Submission for the House of Representatives Standing Committee (Communications, Transport and the Arts) inquiry into managing fatigue in transport -air, road, sea and rail.

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I have been requested to present a brief submission to the above inquiry on our current research into driver and work related fatigue that we have now been conducting since late 1997. Thank you for this opportunity. For any further inquiries, please contact Professor Craig on 02 9514 1358; fax: 02 9514 1359; email: a.craig@uts.edu.au

General Background

There is little doubt that driver fatigue is a major contributor to road and work accidents (Lal & Craig, 2000). For example, transportation, army and industry drivers often conduct 24-hour operations, and ordinary motorists can drive for many hours at a time. These activities expose those involved to disruptions in physiology, mainly in sleep and body rhythms (circadian). Continued activity of a task is also a factor, leading to boredom and lowered arousal. These disruptions can lead to fatigue, and this is associated with impaired sensory motor performance (such as slower reaction times when operating machinery or driving a car) and negative mood. Accordingly, injury prevention related to fatigue has been identified as a national priority and a number of fatigue countermeasures have been implemented. While all these procedures have potential, in-vehicle technological countermeasures to fatigue are believed to be an important strategy needing research. However, there is little scientific research being conducted in this specific area, and there are few if any published field trials that have been conducted designed to evaluate scientifically the validity of in-vehicle technological countermeasures.

Consequently, the research I am presently supervising with a team of scientists at UTS is focussing on (a) physiological and psychological correlates of driver related fatigue in non-professional and professional drivers (b) the development of platform smart technology that can be utilised as in-vehicle fatigue monitors and (c) conducting scientifically credible field trials to evaluate the efficacy of the in-vehicle technological countermeasures.

Professor Craig (behavioural scientist and psychophysiologist) and his team (senior members being Associate Professor Hung Nguyen, Electrical Engineering, Associate Professor Les Kirkup, Applied Physics; and Mr Paul McIsaac, Senior Science Officer) are experienced researchers in the area of health, neuropsychophysiology and signal processing. Craig and Nguyen are directors of the Key University Research Strength (KURS) in Health Technologies in which fatigue research has a primary role. UTS has identified 10 such research strengths across the university research community, demonstrating the high standing and recognition of our research in the university community.

Current State of the UTS Research and Future Directions

(a) physiological and psychological correlates of driver related fatigue in non-professional and professional drivers

In order to be able to develop in-vehicle technological countermeasures, it was important to establish factors or trends that are associated with fatigue. Our data has been obtained from controlled laboratory based research in which we studied physiological and psychological trends in the brain, in the heart and around the eyes associated with fatigue in non professional and professional (truck) drivers. Subjects were assessed in a driver simulator setting in which they drove for up to 50 minutes. To validate fatigue status, the facial activity of all drivers was taken on video throughout the 50 minutes. Alert baselines, pre fatigue, fatigue onset and post fatigue measurements were taken. The non professional drivers have now been completed and we are currently analysing these results. From the results so far, we believe there are clear brain signal or EEG trends that could be used to predict fatigue. Our research suggests EEG may well be the most promising method of monitoring fatigue. We are due to communicate these results at two international conferences in early 2000, as well as preparing to submit the results to an international science journal. The professional drivers (truck drivers) are presently being completed. We believe we will complete this phase by March, 2000. Funding has recently been won in 1999 (for 2000) from the ARC (Small Grants) to complete this work on professional drivers.

(b) the development of platform technology that can be utilised as in-vehicle fatigue monitors

We are currently developing EEG based technology for the Mind Switch research project (Craig et al., 1997; Kirkup et al., 1997; 1998; Craig et al., 1999). This involves monitoring and filtering brain signals (EEG), allowing a person to control remotely and quickly, electrical devices in their environment. This research is being conducted to develop technology designed to allow profoundly disabled persons to control devices independently in their environment. Prototype Four has now been developed. This work has been funded by an ARC (SPIRT) grant (1999-2001) and by the MAA of NSW (1996-2000).

It is intended that the Mind Switch platform technology and software be adapted for use as an in-vehicle fatigue monitor. We do not see any major obstacles in adapting the Mind Switch platform technology for use as a fatigue monitor. We are currently resolving many of the problems we would encounter in the development of an in-vehicle fatigue monitor, such as controlling the influence of electronic noise on the EEG signal, developing neural network capability for quick recognition of the EEG signal, developing smart electrode technology etc. To continue the development of this technology, funding has been requested from the Motor Accident Authority (MAA).

(c) Future Directions: conducting scientifically credible field trials to evaluate the efficacy of the in-vehicle technological countermeasures

This phase of our research has yet to be completed. We intend to conduct controlled field trials involving the placement of the in-vehicle monitor in a specially adapted car. The performance of the monitor based upon various signals to detect fatigue will be compared. The signals to be used in the monitor will include brain signals or EEG, eye blinks or EOG, and heart activity or ECG. We are presently seeking industrial partners to complete this phase of our research. This will involve collaborating with these partners to seek ARC SPIRT funding in 2000 to raise the capital to complete this research. This research is a matter of urgency, as there has never been such a trial completed.

Application of our Research to Managing Fatigue

The data (fatigue trends) obtained from our work will be used for the development and optimization of technology that could be used to reliably warn of an approaching fatigue state. Such an anti-fatigue device could be used for road, air, train or sea applications. We believe our research will provide needy answers to the efficacy of in-vehicle fatigue monitors.

Brief Summary of the Research Being Conducted on Professional Drivers

All truck drivers have to complete a simulated driving task around a two km track at a constant speed of 60-80 kilometers per hour in a controlled laboratory environment with reduced light and constant temperature.

Measures sensitive to the onset of drowsiness such as electro-occulogram (EOG), electroencephalogram (EEG), electrocardiogram (ECG), video recording of facial movements, psychological assessments, as well as self-report of fatigue are being taken for all truck drivers in a 2-3 hour standardized sensory motor test of simulated driving. Psychological measures are being taken which assesses mood, anxiety, control efficacy, expectation and fatigue status. Signal processing using Fast Fourier Transforms will allow identification of EEG and EOG patterns leading to fatigue. Autonomic changes will also be assessed from heart rate activity. The heart rate variability will be assessed via spectral analysis to isolate sympathetic and parasympathetic activity in the low (7-14 Hz) and high frequency (14-35 Hz) bands respectively. Male truck drivers will be randomly selected from truck companies through advertising in magazine articles. Selection criteria will apply. Active drivers only will be entered into the study (that is those currently employed as truck drivers). The age of the subjects will be restricted from 20 to 60 years, and only healthy subjects will be selected (that is, absence of life threatening disease and sleep apnoea, absence of prescribed CNS drugs). Subjects will be approached for consent to participate before the random selection process occurs. Ethics approval for this research project has been obtained from the UTS Human Research Ethics Committee. Subjects will be asked to refrain from coffee, tea and alcohol 24 hours before the study. Subjects will be tested at a standardised time during the day to control for circadian or diurnal variations.

Research Findings

The majority of the non professional drivers are fatiguing within 20 minutes of driving in the simulator task. Interestingly, the majority of the professional truck drivers are fatiguing within 10 to 15 minutes of driving in the simulator task. Caution must be taken as presently, the results on truck drivers are based on smaller numbers. Preliminary findings confirm that EEG could be used as a fatigue monitor. The subjects studied show significant changes in the magnitude for brain signals, including delta, theta, alpha and beta bands during fatigue as compared to the alert baseline periods. The largest and therefore most promising change was observed in the theta and alpha EEG bands. Substantial trends of increases in grouped alpha waves (8-13 Hz) and increases in theta waves (4-8 Hz) seen during drowsiness and fatigue have also been found.

Furthermore, facial changes (eg. head nodding) have reliably indicated the presence of fatigue. Heart rate decreases with fatigue onset and a relaxation in muscle tone in the face and blinks rates decrease with fatigue following an initial increase in blinking.

Conclusion

Fatigue is a dangerous state when driving. Well conducted scientific research into physiological trends associated with driver fatigue are scarce. Our well controlled research has highlighted the potential of physiological measures such as brain signals to monitor and predict fatigue status in both non professional and professional drivers. Further substantial support is needed to fund research into field trials in which in-vehicle technological fatigue monitors are evaluated for their efficacy in detecting the onset of drowsiness.

References

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