BEHAVIOURAL ROAD SAFETY MANAGEMENT

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ABSTRACT

Task performance and fatigue during driving may be influenced by psychological factors since individuals differ in temperament and anxiety status. Fatigue has also been shown to be associated with changes in brain wave activity. However, research on psychophysiological associations with driver fatigue is scarce. Understanding the psychological links could provide information for educating the professional driver on fatigue management. We have in our previous research identified the psychological associations during driver fatigue for the development of fatigue management programs. Psychological profiles influence the fatigue state of a person (1,2&3). It has been found that increased anxiety, and negative mood states such as Tension-Anxiety and Fatigue-Inertia are associated with other direct indicators of fatigue such as physiological activity (2).

In can be concluded from our investigations in this area that driver fatigue is influenced by psychological factors and reducing anxiety as well as increasing positive mood states may help control fatigue effects. Important psychophysiological information for educating drivers on fatigue management is now available (3,4). There are implications the for application of neurofeedback techniques to reduce and manage driver fatigue. Such driver fatigue educational programs will lead to safer road practices.

INTRODUCTION

Driver related sleepiness and fatigue are believed to be significant causes of traffic accidents. While numerous physiological indicators are available to measure levels of driver fatigue, the electroencephalography (EEG) signal may be one of the most predictive and reliable (1,2). However, EEG is still relatively new in the area of investigating the psychology of fatigue. Few studies have investigated the psychological associations of mood states, anxiety levels and locus of control with driver fatigue. In our recent study we found associations between psychological factors such as mood, anxiety and driver fatigue (3). Driver fatigue has been specifically defined as a state of reduced mental alertness that impairs performance of a range of cognitive and psychomotor tasks including driving (4) It generally impairs human efficiency when individuals continue working after the onset of their fatigue state. However, task performance during driving may be influenced by psychological factors because individuals differ in attention and anxiety status. An early study of sustained performance in a flight simulator by Bartlett (5) showed that as performance time on a task increased, changes in attention with an increase in errors occurred. It has been suggested that fatigue could be experienced differently by drivers with different psychological profiles and temperament (6). Other studies have indicated associations between brain activity and psychological factors such as anxiety (7). Lal et al. (8) have recently shown that mood and anxiety levels can influence task performance and outcomes. Although some studies have examined the neurophysiological concomitants of anxiety, firm conclusions about regional brain function associated with anxiety have been difficult to validate.

Investigators have suggested that when long lasting theta waves appear, a rest period should be considered before the subjects become fatigued (9). Deteriorated performance has been associated with increased theta and changes in alpha intensity while beta activity has also been shown to be altered (10). Makeig and Jung (11) also found changes in theta and alpha waves related to fatigue. It has been suggested that in order to improve performance of people who are involved in long-term monitoring activities and monotonous tasks, such as drivers and operators, they should be taught to suppress theta (12). The question that now needs further clarification is which psychological factors influence fatigue during a driving task before the driver is made aware of these factors and taught to control them. Understanding the psychological links to fatigue could provide useful information which may be utilised for fatigue management such as improving task performance and increasing attention levels in drivers using biofeedback and fatigue awareness programs.

DISCUSSION

The nature of driving requires cognitive effort, such as sustained vigilance, selective attention, complex decision-making and the exercise of largely automated perceptual motor-control skills (13). In early research, fatigue was conceptualised as a generalised response to stress experienced over time (14). Fatigue could therefore be viewed as a condition determined by both physiological and psychological factors. The current research aimed to isolate any psychological factors that may be associated with physiological changes in the EEG that occur during fatigue.

In a recent study, Lal and Craig, 2002 showed that psychological factors such as mood and anxiety affect cognitive task performance. In the current study, it was found that increased trait and state anxiety, and negative mood states such as Tension-Anxiety and Fatigue-Inertia were associated with EEG indicators of fatigue such as increased delta and theta levels (3). The results of Lal & Craig' study suggest that having higher levels of anxiety are associated with higher levels of theta activity (3). Therefore, it is possible that increased anxiety status raises the potential to become fatigued. The results also indicated that having a higher Tension-Anxiety level (heightened musculoskeletal tension) also increases risks of experiencing fatigue. The Tension-Anxiety mood sub-scale incorporates somatic tension as well as observable psychomotor manifestations such as 'shaky' and 'restless'. It also refers to vague and diffuse anxiety states (15). The results suggest that fatigue effects may be reduced if subjects can be taught to reduce fatigue related slow wave activity such as delta and theta using EEG biofeedback. For example, beta enhancement and theta suppression using biofeedback may help maintain task performance that requires continuous attention such as during driving. Neurofeedback has been shown to be successful in reducing depression, over-emotionality, anxiety and fatigue (16).

Lal and Craig, 2002 (3) have also found Fatigue-Inertia to be positively correlated to the EEG of fatigue. Fatigue-Inertia represents a mood of weariness, inertia and low energy levels. Not surprisingly, Vigor-Activity was negatively associated with increased delta activity occurring during fatigue. As the name suggests, this factor indicates a lack of vigorousness and high energy (15). Increased trait anxiety levels predicted theta increase and Fatigue-Inertia predicted beta changes during fatigue.

Trait-anxiety refers to relatively stable individual differences in anxiety-proneness, that is, to differences between people in the tendency to perceive stressful situations as dangerous or threatening and to respond to such situations with elevations in the intensity of their state anxiety reactions (17). It is important to distinguish the effects of the two types of anxiety (state-trait anxiety and Tension-Anxiety, a mood sub-scale) (15, 17). Distinguishing types of anxiety may clarify the different associations found between brain activity and anxiety. For example, anxious apprehension and anxious arousal have been hypothesised to be psychologically distinct phenomena. Studies on regional brain activity have shown these two to be distinguished neurophysiologically (7). Therefore, in studies of brain activity for anxiety and mood states, it is important to specify the type of anxiety under examination. Lal and Craig's research suggests that being more anxious, having higher levels of psychomotor tension, cognitive inefficiency and low energy levels may hinder performance by raising the chances of becoming fatigued (3). This is the first study that has identified the possibility that mood states such as vigour, fatigue and anxiety may affect a driver's fatigue state and performance. Driver education on psychological factors associated with fatigue could raise the driver's awareness of variables that are likely to impair driving performance. This study also has implications for neurofeedback techniques, which may be utilised to manage driver fatigue.

From the self-rated Fatigue State questionnaire Lal and Craig, 2002 that similar numbers of subjects were suffering from physical (66%-89%) and mental fatigue (69%-86%) on the day of the study, similar to what they normally experience. However, the remainder of subjects reported that their fatigue levels were worse or much worse than usual (3). Given that the subjective component of fatigue is very important, questionnaire investigations may be beneficial in the study of driver fatigue. Physical fatigue impairs co-ordination and increases chances of errors and accidents (16). Mental fatigue is believed to be a gradual and cumulative process that is linked to disinclination for any effort, reduced efficiency and alertness and impaired mental performance (18,19). However, it should be understood that many factors could influence fatigue such as recuperation periods (20) and the environment and physical activity (21)

The findings from Lal & Craig's study suggest that assessment of mood states, anxiety as well as self-reported fatigue levels in drivers will provide information on psychological factors that are associated with fatigue (3). Educating the driver to control mood and anxiety levels can reduce fatigue effects. The results have implications for application of neurofeedback techniques to reduce and manage driver fatigue.

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REFERENCES

1. Lal, S. K. L. & Craig, A. A critical review of the psychophysiology of driver fatigue. Biological Psychology, 2001a, 55, 173-194.

2. Lal, S.K.L. & Craig, A. Electroencephalography activity associated with driver fatigue: implications for a fatigue countermeasure device, Journal of Psychophysiology, 2001b, 15, 183-189.
3. Lal S.K.L. and Craig A. (2002) Driver Fatigue: electroencephalography and psychological assessment. Psychophysiology, 39, 1-9.
4. Lal S.K.L and Craig A. (2001c). Driver Fatigue: Psychological and Electroencephalography assessment. 2001a. 154-160. Road Safety Research Education and Policing Conference, Australia.
5. Bartlett, F.C. (1943). Fatigue following highly skilled work. *Proceedings of the Royal Society, B, 131*, 248-257.
6. Brown, I. D. & Eng, C. Car driving and fatigue. Triangle 1967, 8(4), 131-137.
7. Heller, W., Nitschke, J. B., Etienne, M. A., & Miller, G. A. Patterns of regional brain activity differentiate types of anxiety. Journal of Abnormal Psychology, 1997, 106(3), 376-385.
8. Lal, S.K.L., Henderson, R.J., Carter, N., Bath, A., Hart, M.G., Langeluddecke, P., & Hunyor, S.N. Effect of feedback signal and psychological characteristics on blood pressure self-manipulation capability. *Psychophysiology,* 1998, 35 (4): 405-412.
9. Yamamoto, S., & Matsuoka, S. Topographic EEG study of visual display terminal (VDT) performance with special reference to frontal midline theta waves. *Brain Topography*, 1990, 2 (4): 257-267.
10. Townsend, R. E. & Johnson, L. C. Relation of frequency-analyzed EEG to monitoring behavior. Neurophysiology, 1979, 47, 272-279.
11. Makeig, S., & Jung, T. Changes in alertness are a principal component of variance in the EEG spectrum. *NeuroReport*, 1995, 7: 213-216.
12. Andreassi, J. L. (2000). The EEG and behavior: sensation, attention, perception, conditioning, and sleep. In J.L.Andreassi (Ed.), Psychophysiology: human behavior and physiological response (4th ed., pp. 61-84). London: Lawrence Erlbaum Associates.
13. Brown, I. Driver fatigue. Human Factors, 1994, 36, 298-314.
14. Cameron, C. A theory of fatigue. Ergonomics, 1973, 16(5), 633-648.
15. McNair, D. M., Lorr, M., & Droppleman, L. F. (1971). Edits Manual. Profile of mood states. San Diego, CA: Educational and Industrial Testing Service.
16. Hammond, D.C. Neurofeedback treatment of depression with the Roshi. Journal of Neurotherapy. 2000, 5, 45-56.
17. Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). State-Trait Anxiety Inventory. (Vols. Form Y) Palo, Alto, CA: Consulting Psychologists Press.
18. Grandjean, E. Fatigue in industry. British Journal of Internal Medicine, 1979, 36, 175-186.
19. Grandjean, E. (1988). Fitting the task to the man. London: Taylor and Francis.
20. Okogbaa, O., Shell, R., & Filipusic, D. On the investigation of the neurophysiological correlates of knowledge worker mental fatigue using the EEG signal. Applied Ergonomics, 1994, 25, 355-365.
21. Sjoberg, H. Physical fitness and mental performance during and after mental work. Ergonomics, 1980, 23(10), 977-985.