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Validation of Optalert™ and the Johns Drowsiness Scale

Many trials have been done by OPTALERT Pty Ltd and others to validate the Johns Drowsiness Scale (JDS) as measured by the Optalert™ Fatigue Monitoring System of infrared (IR) reflectance oculography. More details will be available for most of these studies upon request.

Monitoring Eye & Eyelid Movements by Infrared Reflectance Oculography to Measure Drowsiness in Drivers

Drowsy driving is believed to be a major factor in road crashes, but currently cannot be assessed accurately. A new system of IR reflectance oculography is described that uses transducers attached to a glasses frame to measure driver's drowsiness continuously on a new scale (JDS). Driving in a car simulator was investigated in relation to JDS scores per minute. Fifty (50) volunteers had their eye and eyelid movements monitored while performing RT-tests when alert and drowsy. Multiple regression analysis of ocular variables, measured every minute in alert and drowsy conditions, was used to establish the drowsiness scale (JDS). Driving off the road in the driving simulator was the criterion for dangerous driving by eight (8) sleep-deprived drivers. The regression predicting conditions was highly significant ($R=0.70$, $p<0.0001$). Mean JDS scores and mean RTs in all test conditions were highly correlated ($r=0.70$, $n=88$, $p<0.001$). There were 62 "off-road" events for eight (8) drowsy drivers, and 61 of them were preceded by JDS scores >5.

Effects of sleep deprivation on JDS

Volunteers (N=31) who were deprived of sleep for 24-30 hrs had significantly higher JDS scores than when well rested. They were tested while performing a standardized psychomotor vigilance test, the Johns Test of Vigilance (JTV). Their drowsiness was confirmed by longer reaction-times and more frequent errors of omission in the JTV when sleep deprived. There was an exponential relationship ($p<0.001$) between JDS and the frequency of non-responses in the JTV, measured for all minutes of recording.

The Circadian Rhythm of JDS Scores

Two (2) subjects performed JTVs for 15 min every 3 hrs over a period of 27 hrs of wakefulness. There was a highly significant change in JDS scores across time, particularly after the first 18 hrs of wakefulness.

Relationship between Blood Alcohol Concentration and JDS

Swinburne University of Technology, Drug and Alcohol Research Unit, performed a study in which 19 volunteers drank progressively more alcohol during a period of 6 hrs in the evening (6 pm to midnight). There was a linear relationship between JDS scores, measured during the JTV, and blood alcohol concentration measured by breathalyser.

Relationship between PERCLOS Measurements with the Copilot Video System and Optalert™

Dr. Mark Howard's group at the Institute of Breathing and Sleep, Austin Hospital, Melbourne, confirmed in laboratory experiments that the proportion of time that the pupils were at least 80% covered by the eyelids during eyelid closures that lasted at least 500 millsecs (measured by the Copilot video system) was highly correlated with the "percent time eyes closed" measured by Optalert™.

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A New Method for Assessing the Risks of Drowsiness While Driving

This study described how drowsiness was related to performance failures in two different kinds of reaction-time (RT) tests as well as during simulated driving tests. Thirty-one (31) healthy volunteers performed simple (SRT) and choice (CRT) RT tests for 15 minutes with and without sleep deprivation for 27-33 hours. Their drowsiness was measured as a JDS score (0-10) each minute. In a separate experiment, 15 healthy young adults simulated driving in a car for about 70 minutes when alert and when sleep-deprived while their drowsiness was also measured. After sleep deprivation, RTs increased and errors of omission (failure to respond within 2 seconds from the start of the stimulus) occurred more frequently in both the SRT and CRT tests, the frequency of driving off the road increased, and JDS scores also increased significantly. The risk per minute for each subject of making an error of omission in SRT tests and of driving "off road" in a car simulator increased progressively with JDS scores ($p<0.001$).

Driving Simulator Studies at Monash University Accident Research Centre (MUARC)

An independent study by MUARC established that drowsiness induced by sleep deprivation affected the driving of 20 volunteers who drove for 45 min in the MUARC simulator when alert and when sleep deprived for 27-30 hrs. There was an exponential relationship between the proportion of time that the vehicle was outside the lane and the JDS score, measured from minute to minute as they drove.

The Relationship between EEG Theta Waves and JDS Scores

A study was done in conjunction with the Sensory Neuroscience Laboratory, Swinburne University of Technology, Melbourne. Twenty (20) volunteers performed JTVs when well rested and after being awake for 27-30 hrs. They had EEG recorded at the same time as Optalert™ recordings, while performing JTVs. There was a significant correlation between the theta power, measured by FFT, on 01 -02 derivatives of the EEG and JDS scores across all subjects-sessions. This was true whether the power was standardized for each subject or not.

Effects of Caffeine on JDS Scores

This study was performed in conjunction with Swinburne University of Technology. Fifteen volunteers with normal sleep habits and no reported sleep disorder were studied in a double-blind, cross-over study of the effect of a single dose of 200 mg of caffeine. Even though these normal subjects were not sleep deprived and had JDS scores in the normal range to begin with, there was a highly significant effect of the caffeine on JDS scores, suggesting decreased levels of drowsiness, beginning 30 mins after ingestion of caffeine and lasting 2 or 3 hrs.

Test-Retest Reliability of JDS Scores

The aim of this investigation was to measure the test-retest reliability of mean JDS scores at different levels of drowsiness. Fourteen (14) healthy volunteers (M/F=10/4, ages 21-32 yr) performed 15-min JTV test, twice within 2 hr under three different conditions, a "not sleep-deprived" condition on one day with tests at 1200 and 1400 hr after a normal night's sleep, and two "sleep-deprived" conditions on another day after missing the previous night's sleep with tests at 0945 and 1130 hr and again at 1440 and 1545 hr, i.e. after being awake for 27-33 hr. Repeated measures ANOVA for mean JDS scores showed a significant effect for Condition (sleep deprivation) ($F(2,39)=5.049$, $p=0.01$), but not for Session (test-retest) ($F(1,39)=0.980$, $p=0.33$), or Condition x Session interaction ($F(2,39)=0.863$, $p=0.43$). A paired t-test between test and retest mean JDS scores, combining all 3 conditions, showed no significant difference (mean diff = 0.19 +/- 0.19 standard error, $n=42$, $p>0.3$), and there was a high intraclass correlation ($r=0.80$, $n=42$, $p<0.001$). The mean JDS score per 15-min JTV test increased after sleep deprivation and those scores were very reliable, at least in the short-term.

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