Performance and Behavior of a Codriver When Using a Mobile Device

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Abstract. The performance and behavior of drivers is widely assessed in many studies. If the automation of cars will be technical successful and socially accepted, higher automation levels would make the 'driver' a codriver. Therefore, in this study the performance, glance behavior and comfort of a codriver in an electrical car is evaluated when engaging primary task (text input and Tetris). The results indicate that even (self-rated) motion sickness insensitive people show some signs of slight indisposition. Glances to the road are very rare, nevertheless. When comparing the text input performance while driving to standing still, the text input speed is reduced by about 25% while keeping the human error probability constant.

Keywords. input speed, glance behavior, mobile device, motion sickness, nausea, automated driving

1. Introduction

When fully automated vehicles are present in the media, often it is mentioned that the 'driver' can potentially read newspapers or write emails while the car is driving. Sometimes this is also emphasized with seats that are backward to the driving direction. At least one of the authors of this paper is sensitive to motion sickness; therefore, even these ideas induce indisposition. Motion sickness and the fear of motion sickness are everyday phenomena that can be seen e.g. in public transport when people don't take seats rear-facing to the driving-direction or change their seats when the direction of travel alters in dead-end railway stations. The problem of motion sickness is also known to every-one in the field of driving simulation, where it is an unpleasant end of some subjects' trials. The motion sickness is an individual reaction to a given situation, duration, stimulus frequency components and strength. An estimation for rough conditions (e.g., rough waters) on a ship is that up to 90% (Koch, 1993, p.43) of population are potentially affected; for autonomous cars it is likely lower; e.g., 6-12% (survey from UMTRI, 2015). Therefore, in human factors for calm automated vehicles, motion sickness plays only a minor role. Nevertheless, recently motion sickness and vehicle automation has been, e.g., mentioned by Diels & Bos (2015) with interface considerations. Beside theoretical surveys and interface considerations about motion sickness for autonomous cars, it is easily possible to assess the topic in today's cars with a codriver to get more insight.

2. Method

For the experiment N=20 subjects (female=10, male=10; 22-32 years old M:25.5) where driven by the same driver on the codriver seat 2x 12 minutes in an electrical car (Nissan

Leaf). The experiment was carried out in June 2014. The 12km round trip (duration M: 731s; SD:70s) included different road sections (average time: village 20%, Autobahn 30%, rural road 45%, stop at traffic light: 5%) and two specific maneuvers (parking and kick-down). In one trip (randomized) the subjects typed a given text (fairy tale with no numbers, but umlauts, punctuation marks and lower/upper case) from the dashboard, (see Figure 1). For this user-paced task the Android App Kingsoft Office was used (virtual German quertz keyboard, no text input helpers). In the other round they played Tetris (Android App, Electronic Arts); a system-paced task.

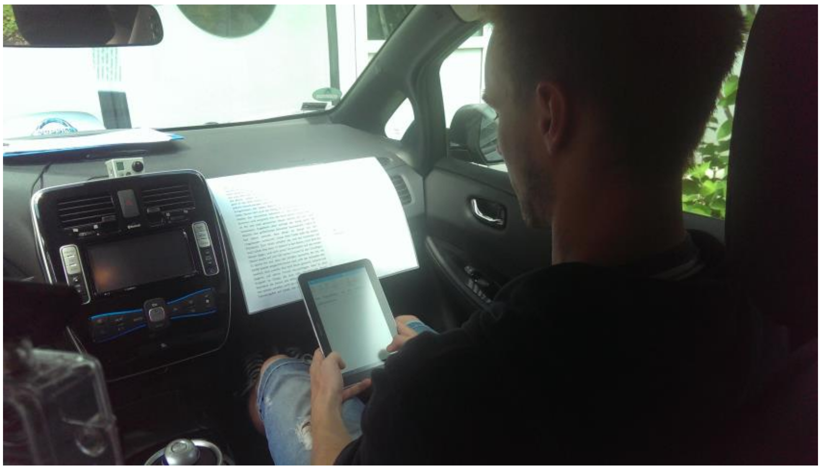

Figure 1. *Subjects on the codriver seat, types a given text into the mobile device*

Half of the subject group used a tablet (Samsung Galaxy Tab 8.9 Inch), while half used a phone (Samsung Galaxy Nexus 4.7 Inch). Before and after the driving trips, the subjects typed for 1 minute each time while the car was standing still (baselines). Before the experiment the subjects filled in a careful translation (by two native Germans and one native of America) of the Motion Sickness History Questionnaire MSHQ (Griffin & Howarth, 2000). Before driving and after each round, the current feeling of the participants was assessed with a rating scale and table of symptoms from MSHQ.
The experiment was recorded with two cameras (GoPro). One recorded the face, the other the person and traffic situation/surrounding (see view of Figure 1). The two recordings were combined and the driving situation and the glance behavior were manually coded with Interact (Mangold International GmbH, Arnstorf). For glances, the definition of ISO 15007 (leading saccade + dwell time) was used and coded by one rater. The subjects were mainly students and members of the faculty. They were only invited if they felt comfortable to do the task as a codriver on a mobile device without motion sickness. The average total susceptibility to motion sickness according to MSHQ was 8.8 (SD: 8.7; MSHQ scale range [-2 to 177]).
The MSHQ item number 13 is a self-rating, regarding the susceptibility to motion sickness: On a five point adjective scale, 6 people rated themselves as ‘much less than average’, 12 people used ‘less than average’ two rated themselves ‘average’.
Two tables where used before the first and after each trip (Griffin & Howarth, 2000; Table 17 & 18) to assess the self-rated illness; one for an overall rating on a 7 point adjective scale (motion illness rating scale; cf. results Figure 2) the other to name the symptoms (see Figure 3).

3. Results

3.1 Motion Illness

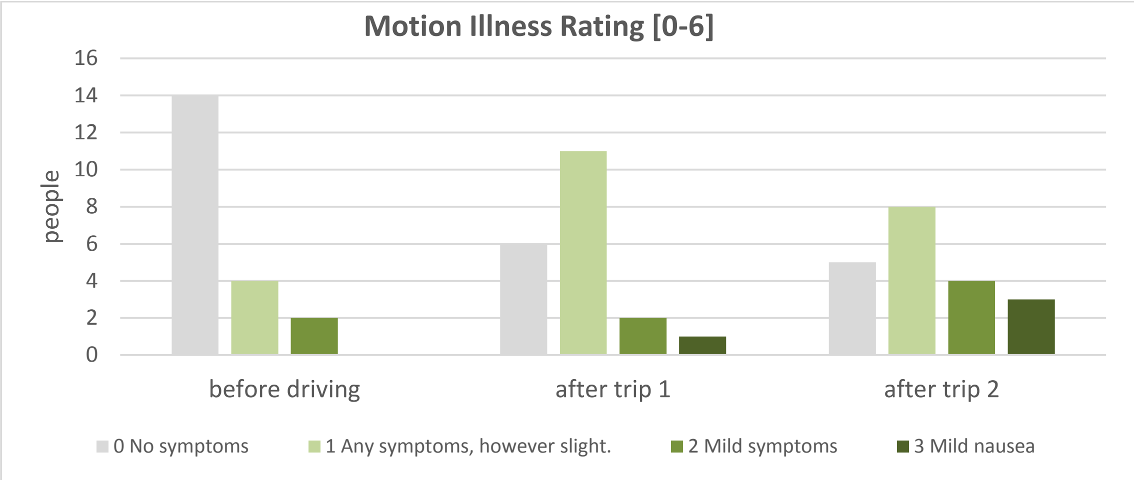

Figure 2. *Motion Illness Rating for three points in time*

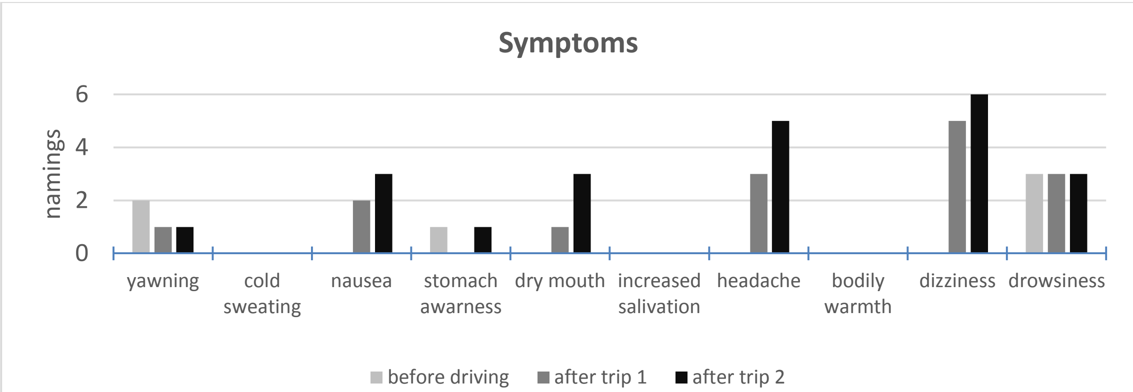

Figure 3. *Symptoms of Motion Illness Rating (see Figure 2) multiple select possible*

3.2 Number of Glances

In total for all subjects, the duration of Tetris while driving was 243 minutes. Cumulated, the subjects looked away from the Tetris task for 1 minute and 20 seconds (0.55% of time) in 126 glances.

In total for all subjects, the duration of text input while driving was 244 minutes. Cumulated, the subjects looked away from the text input task for 1 minute and 35 seconds (0.65% of time) in 92 glances.

One single person dominated with 54 non-task glances for Tetris and 23 glances for the text input the results. The following glance results are therefore reported two times: all test subjects and with this one person excluded:

A two sided paired t-test for non-task number of glances for **text** (M:4.6 SD:6.1) versus **Tetris** (M:6.3 SD:12.1) led to *t(19) =-0.99; p=0.33; Pearson-r:0.84*. When excluding the person, text (M:3.6 SD: 4.4) versus Tetris (M:3.8 SD:4.6) led to *t(18) =-0.2; p=0.84; Pearson-r:0.71*.

The order (Tetris/text) was random when testing number of glances of the first trip against the second trip and disregarding the task type; a two sided paired t-test for non-task number of glances for **first trip** (M:6.3 SD:4.7) versus **second trip** (M:4.7 SD:6.5) led to *t(19)=0.93; p=0.36 Pearson-r:0.81*. When excluding the person, first trip (M:3.7 SD:4.1) versus second trip(M:3.7 SD:4.9) led to *t(18)=0.07; p=0.95 Pearson-r:0.72.*

3.3 Text Input Performance

Due to technical problems, one person (condition: tablet) had to be excluded from the following analysis of input performance in the text task. The participants were instructed for fast and accurate input; input errors were not allowed to be corrected to enable error analysis. The people were free to choose the input position; but only one person (condition: tablet) turned the device to landscape mode. Sometimes people unintentionally skipped one or two lines from the given text. These errors were counted in their own error category and are not included in the following analysis. To calculate the Human Error Probability (HEP) the erroneous number of input characters was divided by the (minimal) correct number of input characters to type in the text up to the reached position. A between groups unpaired two sided t-test for the experiment condition (see Figure 4) led to phone (M:91.1 SD:17) versus tablet (M:103.8 SD:17) *t(18)=-1.64; p=0.12*

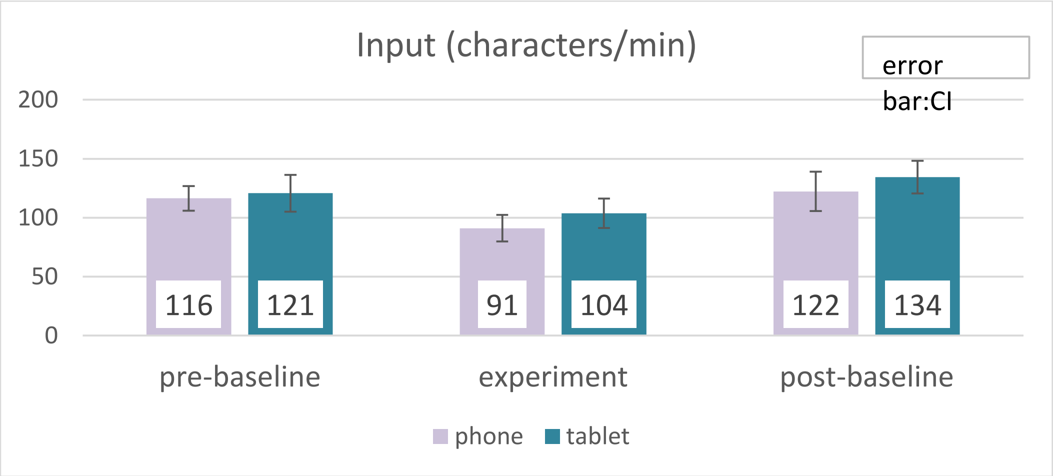

Figure 4. *Text input performance before (car standing), during (car moving) and after (car standing) the experiment for phone and tablet group*

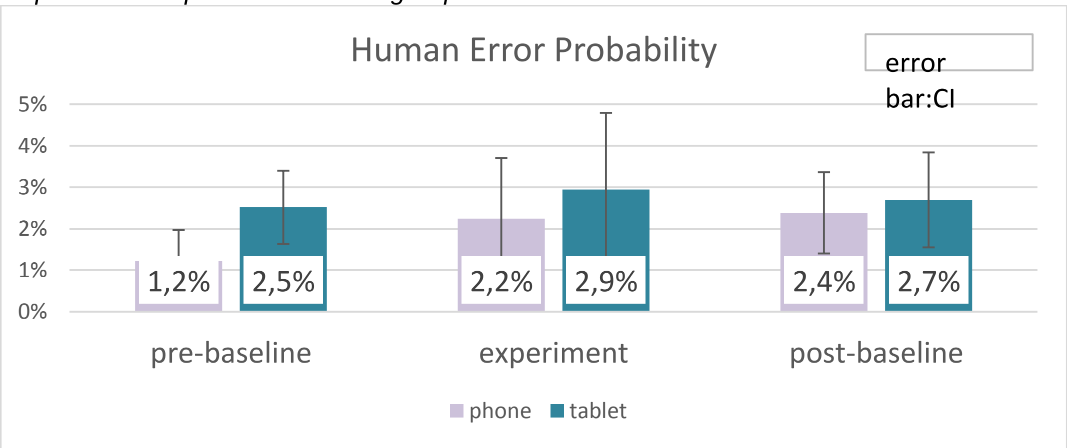

Figure 5. *Text input: Human Error Probability before (car standing), during (car moving) and after (car standing) the experiment for phone and tablet group*

4. Discussion and Conclusion

The results from Figure 2 and 3 indicate that even in a preselected, self-rated motion sickness insensitive group, the illness rating increases over time. While 14 people have no symptoms before the first trip, this is reduced to 6 people even after 12 minutes of driving. This study lacks a control condition or control group. The design of the experiment can be improved if a second group will drive without (mobile) tasks or baseline trips are included in the design, to see the influence onto the illness rating.

The number of glances and glance duration away from the non-driving tasks is surprisingly low; with about 4 glances in 12 minutes, the average span is 3 minutes. The influence of the task type seems not to have had an influence in this experiment. All paired t-tests show a high Pearson-r correlation; this indicates that the number of glances away from the tasks is mainly dependent on the individual person. The glance metrics indicate that the people were highly engaged. There should be at least two main mechanisms that may contribute to glances away from the tasks:

- Curiosity: Where are we now?
- Distraction:
    - Haptic amazement: What happens? (e.g., braking, reverse direction)
    - Visual: e.g. something in peripheral view drags attention (leading car)

On the other hand, a factor that should help to concentrate on the task could be trust in the driver (or automation); see Körber & Bengler (2014): “This attitude [Trust in automation] determines the operator’s reliance on automation and his attentional strategy, e.g. how much he gets involved in non-driving activities.”

An improvement of the experimental design would be an inclusion of an introductory round trip to see the track and/or ask the participants about their previous knowledge of the route. Also, manipulation of the trust in the driver (e.g. two drivers) could be interesting. In the future, the second driver could possible the car itself. When the glance metrics for these two conditions become similar, it could be a proxy for the same trust.

From Figure 4 it can be seen that the two groups (phone/tablet) reduced their input speed (characters/minute) by 26% and 23% in the moving vehicle compared to the second baseline while standing still. Figure 5 indicates that this happens while the error probability is kept constant. Haslbeck et al. (2011) used an iPod Touch in an experiment at a desk. They found an error rate of 2.8%, which is similar to the results in Figure 5 and an input speed of 72 char/min that is 41% worse than the second phone baseline performance in Figure 4 (122 char/min). The reasons are unclear, but plausible contributions could be the slightly bigger device (3.5” / 4.7”), technical improvements and everyday adaption/training of the users.

5. References

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