Slow Eye Closure as a Measure of Drowsiness and Its Relationship to Performance

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Introduction

- Driver drowsiness is a significant contributor to motor vehicle accidents world wide.
- Slow eyelid closure measured as PERCLOS (PERcent eye CLOSure) can be used to assess drowsiness in sleep deprived individuals.
- Automated measures of PERCLOS are not well validated.
- This study determined whether drowsiness can be detected using an automated measure of PERCLOS, and how this relates to performance after sleep deprivation.

Methods

Subjects

- Twelve healthy male professional drivers
- Age (mean ± standard deviation) = 45.6 ± 10.9
- Mean Epworth Sleepiness Scale score = 5.95
- Average number of driving hours per week = 42.4

Procedure

- Two randomized laboratory sessions; a) without sleep deprivation and b) after 24 hours of sleep deprivation.
- Performance was assessed using the AusEd driving simulator and the Psychomotor Vigilance Test (PVT).
- PERCLOS was assessed using the Copilot during the driving task.
- One participant did not complete the PVT.

Statistical analyses

- Repeated measures ANOVA was used to examine differences in PERCLOS and performance between sessions.
- Difference scores between sleep deprived and non-sleep deprived sessions were calculated.
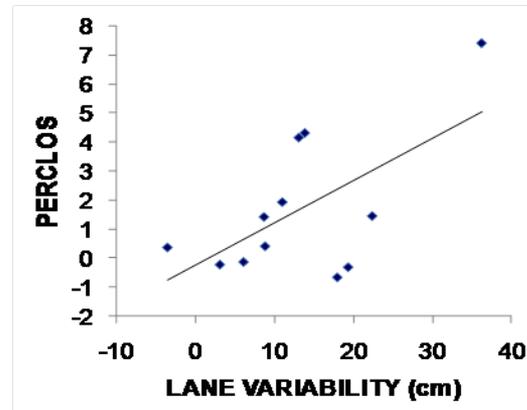- Regression analyses were performed and Pearson's r correlations were assessed.

Figure 1: Relationship by subjects between lane variability on a driving simulator and PERCLOS.
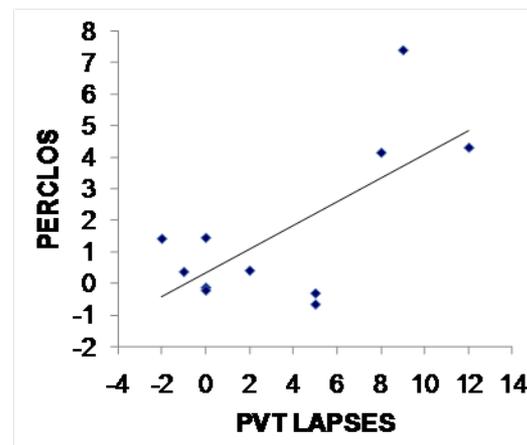

Figure 2: Relationship by subjects between PVT lapses and PERCLOS.

Results

- After sleep deprivation, drivers had significantly more PERCLOS ($F_{1,11}$ = 5.60, p = 0.004), greater variability in lane position during simulated driving ($F_{1,11}$ = 19.63, p = 0.001), and more PVT lapses (RT > 500 ms; $F_{1,10}$ = 6.06, p = 0.034).
- PERCLOS was significantly related to variability in lane position (37% of variance explained, r = 0.61, $F_{1,11}$ = 5.96, p = 0.035); see Figure 1. However, when the subject showing the greatest lane variability during sleep deprivation was removed, the correlation reduced to r = 0.18.
- PERCLOS was significantly related to PVT lapses (47% of variance explained, r = 0.68, $F_{1,10}$ = 7.89, p = 0.020); see Figure 2.

Discussion

- After 24 hours of sleep deprivation, professional drivers had more eye closure, variation in lane position and PVT lapses compared with the non-sleep deprivation session.
- PERCLOS explained a significant portion of the variance of impairment in simulated driving and vigilance performance.
- Although a larger sample is needed to confirm these results, automated measures of PERCLOS appeared to be an effective means of detecting impairment due to drowsiness in a laboratory setting.