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Effect of improving gravito-inertial force of the vehicle occupants in reducing severity of motion sickness

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Keywords: Gravito-inertial force; motion sickness; haptic movement

ABSTRACT – Involuntarily motions during cornering inside a vehicle can lead to misalignment between the head and the gravito-inertial force (GIF) vectors of the occupant and can induce motion sickness symptoms. This study explored an active movement mechanism as a counter measure in mitigating motion sickness. Eighteen participants took part in this within-subjects study. They were driven around a pre-determined route in an instrumented car while reading a text on a tablet. The level of motion sickness was assessed by questionnaires. The results showed that the motion sickness level could be reduced when the misalignment between the head and the GIF vectors is reduced.

1. INTRODUCTION

When driving a conventional car, the driver is rarely susceptible to motion sickness (MS) although he/she is exposed to the same motion experienced by the passengers. This is because when taking a corner, drivers usually do not just lean but also tilt their head toward the curve centre or toward the origin of the centrifugal force, whereas passengers' head usually tilts in the opposite direction. The changes of head orientation relative to the gravity vector, is called gravito-inertial force (GIF).

This misalignment of head orientation relative to the GIF can provoke carsickness or MS. Anyone that experience MS will have uncomfortable feeling with symptoms such as dizziness, sweating, headaches, drowsiness, and vomiting. The severity of MS will be intensified when the repetitive of the cornering is too frequent such as riding in a vehicle on a winding road with a reverse curve [1]. In addition, engaging in a non-driving related task such as reading a book while traveling worsen the MS effect [2].

Passenger that actively tilting the head against centrifugal acceleration force can reduce the severity of MS [3]. However, this condition only possible if the passenger is aware of the immediate trajectory of the vehicle, and they did not engaging in any non-driving related task that required their eyesight. Hence, the objective of this study is to explore a mechanism that actively pushes or holds the participants' body in reducing MS severity while engaging in a non-driving related task.

2. METHODOLOGY

Two separate test runs were conducted on the real road environment. Twenty participants (12 male, 8 female), aged between 18 and 47 years old took part in the first test run and 18 participants (9 males and 9 females), aged between 22 and 33 years old participated in the second test run. All participants have almost similar level of susceptibility to MS that based on Motion Sickness Susceptibility Questionnaire (MSSQ) [4].

The Mobility Lab, an instrumented car, was used as the test platform [5]. The defensive driving style [6] was implemented in both test runs to maintain the same induce forces in all test sessions. Based on ISO 2631-1, Motion Sickness Dose Value (MSDV) and Power Spectral Density (PSD) was used to evaluate the induce forces in tri-axial directions (longitudinal, lateral, and vertical).

Wizard of Oz method was used in conducting this study. An experimenter is the one who interacted directly with the participants for the whole study while a driving wizard the one who is simulating the defensive driving style. The details of the study setup can be found in [7]. The test runs were conducted on the Eindhoven University of Technology's terrain and this study is compliant with the Netherlands Code of Conduct for Scientific Practice (principle 1.2 on page 5).

In the first test run, a prototype that providing an information of immediate trajectory of the vehicle through vibrating sensation on the forearms was implemented [7]. In the second test drive, a similar prototype as in the first test run was implemented too. However, an additional mechanism that providing active movement to the participants' body was introduced (Figure 1). Two movable plates, covered with form cushion and fabric, are fixed on the backrest of the car seat. When entering a corner, the movable plate (the left plate if turning to the right, and vice versa) is activated to turn forward about 40°. This angle was calculated to align the GIF of the participant at about 16° in countering the

0.29 g of lateral acceleration in the defensive driving style [6]. The activation of the mechanism is triggered manually by an experimenter.

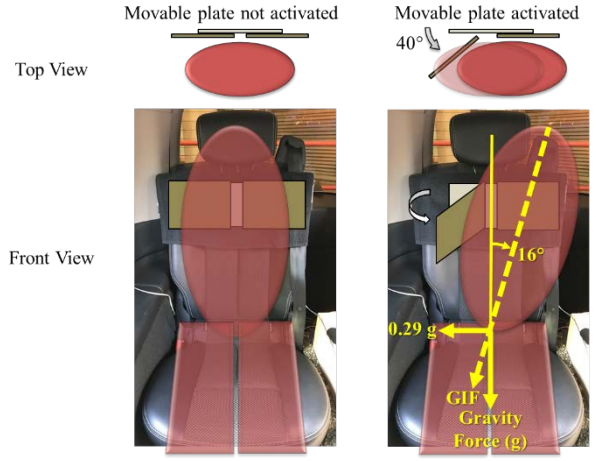

Figure 1 The tilted angle of the GIF from the moveable plate [1].

Motion Sickness Assessment Questionnaire (MSAQ) was used to evaluate motion sickness of the participants [8]. It is a multidimensional questionnaire that use a 9-point Likert scale, resulting in one cumulative percentage score from 0.0 % (no symptoms) to 88.9 % (all items have maximum scored).

3. RESULTS AND DISCUSSION

Table 1 shows the total MSAQ result as a subjective measurement. Although there is a decrease in the mean of MS level (from 15.2 % to 12.9%), the result revealed that there was no statistically significant different between with and without mechanism that providing active movement to the participants' body ($p > 0.05$).

Table 1 Results of statistical analysis on Total MSAQ.

Test Run	Mean	SD	Paired Samples *T*-Test
1	15.2	4.7	95% CI [-5.848, 10.400] t (17) = 0.591, d = 0.139, p = 0.562
2	12.9	16.6	

Based on the observation recording that available inside the Mobility (Figure 2), the participants' head was seen passively move in the opposite direction of the corner (similar to the passenger's head in daily commute).

This observation shows that the prototype in the second test run only restrains the passengers' body from moving in the opposite direction of the corner, but their head still can freely move to any direction.

4. CONCLUSION

Although not significant, the result shows that the implementation of the prototype in the second test run have an effect on the level of MS. Further development will be done on the prototype in gaining results that are more promising.

Figure 2 Example of a video recording of the test run.

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Editorial Preface

This open access e-proceedings contains a compilation of 170 selected papers from the 7th Mechanical Engineering Research Day (MERD'20) that was held virtually at Kampus Teknologi UTeM, Melaka, Malaysia, on 16 December 2020. The event was jointly organized by the Faculty of Mechanical Engineering and Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka. This year, MERD is also be co-organized by Graduate School of Engineering, Nagoya University, Japan.

It was gratifying to all of us when the response for MERD'20 is overwhelming as the technical committees received 230 submissions from various areas of mechanical engineering and related fields to facilitate the mutual understanding of fundamentals, theory and applications including Automotive, Additive Manufacturing, Advanced Materials and Processes, Computer Modeling and Simulation, CBM, Mechanical Vibration and Control, Energy Engineering and Management, Engineering Education, Mechanical Design and Optimization, Structural and Mechanical Testing, Surface Engineering and Tribology, Thermal and Fluids. All submitted papers are then peer-reviewed, revised according to the reviewers' comments and ultimately 170 papers were accepted for publication in this proceeding. This open access e-proceedings can be viewed or downloaded via www3.utem.edu.my/care/proceedings. We hope that this proceeding will serve as a valuable reference for researchers.

With the large number of submissions, the event has achieved its main objective which is to bring together educators, researchers, and practitioners to share their findings and perhaps sustaining the research culture in the university and industry.

As the editors-in-chief, we would like to express our gratitude to the fellow review members for their tireless effort in reviewing the submitted papers for this proceeding. We also would like to say special thanks to all the authors for promptly revising their papers according to the proceeding requirements. Special thanks are extended to the organizer of the MERD'20.

Thank you

Mohd Fadzli Bin Abdollah
Hilmi Amiruddin
Amrik Singh Phawan Singh
Editors-in-Chief
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