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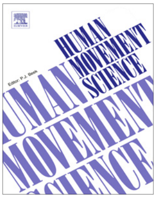

The role of motion platform on postural instability and head vibration exposure at driving simulators ☆

B. Aykent [a,*], F. Merienne [a], D. Paillot [a], A. Kemeny [a,b]

[a] CNRS Le2i Arts et Metiers ParisTech, 2 Rue T. Dumorey, 71100 Chalon sur Saone, France
[b] Technical Centre for Simulation, Renault, Guyancourt, France

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ABSTRACT

This paper explains the effect of a motion platform for driving simulators on postural instability and head vibration exposure. The sensed head level-vehicle (visual cues) level longitudinal and lateral accelerations ($a_{x,\text{sensed}} = a_{x\_\text{head}}$ and $a_{y,\text{sensed}} = a_{y\_\text{head}}$, $a_{yv} = a_{y\_\text{veh}}$ and $a_{yv} = a_{y\_\text{veh}}$) were saved by using a motion tracking sensor and a simulation software respectively. Then, associated vibration dose values (VDVs) were computed at head level during the driving sessions. Furthermore, the postural instabilities of the participants were measured as longitudinal and lateral subject body centre of pressure (X_{CP} and $Y_{CP,}$ respectively) displacements just after each driving session via a balance platform. The results revealed that the optic-head inertial level longitudinal accelerations indicated a negative non-significant correlation ($r = -.203$, $p = .154 > .05$) for the static case, whereas the optic-head inertial longitudinal accelerations depicted a so small negative non-significant correlation ($r = -.066$, $p = .643 > .05$) that can be negligible for the dynamic condition. The X_{CP} for the dynamic case indicated a significant higher value than the static situation ($t(47)$, $p < .0001$). The VDV_x for the dynamic case yielded a significant higher value than the static situation ($U(47)$, $p < .0001$). The optic-head inertial lateral accelerations resulted a negative significant correlation ($r = -.376$, $p = .007 < .05$) for the static platform, whereas the optic-head inertial lateral accelerations showed a positive significant correlation ($r = .418$, $p = .002 < .05$) at dynamic platform

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* Corresponding author. Tel.: +33 (0) 385909865; fax: +33 (0) 385909861.
E-mail address: b.aykent@gmail.com (B. Aykent).

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condition. The VDV_y for the static case indicated a significant higher value rather than the dynamic situation ($U(47)$, $p < .0001$). The Y_{CP} for the static case yielded significantly higher than the dynamic situation ($t(47)$, $p = .001 < 0.05$).

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1. Introduction

There are so many implications to be fullfilled in the area of driving simulators. The most important of them is to sustain the reality for the represented dynamics. The major leading problems are the restricted workspace of the driving simulator and whether a motion base exists integrated with the driving simulator. The first driving simulators were fixed-base and the simulation was principally performed by the visual stimulus (Bertin & Berthoz, 2004; Stratulat, Roussarie, Vercher, & Bourdin, 2010) to create the self-motion perception. This perception is based upon the principle of visual scene flow on the retina referring to the velocity, direction of the motion and the relative distances (Bremmer, Kubischik, Pekel, Lappe, & Hoffmann, 1999).

For the static platformed driving simulators, illusory self-motion 'vection' often occurs because the driver is stationary and the visual scenario is mobile (Berthoz, Pavard, & Young, 1975; DiZio & Lackner, 1989; Draper, 1998; Hettinger, 2002; Hettinger, Berbaum, Kennedy, Dunlap, & Nolan, 1990; Hettinger & Riccio, 1992; Kolasinski, 1995; Lepecq et al., 2006; McCauley & Sharkey, 1992).

The incompetencies in the domain of driving simulators, whether they are fixed or motion base simulators, might make the motion sickness an inevitable topic for the development of the researches undertaken.

The methods of evaluating and measuring the motion sickness divesifies depending on the type of the research. In general, there are some ways to assess the sickness level. Some methods refer to the measurements of head level, postural, vehicle and motion platform level dynamics; whereas the verbal methods imply the evaluation via Simulator Sickness Questionnaires (SSQ). Driving simulation sickness was assessed between dynamic and static simulators in some studies (Curry, Artz, Cathey, Grant, & Greenberg, 2002; Watson, 2000). A relation was made between the illness and the head movements of the pilot in absence and presence of the motion base (Kennedy, 1987). A significant reduction in motion sickness occurs when an individual adopts a postural position was expressed in (Reason & Brand, 1975). "Postural instability theory" was introduced also to define relations between perception and the control of action by (Riccio & Stoffregen, 1991). This approach considers the behavior of the individual as fundamental in motion sickness etiology. The postural instability theory of motion sickness presumes that motion sickness is resulted and estimated by instabilities in control of the spine. This was attributed to constraints in motion of the head. Relations were declared between head motions and motion sickness through the mechanisms of Coriolis (with actual inertial cues: motion platform) and pseudo-Coriolis (through visual cues) stimulation (Kennedy et al., 1987; Reason & Brand, 1975). Coriolis stimulation occurs when the head is tilted out of the axis of rotation during actual body rotation (Dichgans & Brandt, 1973; DiZio & Lackner, 1988, 1989; Guedry, 1964; Guedry & Montague, 1961). Pseudo-Coriolis stimulation occurs when the head is tilted as perceived self-rotation that is induced by visual stimuli (Dizio & Lackner, 1989).

In a moving-base simulator, the subjects' head movements were similar to those in the actual vehicle according to those studies in (Dichgans & Brandt, 1973; Dizio & Lackner, 1988, 1989; Guedry, 1964; Guedry & Montague, 1961; Kennedy et al., 1987) where the head movements in fixed-base simulators were often in conflict with the inertial stimulus, which increased the discrepancy of the simulation (Dizio & Lackner, 1989).

Another research on the motion platform effects revealed that using active platform driving simulator yielded more realistic optic-head inertial cues, in other words less conflict, at the lateral