Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 111 (2014) 955 – 964

Procedia
Social and Behavioral Sciences

EWGT2013 – 16th Meeting of the EURO Working Group on Transportation

Effects of driver task-related fatigue on driving performance

Massimiliano Gastaldi [a,]*, Riccardo Rossi [a], Gregorio Gecchele [a]

[a]*Department of Civil, Environmental and Architectural Engineering, University of Padova, Via Marzolo, 9, 35131 Padova, Italy*

Abstract

In this study, passive task-related fatigue effects on highway driving were analyzed by means of driving simulator experiments. Ten drivers were asked to drive in various environments in the morning (9:00-11:00 a.m.) and early afternoon (1:00-3:00 p.m.). Mean of Absolute Steering Error and Standard Deviation of Lateral Position, calculated on sub-intervals of 4 minutes, were analysed as response variables. The results confirmed the negative influence of the duration of driving tasks and circadian effects on driving performance, increasing the likelihood of "near misses" and accidents.

Keywords: Driving Simulator; Fatigue; Monotony.

1. Introduction

There is converging evidence from analysis of road safety statistics that driver fatigue is a contributing factor in many accidents and that every year about 20% of total accidents are related to sleepiness (MacLean, Davies, & Thiele, 2003). According to the sub-categorization of the fatigue concept of May and Baldwin (2009), this paper examines the passive task-related (TR) effects of highway driving. The main aim of the study is to evaluate the separate relative importance of each effect in the fatigued state.

The analysis is based on results from driving simulator experiments (conducted at the Transportation Laboratory, University of Padova), widely adopted in recent years for this kind of study. The aim of the research is better comprehension of driving fatigue phenomena, which can affect methods and/or equipment intended to reduce the risk of accidents and to enhance driving safety.

* Corresponding author. Tel.: +39-049-827-5574; fax: +39-049-827-5577.
E-mail address: massimiliano.gastaldi@unipd.it.

doi:10.1016/j.sbspro.2014.01.130

The paper is organized as follows: Section 2 gives a brief description of previous works concerning driving fatigue. Section 3 describes the laboratory experimental design and Section 4 deals with case-study analysis. Concluding remarks and future developments are presented in Section 5.

2. Theoretical background

The analysis presented here is based on the study by May and Baldwin (2009), who proposed a sub-categorization for fatigue based on its causal factors (Figure 1), i.e., making a distinction between sleep-related (SR) and task-related (TR) fatigue.

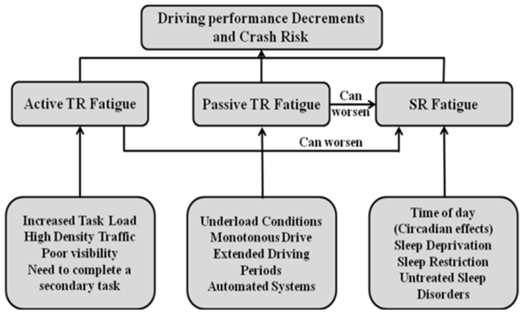

Fig. 1. A model of fatigue. Source: (May & Baldwin, 2009)

SR decrements in driving performance are related to the circadian rhythm (i.e., time of day), sleep disorders, and sleep deprivation or restriction. The body's natural circadian rhythm controls sleep/wake alternation during the day, including a loss of attentiveness in the early afternoon, when people are sleepier. Decrements in driving performance as effects of the circadian rhythm have been examined in previous driving simulator studies (e.g., Lenné, Triggs, & Redman, 1997) and may be correlated to the increased numbers of sleep-related car accidents observed at the peaks of sleep needs (Pack, Pack, Rogman, Cucchiara, Dinges, & Schwab, 1995) in the early morning (2–6 a.m.) and early afternoon (2-4 p.m.). Similarly, sleep deprivation or restriction causes impaired driving performance (Akersted et al., 2010).

Instead, TR fatigue depends on driving conditions (Figure 1): active and passive task-related fatigue may arise according to the combination of driving task and driving environment. Active TR fatigue is related to overload (high-demand) driving conditions [(Gimeno, Cerezuela, & Montanes, 2006); (Desmond & Hancock, 2001)], which include driving in high traffic density, poor visibility, or being required to perform an auxiliary secondary task in addition to driving, e.g., cell-phone conversations, in-car passenger conversations, auditory tips from navigation systems, or auditory alerts from driver warning systems. Passive TR fatigue is associated with underload driving conditions, which include driving in monotonous environments for extended periods of time, or partially/completely automated driving tasks (Gimeno, Cerezuela, & Montanes, 2006).

In fatigue studies, the use of driving simulators has been widely adopted in recent years [(Ting, Hwang, Doong, & Jeng, 2008); (Philip et al., 2005), (Thiffault & Bergeron, 2003)], in view of the opportunity of analysing hazardous driving conditions in a safe environment, to control effects induced by subjects' characteristics, and to measure changes in driving performance accurately. However, May and Baldwin (2009) argued that, in most studies, the experiments confused different causes of fatigue, focusing, for example, on circadian rhythm effects (SR-Fatigue) during highway driving performance (TR-Fatigue).

As a consequence of these remarks, in this paper we focus on analysis of passive task-related (TR) effects of highway driving in monotonous environments, studying the temporal evolution of performance indicators, with