

A novel driving simulation-based wakefulness test: Preliminary comparison with the standard maintenance of wakefulness test in healthy adults

1. Background

Excessive daytime sleepiness (EDS) is a major yet under-recognised contributor to road traffic accidents. Standard tools such as the **Maintenance of Wakefulness Test (MWT)** assess wakefulness under passive conditions and may not reflect real-world driving demands. A novel **Driving Simulation-based MWT (DS-MWT)** was designed to assess sleepiness in an ecologically valid context.

2. Aim

Systematic comparison of standard **MWT vs DS-MWT**.

3. Methods

Seventeen healthy adults (mean age: 28 years, SD = 2.3; range: 20.02–55.64 years; three male) participated in a randomized, within-subject crossover clinical trial.

Each participant completed four test days—two MWT and two DS-MWT days—in randomized order. The DS-MWT involved a 40-minute nighttime drive in a high-immersion simulator, whereas the MWT involved sitting in a semi-recumbent position for 40 minutes in a quiet, dimly lit environment (fig.2).

EEG, eye-tracking, and video data were recorded during all trials, and each test day was preceded by at-home polysomnography.

The primary outcome was the mean latency across four trials per test day. MWT trial latency was defined as the time from lights-off to either three consecutive N1 epochs or one epoch of a deeper sleep stage. DS-MWT trial latency was defined as the time to a sleep accident, identified from simulator events such as a collision or complete lane departure.

4. Preliminary Results

MWT vs DS-MWT Latency

Participants generally stayed awake longer during the driving simulation, with mean latencies of around 37 minutes in the DS-MWT compared with 33 minutes in the classical MWT. While an initial paired t-test did not show a significant difference, a refined linear mixed-effects analysis accounting for repeated measures and week effects confirmed a significant condition effect ($p = 0.001$).

Performances in the classical MWT appeared much more variable, whereas DS-MWT results were more consistent.

No correlation was found between MWT and DS-MWT latency ($r = 0.08$, $p = 0.74$), suggesting low individual consistency. Furthermore, participants who performed poorly in the passive MWT did not necessarily perform poorly in the driving simulation, and vice versa (illustrated at fig.3 with diverging individual trajectories).

Sequence effects

No effects of time of sequence or week were observed (fig.4).

Time of the day effect

In the classical MWT, we observed a non-significant trend toward shorter latencies across the day, suggesting gradually increasing sleepiness. In contrast, the DS-MWT showed a significant drop (coef. -5 , $p = 0.008$) in latency during the 13 o'clock trial, followed by recovery in the afternoon. This suggests that the driving simulation may be more sensitive to daytime fluctuations in driving-related fatigue.

Sleep onset vs MWT latency

MWT latency correlated with sleep onset (SO) latency ($r \approx 0.77$), though not perfectly, indicating relevance of earlier markers such as microsleep episodes (MSEs).

Subjective sleepiness

The Epworth Sleepiness Scale (ESS) scores were not associated with latencies.

5. Conclusion

Passive MWT may not fully capture driving-related sleepiness. The DS-MWT was more sensitive to time-of-day variations and yielded longer sleep latencies, with MSEs emerging as a potentially sensitive marker for fitness-to-drive assessment.

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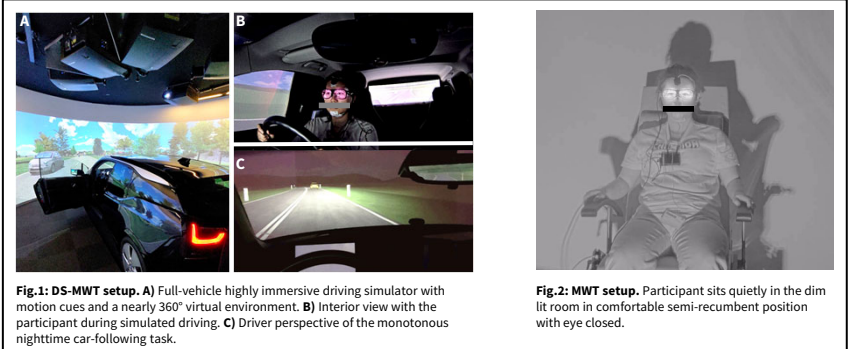


Fig.1: DS-MWT setup. A) Full-vehicle highly immersive driving simulator with motion cues and a nearly 360° virtual environment. B) Interior view with the participant during simulated driving. C) Driver perspective of the monotonous nighttime car-following task.



Fig.2: MWT setup. Participant sits quietly in the dim lit room in comfortable semi-recumbent position with eye closed.

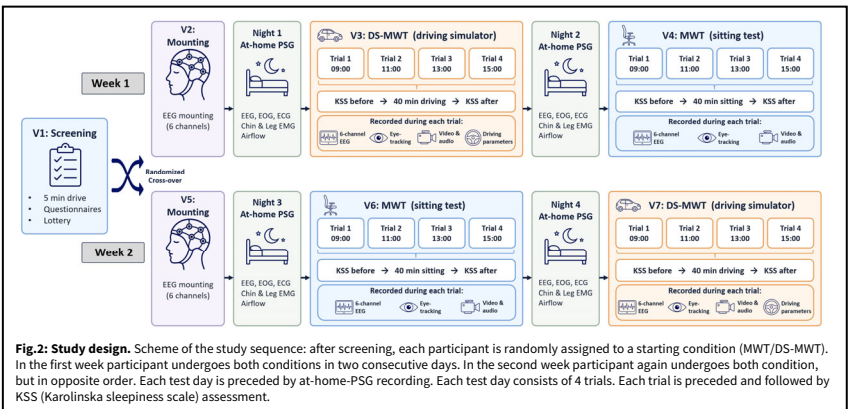


Fig.3: Study design. Scheme of the study sequence: after screening, each participant is randomly assigned to a starting condition (MWT/DS-MWT). In the first week participant undergoes both conditions in two consecutive days. In the second week participant again undergoes both condition, but in opposite order. Each test day is preceded by at-home-PSG recording. Each test day consists of 4 trials. Each trial is preceded and followed by KSS (Karolinska sleepiness scale) assessment.

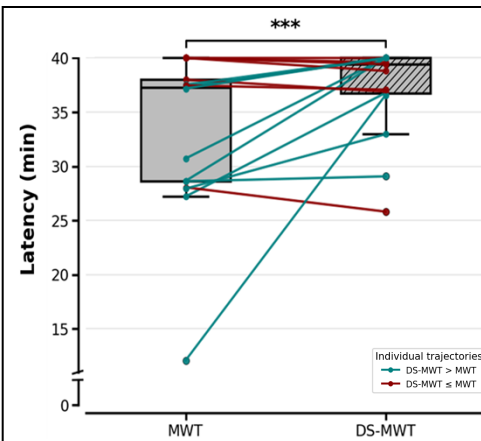


Fig.3: MWT vs DS-MWT latency. The gray and hatched boxplots show participant-level mean latencies for MWT and DS-MWT, respectively, averaged across weeks and days. Boxes indicate the IQR, black lines the median, and whiskers the most extreme non-outlying values. Lines connect paired observations (green: DS-MWT > MWT; red: DS-MWT < MWT). The bracket indicates the LMM condition effect (coefficient = -3.818 , $p = 0.001$).

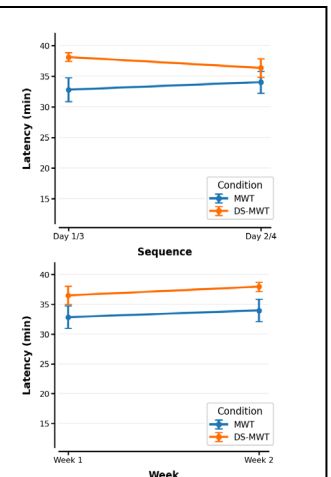


Fig.4: Effects of sequence and week. A) Neither sequence (coefficient = -0.271 , $p = 0.816$) nor week (coefficient = 1.289 , $p = 0.268$) had a significant effect on test latencies.

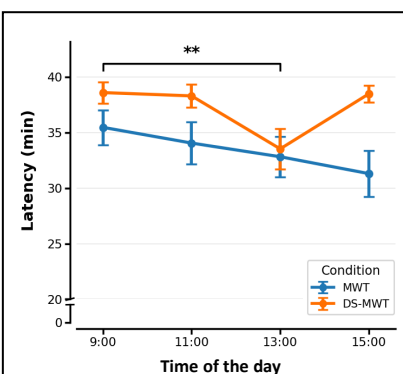


Fig.5: Time of the day effect. Points and error bars show mean latencies and their variability at each trial time point. The bracket marks significant dip in DS-MWT latency at 13 o'clock compared to 9 o'clock trial (coefficient = -5.00 , $p = 0.008$; **).

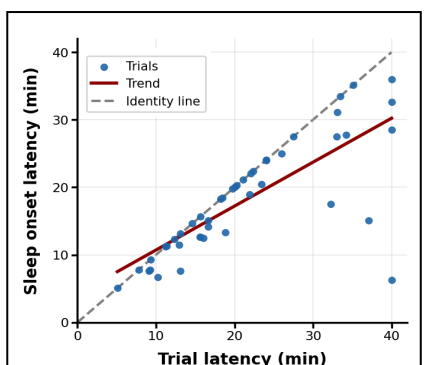


Fig.5: SO vs MWT latency. Each blue point represents one trial, the red line shows the fitted trend, and the gray dashed identity line indicates equal latencies. MWT trial latency was strongly, but not perfectly, correlated with sleep-onset latency ($r = 0.77$).