SIMULATORS IN MEDICAL RESEARCH

BM595

MEASURING of ALPHA and DETECTION of FATIQUE during SIMULATED DRIVING

TERM PROJECT

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OUTLINE of the PROJECT

A – MEASURING of ALPHA and DETECTION of FATIQUE during SIMULATED DRIVING

1 INTRODUCTION

The ability of an individual to control and operate a motor vehicle depends upon a wide variety of cognitive skills. While the cognitive processes associated with driving emphasise contributions of planning, memory, psychomotor control, and visual spatial abilities, all depend on the central role of attention. Therefore, the assessment of attentional abilities may prove useful in the assessment of driving abilities.

One problem with attentional tests is that they cannot be used simultaneously with driving as they interfere with the underlying process and distort the fundamental task of driving, when used in the typical divided attention paradigm.

Waller (1992) described the need for using new technologies in transportation research on representative samples of users, particularly in the human factor aspect of highway research. One method of introducing new technology is to make use of simulations and simulators, which have several advantages to research. The benefits of simulators include safety, exposure to high-risk, low likelihood events, and cost-effectiveness. The impact of simulator learning on performance in the real situation has been evaluated, and is standard practice in the aviation, and space industries for example. However, the applications of simulators in driver training have not yet been established as ‘standard’ practice. Simulators have been used to examine participants’ responses to such parameters as road curvature. Evidence to date indicates that driving simulators provide an adequate representation of the real world.

Vehicle simulators can be separated into two distinct types: one is expensive, fully instrumented vehicles, for example the George Washington University, CIS vehicle and the other inexpensive computer game-based simulators, such as ‘Indycar’ (Micropose, 2000), ‘Need for Speed’ (Electronic Arts, 2002), and ‘Grand Prix 2’ (Micropose, 1998). Originally this type of system was considered only as a game. With the advent of more sophisticated graphics cards and monitors, the simulation has become more realistic, especially when coupled with specialist hardware of realistic and familiar vehicle controls. This type of simulation software has a ‘replay’ feature that can be exploited to review performance. The systems are of reasonable integrity, and some International Formula-One teams were reported to be making use of them for driver practice, to allow drivers to ‘learn’ circuits, and consolidate attentional factors associated with the driving task.

2 EEG MEASURES

One method with demonstrated validity for measurement of attention uses brain electrical activity EEG measures. The EEG is known to be responsive to changes in state, particularly the alpha activity. Alpha activity has been sometimes referred to as 'idling' activity, and the reduction in alpha activity as a result of attentional activity is referred to as 'alpha blocking'. Alpha activity and beta activity appear to have an inverse relationship, so that beta activity will increase when processing demands increase. In addition, some researchers found that alpha activity reflects changes in external events such as sensory information, while beta activity reflects internal events such as mental manipulation tasks. This may be simplifying matters greatly, although it is in agreement with the inrattention model of Shaw (1996). The time-varying characteristics of the EEG have been related to temporal attentional events in participants. This dynamic study of alpha activity in response to the changing external environmentis referred to as Event-Related Desynchronization (ERD).

Recent work by the Austrian Simulator Group relates synchronous brain alpha activity to deactivated cortical areas. The presence or absence of phase-locked events and their relationship to ERD and Event Related Synchronization (ERS) is explored in depth . The ERD is related to the Steady State Visually Evoked Potential (SSVEP), and shows similarities in the type of activity and events that reduce the SSVEP and alpha activity. When the ERD is reduced, the SSVEP is also reduced. The ERD is one measure applicable to the assessment of attention.

3 MEASURES OF DRIVER PERFORMANCE

Other parameters that have been recorded during driving studies can be divided into three types physiological, behavioural, and vehicular :

1. Physiological measures include eye movements as measured by the electro-oculogram EOG , electroencephalogram EEG , heart rate, and respiration.
2. Behavioural measures include, inventories of behaviour such as, sleepiness scales, personality scales , and reaction times.
3. Vehicular measures include steering wheel position, lane position, speed, and others.

Studies of all over the world have usually examined one or two of these measures. These measures provide complementary information, and only one large study in the USA involved recording approximately 10 000 hour of all three types of data from 80 truck drivers in California.

The current study will examine aspects of all three parameters in a simulation environment, with particular emphasis on the EEG information in the alpha band (8 -13 Hz). After taking the EEG signals from driver, power spectra of these signals are computed after applying a Hanning window to data segments of 1.28 seconds. From the power spectra the area under the curve is computed for the band alpha (8 -13 Hz) for each channel and segment. These values are normalised with respect to the area under the curve between 0.5 and 26 Hz for each channel and segment, and labelled relative power.

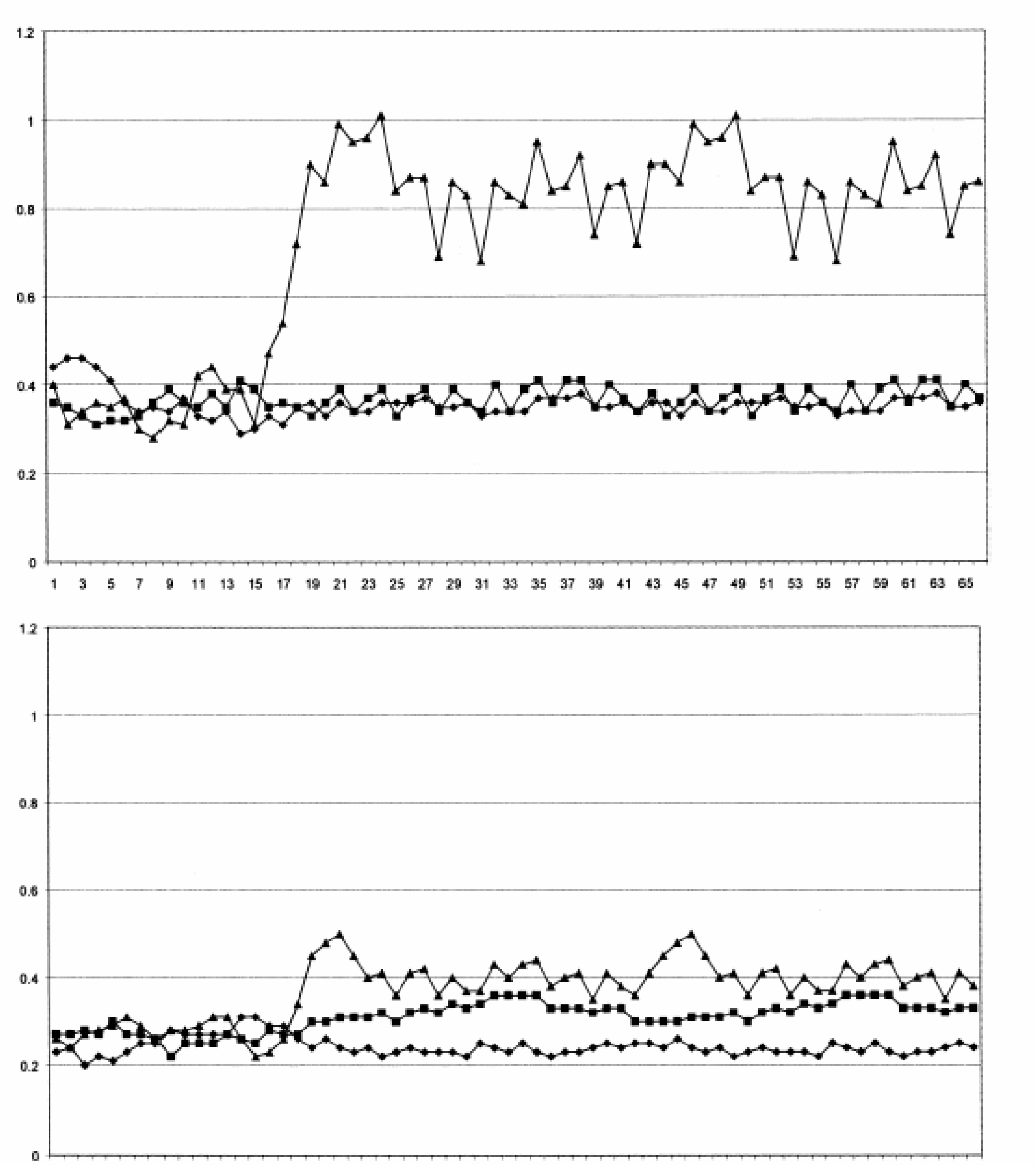

Fig. 1. Relative alpha activity plotted against time or epoch number . The diamonds correspond to driving lap 1, the squares to driving lap 2, and the triangles correspond to the replay of lap 2, respectively. The upper plot is for driver 1 taken from electrode on brain frontal lobe, while the lower is from driver 2 at the same electrode site.

The power spectra are averaged and integrated over a period of 5.12 s to produce dynamic values of alpha for each channel and segment. An increase in alpha activity should be interpreted as less attentional activity, and a decrease as more attentional activity, as the alpha indicates 'idling' activity, or is indexing spare capacity.

4 ANALYSIS of ALPHA ACTIVITY

In the figure, experiments are applied on 2 distinguish person and over 2 laps by Mark A. Schier from Swinburne University of Technology, Melbourne, Australia. The greater alpha activity seen during lap 2 is consistent with fewer attentional resources required once the driver has become used to the circuit. This coincided with known aspects of alpha activity.

The largest changes are seen in the right frontal region site. This is consistent with the reported role of the frontal lobes in attentional systems , and also consistent with the role of the right hemisphere with blood flow measurements during attentional tasks. One possible explanation relates posterior alpha activity to oculomotor control with and without retinal feedback, where using retinal information leads to decreased alpha activity. The design of the current investigation is such that the same stimuli were used in all sections of the experiment, to minimise any such differences in retinal changes during the task.

Differences between the two drivers are evident, in that driver 2 showed a greater difference in relative alpha power between the two laps. The largest effect is seen for the comparison of driving and replay tasks. This is entirely as expected, as the replay task had very few demands compared to driving. This may also be related to the intake vs. rejection model, which would suggest that alpha activity should increase when changing from a largely intake task driving to a mixed intake rejection task watching the replay .

SSVEP when an altered symbol appeared that was expected, but whose exact timing was unknown to the participants. Such expectation altered the magnitude of the SSVEP until after the modified shape had occurred. The spontaneous alpha activity has some relationship to driven frequency , and the same effects could be indexed by spontaneous alpha activity.

5 DETECTION of FATIGUE during DRIVING

Most human manual activities dealing with regulation and control have nowadays been substituted by automatic control. However, there is one major area where manual control by a human operator is still utilized: driving various kinds of vehicles, especially automobiles. In fact, this is one of the most-performed of all human activities. According to a rough estimate, people world-wide devote over 10 million man-years each year to driving automobiles, and this figure is constantly increasing.

The human operator as a controller is very flexible and can learn and adapt to changing ambient conditions, etc. This ability to change his/her properties is a great disadvantage in the case of repeating monotonous activities. During any long-term monotonous activity a human being becomes tired, loses motivation, and his effectiveness as a controller deteriorates considerably. In critical situations his control function diminishes – he/she may fall into a microsleep. Not only long periods of driving can cause this negative phenomenon, but it may also result from initial conditions, or from previous activities. Previous physical activity or sleep deprivation, in particular, has a negative effect. A set of other factors such as age, sex, daytime or night-time driving, driver's circadian rhythms, etc., play an important role.

During long periods of driving or as a result of above-mentioned initial conditions, motivation for steering declines, reaction time extends, short-term memory deteriorates, attention drops, variability of control actions as a response to the same impulse increases, important signals are ignored, decision errors and short-term failures of memory occurs. In extreme case a microsleep comes on. This can have fatal consequences. It is very difficult to prove that an accident was caused by driver fatigue, but the US National Transportation Safety Board estimates that it is the cause of more than 10% of all traffic. 28% of these accidents are fatal. Taking into account the total number of accidents, the losses caused by them reach tens of billions of dollars. The economic and safety reasons mentioned above have led to an attempt to solve this problem by all possible means. Technical means are possibly the most promising. More advanced technological means include automatic freeways and intelligent cars. The intelligent car is assumed to be equipped in such a way that it is capable of analysing the drive signals or physiological signals of the driver, and can warn him in advance that his ability to drive has distinctly worsed due to fatigue, or that he could fall asleep. This is the main motivation underlying our research. We do not suppose that we will able to use the measured data as a basis for predicting the driver will fall asleep, but we aim to provide a warning against enhanced risk, probability or possibility of this event.

6 WHAT IS FATIQUE?

First of all it should be stated that fatigue is very a vague concept used as an umbrella term for phenomena caused by many different factors. Driver's activities can be divided into perception (distinguishing his course, obstacles, signs, optical and acoustical signals, etc.), cognitive activities (decision on appropriate behaviour) and his motorics (his/her control actions, steering movements, braking etc.). All these activities, including functions connected with memory, are influenced by fatigue to a varying extent.

This concept has been referred to by various terms that are more less mutually interchangeable in the research literature. There is no significant difference between "loss of alertness" and "drowsiness". Let us try to define the concept of fatigue. Distinctions are often made between physical and mental fatigue, subjective and objective fatigue. Our interest is focused especially on mental (or central) fatigue. Mental fatigue often follows from physical fatigue, and both are very probably caused by the same physiological mechanism. There is no commonly accepted physiological explanation of the origin of mental fatigue. However, there are hypotheses supported by experimental evidence.

Much more is known about physical (muscular) fatigue. This kind of fatigue is caused by exhausting the sources of energy in the muscles. We know much less about the origin of mental fatigue, which is closely connected with physical fatigue. (Physical fatigue leads to mental fatigue in the case of long-term load.) This connection is carefully explained by a hypothesis of central fatigue which, indeed, is supported by a number of positively proved facts. Briefly, this central fatigue hypothesis claims that a higher level of free tryptophan in conjunction with a lower level of branched chain amino acids increases the level of serotonin in the blood, which is the main cause of central (mental) fatigue.

Central fatigue decreases the number of active motoric units and decreases the frequency of nervous impulses stimulating the motoric units. Further, it diminishes the activity of those parts of the cortex which participate not only in motorics but also in decisive processes. It also leads to a number of other changes which are not really substantial from our point of view.
These facts indicate that most probably, there exists no single measure providing comprehensive information on the degree of fatigue. Online measurement of a driver's tryptophan or serotonin concentration is scarcely possible. Since there are at least five types of membrane receptors for serotonin, its increased concentration may be manifested quite differently in distinct parts of the nervous system. However these facts indicate where we may find indicators carrying most information on fatigue.

Changes in the neuro-motoric system will be most distinctive on the most innerved muscles i.e., eyelid muscles and muscles for eye movement. Changes in cortex activity will be followed by changes in EEG activity, and both will cause secondary changes in the function of autonomous control loops such as heart rate variability. It is clear that degree of fatigue is measurable only indirectly, on the basis of measurement of a lot of signals carrying any information about fatigue. All symptoms extracted from these signals will be called the [4] fatigue indicators.

7 INDICATORS OF FATIGUE

Many physiological measures have been examined in earlier studies as predictors or indicators of driver's fatigue. An enhanced percentage of *eyelid closure* in one of the most reliable predictors of the onset of sleep. However, a camera and demanding eye-tracking software must be used to measure this percentage. As the driver‘s drowsiness increases the *eye movements* slow down, sometimes accompanied by characteristic rolling movements. Eye blinking is also slower and more frequent with increasing level of fatigue. The type and speed of these eye movements can be determined on the basis of analysis of vertical and horizontal electrooculogram (EOG).

Human consciousness and psychological states (among which fatigue belongs) are closely related to brain activity. Variations in the subject’s alertness cause changes in both the temporal and the frequency domain of the EEG signal. It is a well-known fact that states close to sleep are characterized by increasing alpha and theta activities and diminishing amplitude of beta activity. Spectral EEG analysis is the most appropriate method for detecting the onset and different stages of sleep – but automatic evaluation of drowsiness via EEG analysis failed. The EEG of an alert person has proved be very individual, and influenced by many psychological phenomena.

The correlation between changes of heart rhythm and fatigue is still an issue of controversy. Some authors take it for granted, while others reject it. Some sources mention a dependence between skin potential level (SPL) and alertness, but no reliable relation was found, because SPL varied significantly with the subject’s mood, his body activity and temperature. It has been found that facial muscle activity changes according to alertness and drowsiness, but not enough research has been performed in this field.

Measures characterizing the quality of driving performance reflect the driver’s driving skills also affected by fatigue. These measures are obtained via sensors installed in the car. The properties of these measures were thoroughly investigated by Wierwille et al. *Lane-related measures* are computed from the relative position of the car to the lane border.

They include, for example: lane deviation, standard deviation of the lane position, the global maximum lane deviation and the mean square of lane deviation. The last of these is considered to be a reliable measure for detection of fatigue. Another group of measures is derived from the steering wheel position – steering-related measures. The main interest is focused on small steering wheel movements compensating the direction of the moving car. A drowsy driver shows worse sensitivity to small movements and, as a result, the number of micro-wheel adjustments decreases. Steering velocity was found to be highly correlated with eye movements. Heading/lateral acceleration related measures have similar properties as the two previous groups. Global maximum yaw deviation, yaw deviation variance and mean yaw deviation were found as a good predictors of fatigue. The accelerometer's signals are disturbed by the high level of high-frequency noise caused by vibrations of the fast moving car.

Long distance driving affects the *behaviour-related measures* of the driver. Shortly after beginning his drive, the driver frequently looks into his rear view mirror and side window mirrors, and actively watches the road. After 30-60 minutes this activity decreases: the driver prefers to move his eyes rather than turn his head when checking mirrors, and stretches his body when he feels tired. With increasing fatigue he yawns, bends his head to the left or right, takes deep breaths from time to time, and so on. These epiphenomena must be recorded by a camera inside the cabin – and can hardly be evaluated automatically.

8 METHODS to DETECT FATIGUE

The EEG is a generally accepted method to discriminate different stages of wakefulness and indicates variations in vigilance by variations of the power in the **alpha** and theta frequency bands. An increased alpha power and a reduced dominant frequency inidicate a less active state. Unfortunately, a sufficiently high resolution in the frequency domain results in poor time resolution. In contrast we think that the process of diminishing vigilance is not steady, so one has to look for short lapses. Therefore, introducing a new rationale which determines so-called „alpha events“. They describe the development of wakefulness depending on time on task as well as on circadian influences with high resolution.

There are **4 classes of fatigue detection** and prediction technology identified by Dinges and Mallis, (1998):

1. Readiness-to-perform and fitness-for-duty technologies;
2. Mathematical models of alertness dynamics joined with ambulatory technologies;
3. Vehicle-based performance technologies;
4. In-vehicle, on-line, operator status monitoring technologies.

Table: *Readiness – to – perform and fitness – for – duty tests*

Test name	**Described by**	**Measure/s**	**Comments**
Truck Operator Proficiency System	Stein, *et al*. 1990; Charlton & Ashton,1998; Charlton & Baas, 1998.	Psychomotor test,Divided attention test, Part-task computer driving Simulator installed in a trailer. These can be adapted for Australian/ New Zealand conditions.	Developed specifically for detecting truck driver fatigue. Successful validation reported. Been in service in the USA since 1992.
FACTOR 1000	Allen, Stein & Miller, 1990.	Critical Tracking Task (Eye-hand coordination task) based on CTT developed by Jex.	Concern over predictive validity of eye-hand coordination task for divided attention tasks
ART90	Charlton & Ashton, 1998.	Computer-based test battery of 8 to 10 tests including; visual perception, reaction time, concentration, cognitive processing & personality.	Used widely in Europe and elsewhere. Predicted 66% of driving mistakes, 50% of conflicts and 68% of specific driving errors.
FIT[R] 2000 Workplace Safety Screener	PMI Inc. Rockville, Maryland, USA	FIT 2000 is a table top eye testing instrument that gauges fitness for duty by measuring involuntary eye reflexes via a 30 sec viewing test to detect performance impairment.	Only 80% detection of alcohol impairment & only assessed 40% of subjects as high risk after 48 hours awake.
OSPAT	Romteck, Perth WA Australia	Computer-based psychomotor hand-eye coordination test.	Similar to Critical Tracking Task (Factor 1000).
Psychomotor Vigilance Test (PVT)	Dr. David Dinges, University of Pennsylvania	A 10 minute administration of visual reaction time testing via a hand held device.	Principally a research tool and used to validate several of the fatigue detection technologies but could be used to assess fitness.

Fitness-for-duty or readiness-to-perform approaches, which are becoming popular replacements for urine screens for drugs and alcohol, can involve sampling aspects of performance capability or physiological responses. Because these tests are increasingly becoming briefer and more portable, the developers are seeking to extend their use beyond prediction of functional capability at the start of a given work cycle to prediction of capability in future time frames (e.g., whether someone is safe to extend work time at the end of a shift or duty period)

Fitness-for-duty systems attempt to assess the vigilance or alertness capacity of an operator before the work is performed. The main aim is to establish whether the operator is fit for the duration of the duty period, or at the start of an extra period of work. The tests roughly fall into one of two groups: performance-based or measuring ocular physiology.

Application of *mathematical models* that **predict** operator alertness/performance at different times based on interactions of sleep, circadian, and related temporal antecedents of fatigue. This is the subclass of operator-centred technologies that includes those devices that seek to monitor sources of fatigue, such as how much sleep an operator has obtained (via wrist activity monitor) and combine this information with a mathematical model that is designed to predict performance capability over a period of time and when future periods of increased fatigue/sleepiness will occur.

Several *mathematical models* have been devised which may be capable of predicting the level of performance for an individual, based on past sleep and workload factors. These highly Complex algorithms allow for individual patterns of sleep, work and rest to be entered into a system that will then show outputs describing how levels of performance will be affected by the individual's sleep/work history.

As concentrating on *vehicle based performance technologies*, these are directed at measuring the behaviour of the driver by monitoring the transportation hardware systems under the control of the operator, such as truck lane deviation, or steering or speed variability, which are hypothesized to demonstrate identifiable alterations when a driver is fatigued as compared with their 'normal' driving condition." These technologies have a sound basis in research which has shown that vehicle control is impaired by fatigue. However, these technologies are not without their own problems. What for example, is 'normal' or safety critical 'abnormal' variability for these measures? What is the range of 'normal' variability of these measures in the driving population? Could a perfectly safe driver be classified as 'abnormal' on occasions, eg. score a false positive? How has the threshold of 'abnormal' driving behaviour been selected? With rare exceptions these questions are not answered in the product descriptions. Thus these technologies also fail to provide satisfactory answers to the problem of successful validation.

Generally such technologies involve no intrusive monitoring devices and the output relates to the actual performance of the driver controlling the vehicle, hence technologies in this group seemingly have a great deal of face validity, despite the absence of satisfactory information on concurrent and predictive validity.

Driver steering wheel movements are used as the most common indicator of fatigue impairment and are mainly assessed through the reduction in number of micro-corrections to steering, which are necessary for environmental factors such as small road bumps and crosswinds. When these micro-corrections lessen, the operator is defined as being in an impaired state. The Steering Attention Monitor (S.A.M.) is a commercial product currently priced at US $210 that monitors micro-corrective movements in the steering wheel using a magnetic sensor that emits a loud warning sound when it detects 'driver fatigue' by the absence of micro-corrections steering.

Driving steering wheel input monitors have been developed, evaluated and in some instances were even commercially available from certain motor manufacturers (eg Nissan and Renault, and for trucks as described by MAN) main problem with steering wheel input monitors is that they do not really work very effectively, or at least only work in very limited situations. Such monitors are too dependent on the geometric characteristics of the road (and to a lesser extent the kinetic characteristics of the vehicle), thus they can only function reliably on motorways. Thus the approach now being developed by Renault is to integrate steering wheel input data with a video of the driver's face (to monitor eye lid droop). This work is still being developed and evaluated (see below for the difficulties associated with monitoring eye lid droop in the discussion of PERCLOS).

Other technologies measure drivers' acceleration, braking, gear changing, lane deviation and distances between vehicles. One such system is the DAS 2000 Road Alert System that detects and warns drivers that they have inadvertently crossed the centre line or right shoulder lines (in the USA). If either line is crossed without using the turn signals, the computer automatically sounds an audio alarm to alert the driver. No formal evaluation of this system has been located. (The product is available at www.premiersystems.com/market/) However as a very general statement, after reviewing such methods the Accident Research Centre at Monash University Australia (1997) did not recommend them on their own as driver fatigue measures.

The use of several different forms of measurement is attractive to identify fatigue because if one measure fails to detect low arousal, another measure might be expected to pick it up. Most of these multi-sensor or 'hybrid' combinations are still in the prototypic or developmental stage and are yet far from being scientifically validated. For example, a system in the US by scientists from the Applied Advanced Technologies group is being developed as one component of the NHTSA's Intelligent Vehicle Safety System (Carnegie Mellon University, 2000). It aims to combine detection of eyelid movements with lane deviations and steering movements. As discussed the U S Federal Motor Carrier Safety Administration is collaborating with the American Trucking Associations Foundation to test the over the road benefits of combining several fatigue detection technologies including lane tracking. The latter system will be provided by a company called AssistWare Technology (www.assistware.com) . The system is called: SafeTRAC: Drowsy Driver Warning System. It is a Lane Tracker system that mounts a tiny video camera on the windshield of the vehicle, facing outward toward the highway. It looks for lane markings and other road features, and it "senses" the driver's level of alertness by watching for weaving or erratic steering over a short prior history (e.g., 5-10 seconds of immediately previous driving). The system can provide an audible alert, and/or a visual display of vehicle centering or displacement relative to the center of the lane. To our knowledge no validation data have been collected.

Another device is: ZzzzAlert Driver Fatigue Warning System manufactured by DrivAlert Systems, Inc. in Indianapolis, Indiana, USA. Web site: www.zzzzalert.com. The supplier's description is as follows: ZzzzAlert is a small computerized electronic device that monitors corrective movements of the steering wheel with a magnetic sensor. When normal corrective movements cease, within four seconds (setting is adjustable) driver is alerted by an audible alarm. The alarm is automatically reset as soon as normal steering motion is restored. Alarm can be mounted almost anywhere in the truck cab. We know of no validation data on this product.

Another truck or driver weaving detection system is: TravAlert Early Warning System produced by TravAlert Safety International, in Margate, Florida, USA. The supplier's description of TravAlert is as follows: It was developed to loudly notify a motor vehicle operator that he/she has lost attention to the proper steering. TravAlertÆÊ is automatically activated when the speedometer reaches 42 miles per hour (MPH). The Erasable Electrical Programmable Read Only Memory (EEPROM) receives data from the Steering Shaft Sensor relating to motion. If proper driving procedures are followed the alarm will remain silent. If the operator is not attentive to proper steering patterns for a preset delay period (4-13 seconds), the alarm will sound gradually, ramping up to 110 decibels. The system automatically resets when proper steering patterns are resumed. The EEPROM records each alarm allowing for a download of information including real time of alarm, duration of alarm, and total alarms. The system is in no way physically connected to the operator of the vehicle and is completely tamper resistant. We know of no validation data on this product.

The **S**ystem for effective **A**ssessment of the driver state and **V**ehicle control in **E**mergency situations (SAVE system) of Brookhuis, de Waard, Peters, & Bekiaris, (1998), is further developed and has undergone validity testing during 1998. In SAVE a Principal Component Analysis to reduce the data is first conducted, then a Neural Network calculation is conducted to decide on impairment and finally Fuzzy Logic is carried out to arrange the HMI (Human Machine Interface). Currently, the system appears to be detecting around 90% of fatigue cases, suggesting good concurrent validity but there is no formal report on the evaluation of the validity of the system. The use of multiple inputs to a model to detect fatigue requires that the inputs are integrated. Multiple inputs do not increase the likelihood of false alarms but reduce them essentially by checking all inputs. At present this system is still a long way from being commercially available.

As focusing on the last methods, In-vehicle, on-line, operator status monitoring technologies, these includes a broad array of approaches, techniques, and algorithms operating in real time. Technologies in this category seek to record some biobehavioral dimensions of an operator, such as a feature of the eyes, face, head, heart, brain electrical activity, reaction time etc., on-line (i.e., continuously, during driving). As such, in-vehicle, on-line, operator status monitoring is simply the measurement of some physiological/biobehavioural events of the operator whilst in the act of operating the machinery.

Physiological aspects of humans are known to reflect the effects of fatigue or other forms of impairment. A large number of monitors have been developed. The Electroencephalograph (EEG) has been acclaimed as one of the most successful monitors, sensed via an array of small electrodes affixed to the scalp, and examining alpha, beta and theta brain waves to reflect the brain status, identifiable in stages from fully alert, wide awake brain, through to the various identifiable states of sleep. EEG monitors are, however, not very practical for in-vehicle use. One such device that does not require such intrusive electrodes is the ‘Mind Switch’, currently being developed at the University of Sydney; instead it employs a (slightly less intrusive) headband in which the electrodes are embedded or positioned to make contact with the driver's scalp to monitor brainwaves. However, it will be some time before a prototype is ready and the validity and practicality of the device can be established.

As well as concerning of ocular measures, measure eye closure, eye movements or ocular physiology would appear to be a very suitable method to monitor driver fatigue. The fundamental premise is that eye behaviour can provide significant information about a driver’s alertness, and that if such visual/ocular behaviour can be measured then it would be feasible to predict a driver’s state of drowsiness, vigilance or attentiveness with regard to the driving task.

A plethora of eye blinking, pupil response, eye closure or eye movement monitors have been developed to assess driver fatigue, most of these however, have only reached the stage of being tested in the laboratory/simulator as a kind of ‘proof-of-concept’. Whether such techniques can be successfully employed in the vehicle in real driving conditions is stil largely a matter for intensive research and development and on the road testing. A wide-ranging, recent evaluation of techniques for ocular measurement as an index for fatigue in which the 6 techniques were compared: an eye closure rating (PERCLOS), two EEG algorithms (Consolidated Research Inc, EEG algorithm, and Dr. Makeig’s EEG algorithm), a head position monitoring device (Advance Safety Concepts Proximity Array Sensing System) and two Eye blink monitors (MTI Research, Inc. Alertness Monitor, and IM Systems, Inc. Blinkometer). The results found that nearly all the devices showed potential for detection of drowsiness-induced hypovigilance in at least one subject or subset of subjects. However, only one technology produced results (both intra-subject and inter-subject) that correlated with the validation criterion variable (psychomotor vigilance task performance lapses). Thus while all technologies showed some promise, the most effective performer was the eye closure rating called PERCLOS. It should be noted that the validation was against the vigilance task and not against driving behaviour or crashes, which raises the question of the predictive validity of the vigilance task for crashes.

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