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Comparative evaluation of two peripheral information systems using motion sickness subjective rating

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ABSTRACT – Motion sickness (MS) mitigation devices have gained attention in the research related to automated vehicle (AV) driving. While different modalities have been proposed, the visual-related modality has shown promises as most activities inside the AV. In this study, we measured the level of MS experienced by the 38 participants using two visual-based prototypes when they underwent the automated driving test rides. Results indicated that participants experienced less MS when using P1 than P2.

1. INTRODUCTION

In the coming age of automated vehicle (AV), users are no longer have to drive. Therefore, they can indulge themselves in engaging in the non-driving related task (NDRT). However, it is predicted that the users who perform NDRT will be susceptible to motion sickness (MS) [1]. To make matters worse, travelling in an AV would also expose the occupants to low-frequency accelerations that are known to amplify the experienced MS. The possible preventions and treatment of MS are either not practical or will degrade the experience when engaging in the NDRT in AV. It is ideal for keeping informing the occupants regarding the information that will lower the risk of getting MS but at the same time, allow them to indulge in their preferred activities. One way to deliver the information mentioned above is by using a peripheral information system (PIS) [2-3].

One of the modalities that can be both aesthetic and informative is a visual-based PIS that is placed in the peripheral visual field. In this study, the performance of two visual-based PIS will be evaluated based on the subjective evaluation of the level of experienced MS by 38 participants.

2. METHODOLOGY

The Motion Sickness Dose Value (MDSV) was used to characterize the vehicle's motion in relation to MS. MSDV was calculated based on the collected data on acceleration in the longitudinal (x-axis), lateral (y-axis), and vertical (z-axis). The equation of MSDV is shown in Equation (1).

$$MSDV = \sqrt{\int_0^T [a_w(t)]^2 \, dt} \qquad (1)$$

Where a_w is the root mean square of the acceleration that has been weighted with frequency-weighing and T is the exposure period to the motion. MSDV can be calculated individually in each of the three axes.

In this study, two separate AV test runs on the real road setting was performed using AV defensive driving style [4]. In the first AV, test runs with the first prototype (P1), while performing watching a movie as the NDRT. While in the second AV test runs, the second prototype (P2) was tested with reading as NDRT. The generated Motion Sickness Dose Value (MDSV) in the lateral direction was 7.012 $ms^{-1.5}$ for P1 and 9.028 $ms^{-1.5}$ for P2. P1 was designed to deliver the information regarding the intention of the AV (turning to the right or left) that is abstracted into light movement (see Figure 1) and consists of two displays, right and left, where each display comprises of 32 LED lights under a customized 3D-printed cover. See [3] for more information.

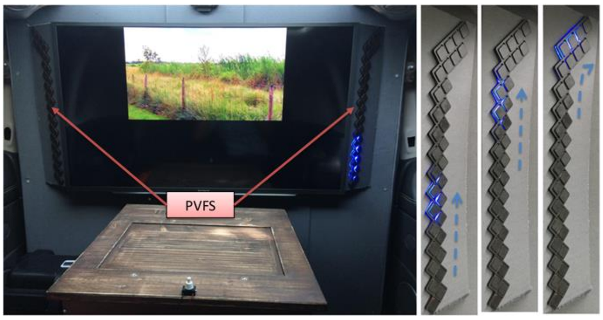

Figure 1 P1 prototype (Source: [3]).

For P2, it was also used to provide navigational information of the AV. The P2 consisted of a 4.0 inches display and two LED-filled arrangements, at around an 8.9 inches tablet (see Figure 2). Each of the arrangements was fitted with 7 blue-emitting LEDs that switched on 3 seconds before the test vehicle entered a corner/turning. Further information can be accessed in [5]. Twenty participants (13 males and 7 females) aged between 18 and 33 years old (Mean = 26.2, SD = 4.8) participated in the first test run. Only the participants with mild to severe susceptibility to MS were selected based on the Motion Sickness Susceptibility Questionnaire's (MSSQ) scores (Mean = 74.7%, SD = 22.1%) [6]. For the second test run, 18 participants took part (9 males and 9 females) aged between 22 and 33 years old (Mean = 28.4, SD = 3.0). Participants' susceptibility were selected based on the MSSQ's scores (Mean = 79.1%, SD = 17.3%). In both test runs, participants were driven in a backseat of an instrumented vehicle which was built to mimic an AV in terms of driving and appearance (see [7] for further explanation). Motion sickness Assessment Questionnaire (MSAQ) was used as the subjective evaluation of the experienced MS [8]. MSAQ comprises of 16 questions on a 9-point scale *(1= not at all, 9 = severely)*. A total MSAQ score was used for the statistical analysis. This study complied with the Netherlands Code of Conduct for Scientific Practice (principle 1.2 on page 5) [9].

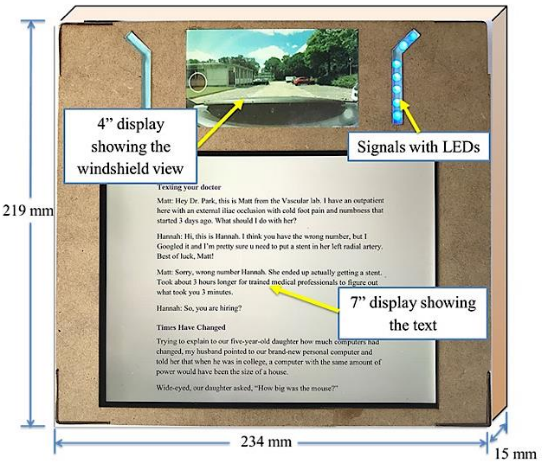

Figure 2 P2 prototype (Source: [5]).

3. RESULTS AND DISCUSSION

Table 1 showed the total MSAQ result when paired samples T-test were used to compare the means between MSAQ for P1 and P2. Shapiro-Wilk's test of normality was done, and the data were shown to be normally distributed. There is an increase in the mean of MS level (from 6.98 % to 21.37 %). There was a statistically significant different between P1 and P2 ($p < 0.05$). Participants experienced a higher MS when using P2 than when using P1. P1 was mounted about 1.2 m from the participant. In contrast, P2 was much closer to the participants. Besides, the P1's NDRT was watching a video on the television. Hence, there might be possibilities that the location where the PIS was placed might play a crucial role in determining the experienced level of MS.

4. CONCLUSION

The result shows that the implementation of P1 is better than P2. A further study can be done in future by using different NDRTs for each prototype.

Table 1 Statistical analysis on Total MSAQ.

Test Run	Mean	SD	Paired Samples *T*-Test
1	6.98	10.31	95% CI [-26.06, -2.72] t (17) = -2.60, d = - 0.61, p = 0.019
2	21.37	22.28	

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