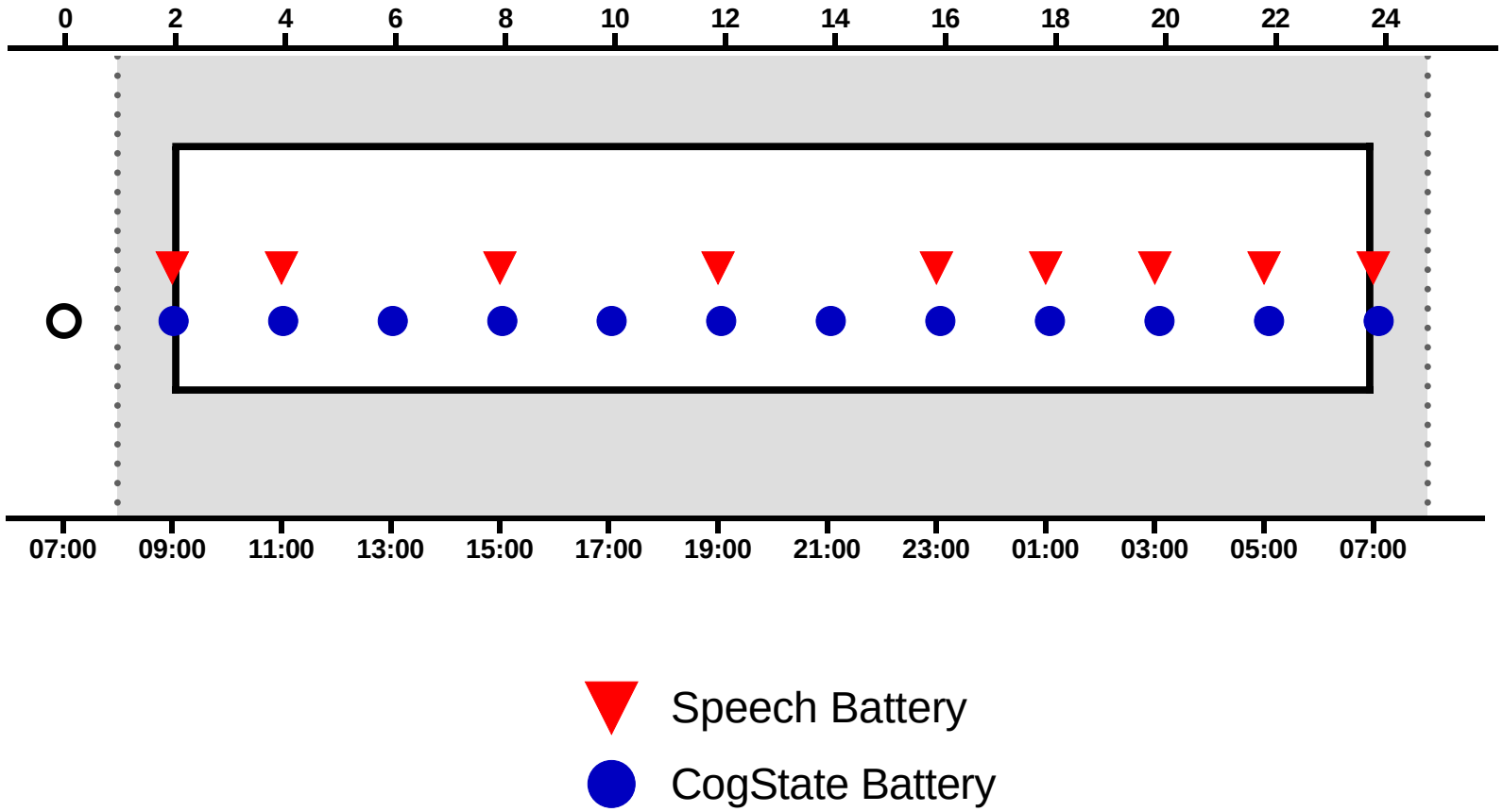
- Examine **temporal changes in speech biometrics** (timing , pitch and vocal quality) over 24-hours of sustained wakefulness

- Determine the relationship between **speech biometrics** and **objective measures of alertness impairment.**

Protocol

- **18 participants (11M, 7F)**
- 27.7 ± 2.9 years (18-28)
- Non-smokers & drug users
- < 300 mg coffee/day
- Good vocal health
- No reported neurological condition/trauma

Required to maintain an 8-hour sleep opportunity for 7 nights prior



Test Battery

Detection Task – Psychomotor Function

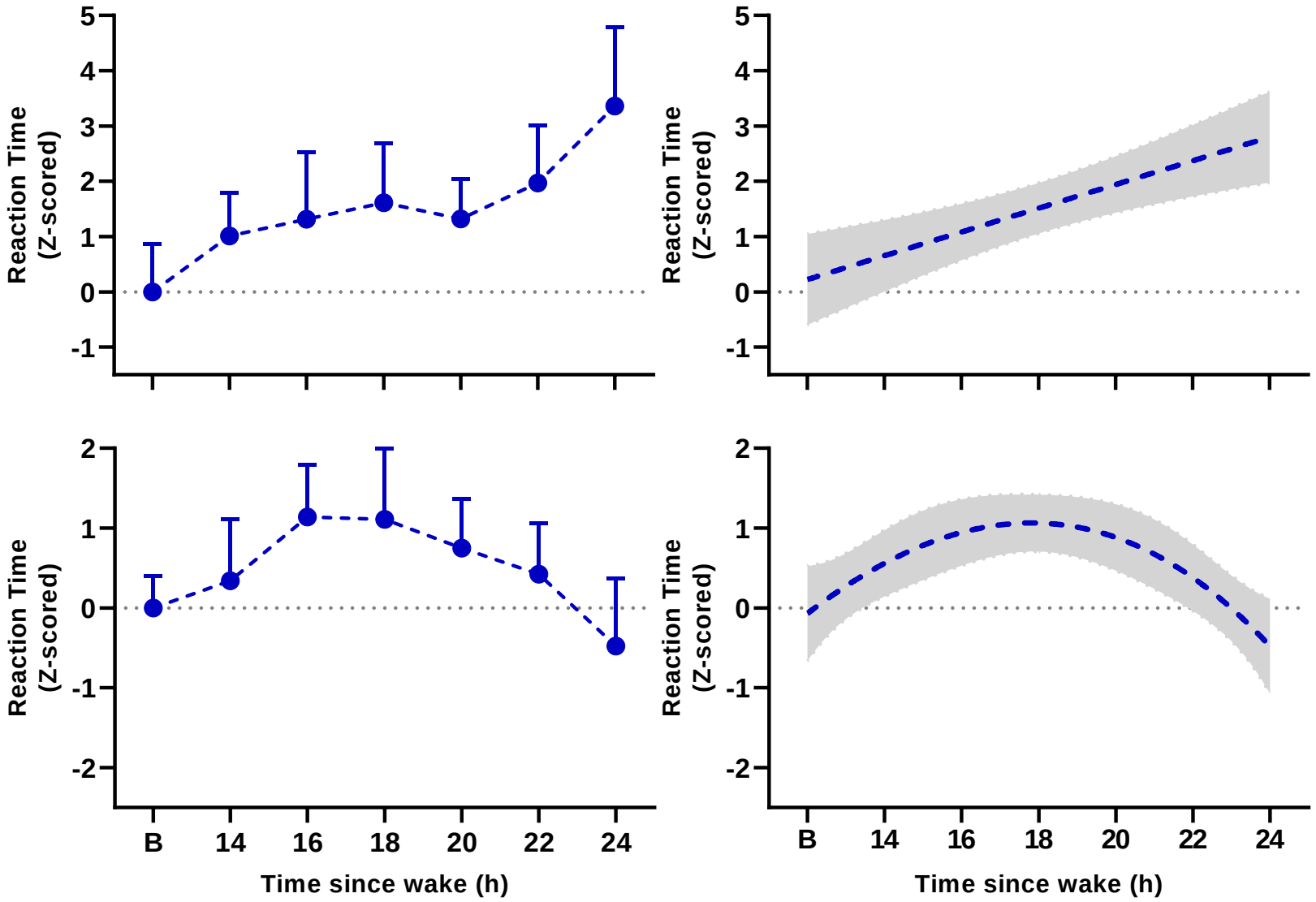
Go-No-Go Task – Executive Function

Groton Maze learning – Executive function

Continuous Pairs Associate Task – Visual Memory

Task	Abbreviation	Description
Grandfather passage (reading)	GRAN	129 words, 178 syllables. Phonetically balanced text
Sustained vowel (/a:/)	AAAH	Open vowel for approximately 6 s
Extemporaneous speech	FREE	Monologue with positive content (i.e., happy memory, amusing story, topic of interest to participant) for approximately 1 min
Automated speech: Counting	C120	Counting from 1 to 20
Automated speech: Days of the week	DAYS	Saying the days of the week beginning with Monday using one breath

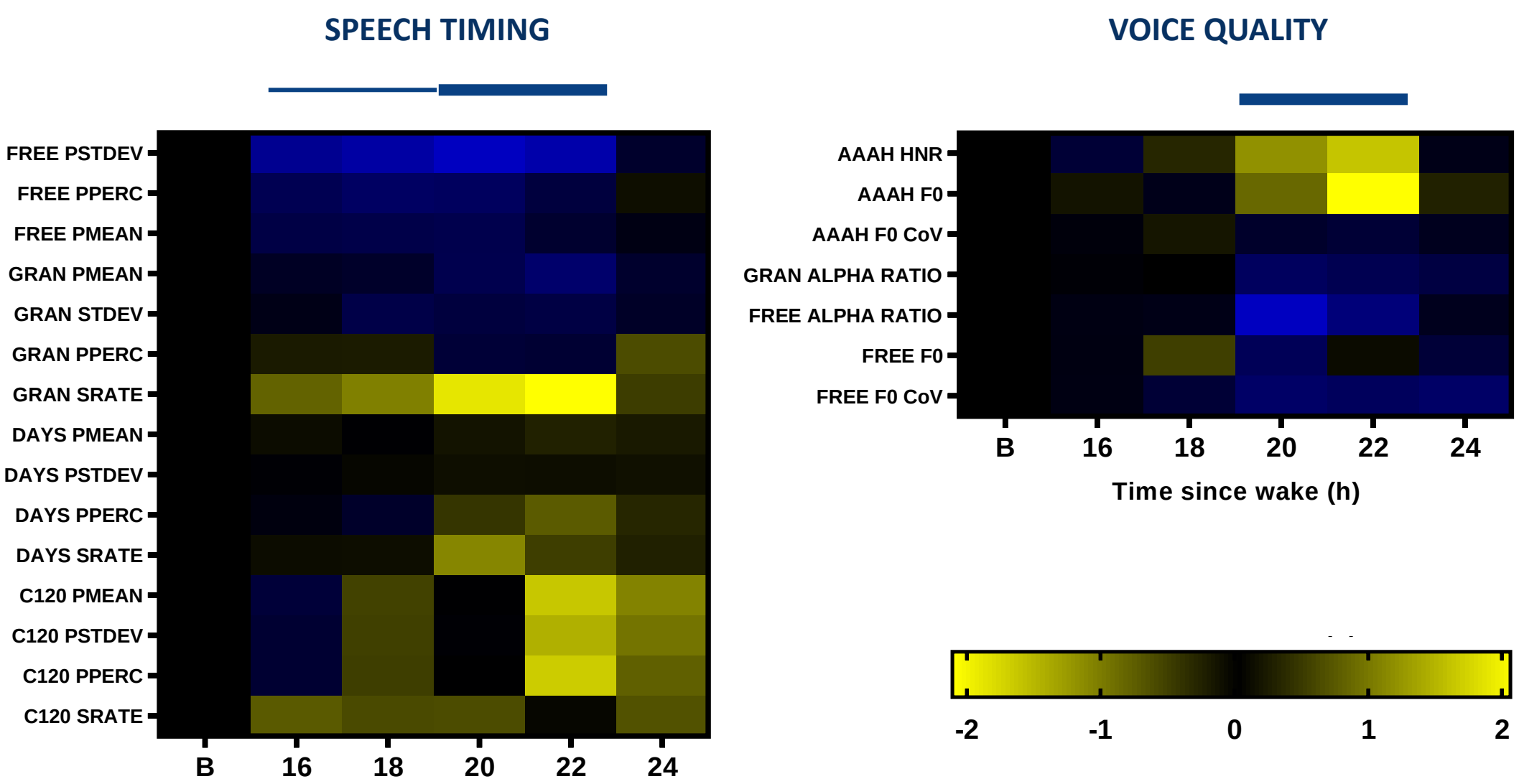
Psychomotor and Executive Function



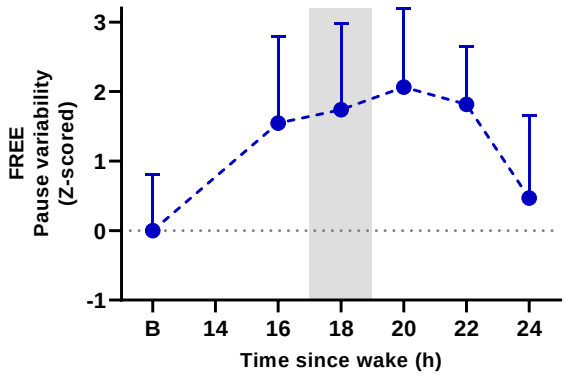
Psychomotor Function
Sustained Attention

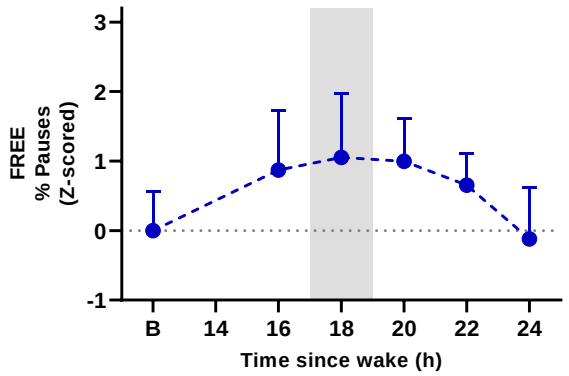
Response Inhibition
Executive Function

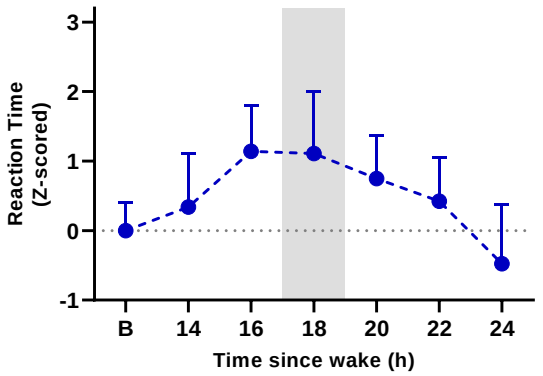
Temporal dynamics of speech biometrics

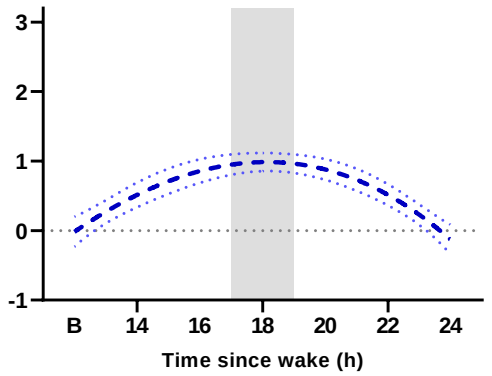


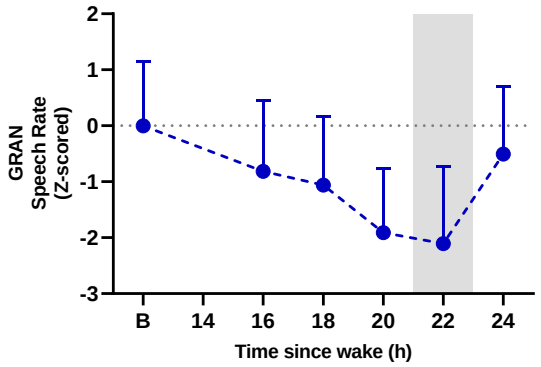
Speech Timing and Performance



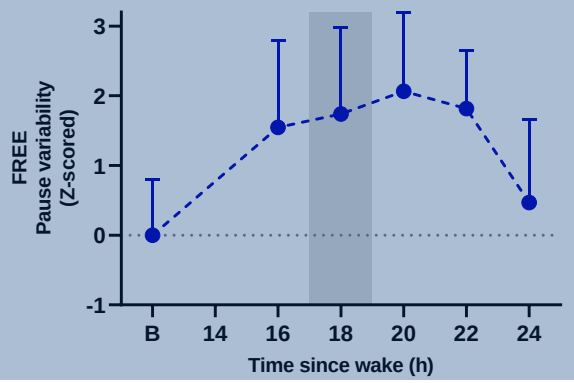


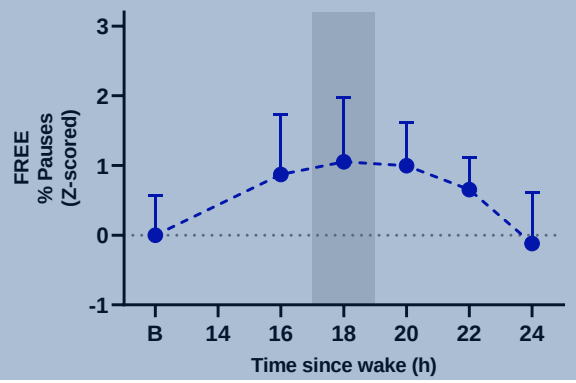


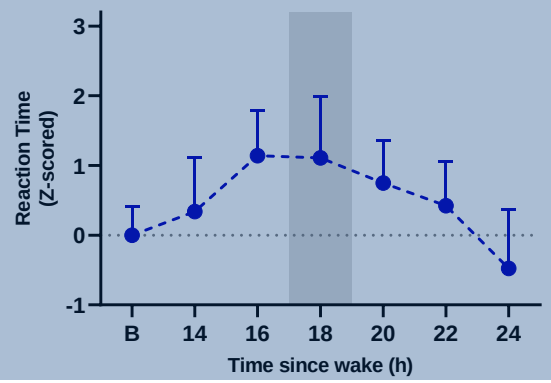


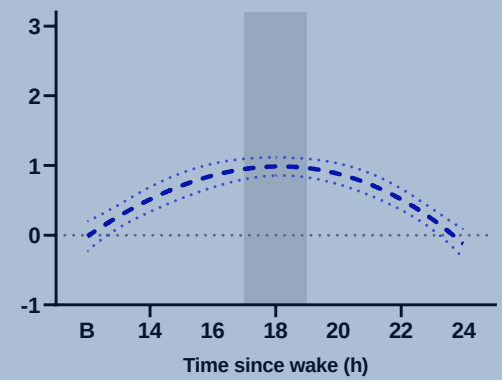


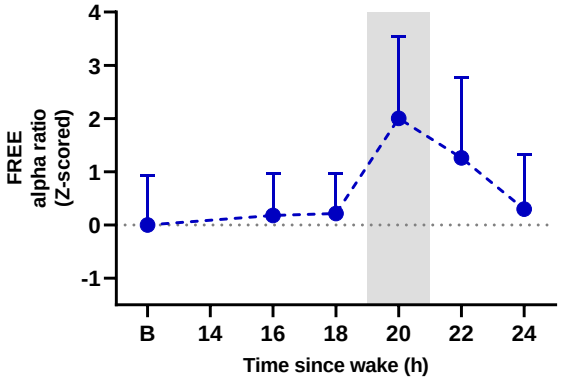
Pitch and Vocal Quality and Performance

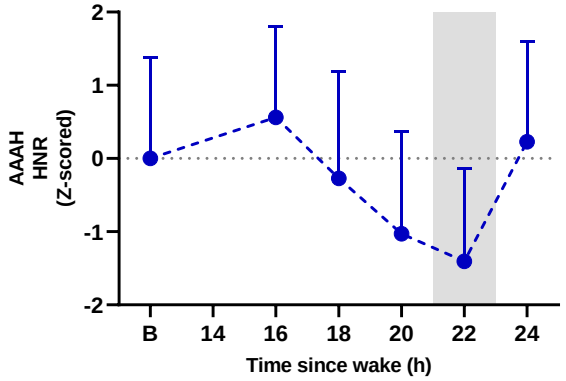


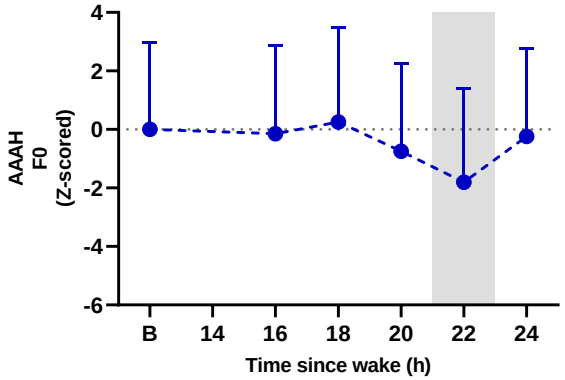












Conclusions

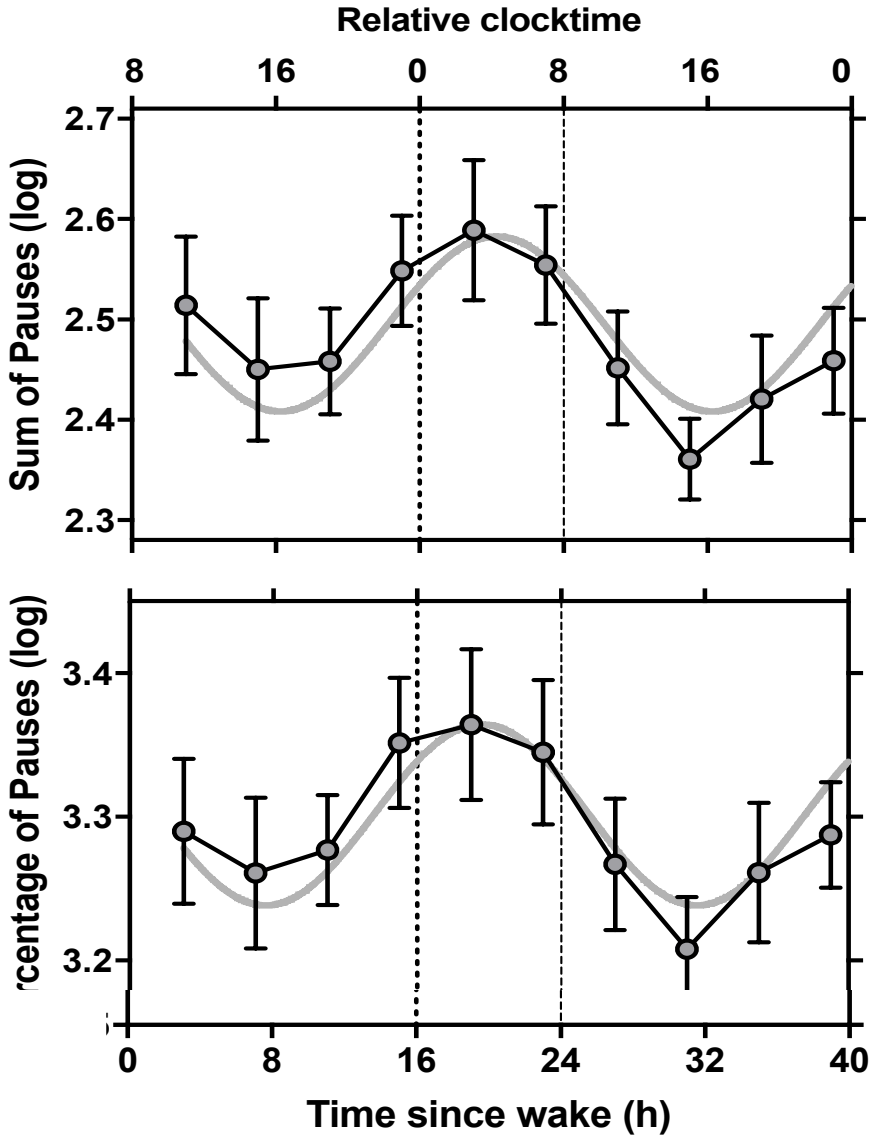
- Acoustic biometrics extracted from FREE speech align with decrements in executive function

  - most prominent at 18-20 hours post wake, aligning with timing of expected circadian nadir

- Pitch and vocal quality = large variability
- Need to investigate more biometrics properties of speech at great resolution (hourly)

- No one speech biometric will predict alertness impairment
  - More complex analysis combining speech measures required

Current programs of work



- **LABORATORY**
  - 40-hour constant routine
  - assess homeostatic and circadian driven changes in speech biometrics
  - utilising board discovery approach

- **FIELD**
  - ICU nurses and registrars
  - Day shift and subsequent consecutive night shifts

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Thank you

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