INTRODUCTION
Drowsiness is thought to cause about 20% of all road crashes in Australia [1]. However, this is likely to be a conservative estimate as it has not been possible to measure a driver’s drowsiness accurately at the time of the accident. We have developed a system of infrared reflectance oculography IRO (Optalert™), that makes it possible to monitor alertness/drowsiness continuously, without interfering with the driving task.

Optalert glasses look like ordinary glasses and are worn in the same way. They contain sensors that measure how quickly the eyelids close and reopen during blinks, and for how long the eyelids remain closed at a time. Optalert uses a combination of several characteristics of these eyelid movements to derive a measure of drowsiness every minute on the Johns Drowsiness Scale (JDS) which ranges from 0 to 10, where 0 = fully alert and 10 = very drowsy. Drivers receive a cautionary warning if their JDS score exceeds 4.5 and a critical warning above 5.0, when they would be expected to stop driving as soon as it was safe to do so. In the present study we investigated the JDS scores of young adults driving in a car simulator with and without sleep deprivation.

METHODS
Fifteen healthy young adults (M/F =11/4 , mean age = 23.6 +/- 3.2 (SD) yr, range = 21-32 yr) participated in the experiment conducted at the Monash University Accident Research Centre. They drove for 70 minutes in a high fidelity car simulator, once in the morning after their usual night’s sleep and again the next morning after about 27 hours without sleep.

Their eye and eyelid movements were monitored by IRO using Optalert during the drive. A JDS score was calculated for each minute of driving. A lane-departure episode was said to occur whenever all 4 wheels of the car were outside the lane. However, drivers continued to drive without intervention. One-way ANOVA was used to compare JDS scores in alert drivers, those who were sleep-deprived but did not have any lane-departure episodes, and those who were sleep deprived and who had lane-departures. We also calculated the percentage of lane-departure episodes that were preceded by a JDS score of at least 5.0 in 5 minute increments, from 5 minutes up to 30 minutes before such episodes.

RESULTS AND DISCUSSION
None of the 16 subjects had any lane departure episodes without having been sleep-deprived, but six subjects had a total of 102 unintentional lane-departures after sleep deprivation. The mean JDS score for all subjects before sleep deprivation was 3.4 +/- 1.9 (SD). After sleep deprivation, the 10 drivers who still did not have any lane-departures, had a mean JDS score of 4.3 +/- 2.0, and the 6 drivers who had lane-departures had a mean JDS score of 6.5 +/- 2.2 (ANOVA, p<0.001; all post-hoc Scheffe tests, p<0.001). The percentage of lane-departure episodes associated with JDS scores of 5.0 or higher during the preceding 5 min was 88.2%, and that increased to 100% for 30 min before each episode (Figure 1).

CONCLUSIONS
We have shown that by measuring drowsiness every minute by IRO, using a new scale of drowsiness (JDS, 0 – 10), that the ability to drive was progressively impaired as JDS scores increased. We suggest that for a driver to have a JDS score above 5 would be incompatible with safe driving. This device is being used by drivers in the road transport and mining industries in Australia and elsewhere.

REFERENCES