Effects of Navigational Interface Type on Distracted Driving

Audrey W. Fok, Timothy B. Frischmann, Ben Sawyer, Melissa Robin, & Mustapha Mouloua
Department of Psychology, University of Central Florida

ABSTRACT

This study empirically examined the effects of keyboard type in a GPS system on driver distraction. Fifty-two undergraduate students were recruited to drive in a simulated environment while using either a QWERTY or ABCD keyboard embedded in a GPS interface. Driving errors, as well as bio-behavioral assessments, eye fixation durations, and EEG (Electroencephalography) theta frequency level were collected to determine the level of distraction and driving performance of participants. Significant differences in driving and distraction measures were found between driving with and without GPS data entry. Despite greater pre-existing participant skill in using two-handed QWERTY keyboards, no differences were found between the two keyboard types when used one-handed while driving.

INTRODUCTION

Driver distraction has attracted great attention not only within research, but also transportation, manufacturing, legislation and public policy. In 2008, government transportation officials reported nearly 6,000 fatalities and half a million injuries in accidents determined to be caused by driver distraction (NHTSA, 2009). Thirty nine states and the District of Columbia currently have legislation either banning or limiting the use of cellular phones while driving (IIHS, 2011). However, cell phones are hardly the sole causes of driver distraction.

Entering data by keyboard is high among GPS tasks that may be a cause for concern (Tsimhoni, Smith & Green, 2004). Keyboard interfaces across all types of devices, regardless of display size and degree of haptic feedback, largely default to the QWERTY layout. Designers assume users will already be familiar with QWERTY, and therefore enjoy some level of skill transfer to this popular format (Green et al, 2004, Isokoski & Raisamo, 2000). However, users are generally skilled in computer keyboard use, and little research exists on skill transfer from two-handed to one-handed keyboards, much less in the context of a high-load situation like driving. Even assuming that users are more comfortable with a familiar keyboard, there has not been sufficient research to connect this asserted comfort level with less distracted driving.

The current research sought not only to empirically examine the adverse impact of GPS systems on driver distraction shown in previous research (Jensen, Skov & Thiruravichandran, 2010), but to also explore the relative distraction contributions of two diverse keyboard layouts: QWERTY and ABCD. It was expected that the lack of familiarity participants had with the ABCD layout would lead to diminished preference and usability ratings for that layout, as well as poorer driving performance in contrast to the already familiar QWERTY layout.

REFERENCES

Green, N., Kruger, J., Faldu, C., & St. Amant, R. (2004). A reduced QWERTY keyboard for mobile text entry. In *Extended abstracts of the 2004 conference on Human factors and computing systems - CHI '04* (p. 1429). Presented at the Extended abstracts of the 2004 conference, Vienna, Austria.

Insurance Institute for Highway Safety. (2011). *Cellphone Laws*. Retrieved from http://www.iihs.org/laws/cellphonelaws.aspx.

Jensen, B. S., Skov, M. B., & Thiruravichandran, N. (2010). Studying driver attention and behaviour for three configurations of GPS navigation in real traffic driving. In *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10* (p. 1271). Presented at the the 28th international conference, Atlanta, Georgia, USA.

Lin, C., Lin, H., Chiu, T., Chao, C., Chen, Y., Liang, S., & Ko, L. (2008). Distraction-related EEG dynamics in virtual reality driving simulation. Proceedings from ISCAS '08: *IEEE International Symposium on Circuits and Systems*. Seattle, WA.

Seeing Machines. (2011). faceLAB 5.

NHTSA: National Highway Traffic Safety Administration (2009) NHTSA Report *Distracted Driving 2009* National Center for Statistics and Analysis. Retrieved January 12, 2011, from http://www-nrd.nhtsa.dot.gov/Pubs/811379.pdf

Tsimhoni, O., Smith, D., & Green, P. (2004). Address Entry While Driving: Speech Recognition Versus a Touch-Screen Keyboard. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 46(4), 600-610.

METHOD

Participants

Fifty-two undergraduate students (21 males and 31 females) between the ages of 18 and 22 participated in this study. They were given course credit as compensation. The treatment of the participants was in accordance with the ethical standards of the APA.

Materials

Participants were asked to complete their driving task using a GE iSim fixed platform driving simulator. The GPS device used was a Omitech with Distinator 8 maps. Participants were also given a typing skill test and a number of questionnaires in order to assess various state and trait attributes of the participants, as well as assess their perceptions of their own performance with the aforementioned devices. Glances away from the roadway while driving were recorded using a Facelab eye tracking system. EEG data was recorded with a BrainMaster Atlantis EEG amplifier.

Procedure

Upon arrival to the lab, participants were randomly assigned to a keyboard type to use in the study (QWERTY or ABCD), given a consent form, and an opportunity to ask questions before beginning the study. In addition to standard opt-out procedures included in the informed consent, participants were also verbally informed of the simulation sickness phenomenon and advised to alert the researchers to halt the simulation at any point if they experienced troubling symptoms. Participants were first given a two-minute typing test to gauge their skill on a full QWERTY keyboard at a computer desk. Next, they completed a Driving Behavior Survey, and a questionnaire about their prior experience using GPS devices and both keyboard layouts. They were then given an opportunity to practice navigating the menus and typing a sample address and a sample "point of interest" (POI) into the GPS on their assigned keyboard type. Following this practice period, participants were asked to rate the usability of the GPS interface to which they were assigned.

After this initial round of practice and questionnaires, participants were seated in the simulator so that the eye tracking and EEG equipment could be calibrated for that person's height and seat position. A researcher placed one electrode on the participants head (channel Fz), one on the right ear as a reference (channel A2), and one on the left ear as a ground (channel A1). After the electrode connections were correctly positioned and fixed, the participant was asked to relax and sit still while a one-minute baseline EEG reading was recorded.

Participants were given an opportunity to practice driving on the simulator for two minutes. Each participant drove in three separate, 4 minute sessions through the simulation environment, following road signs with black directional arrows on a white background. During the second session only, the participant was instructed to enter four pre-determined locations into the GPS while they drove. These locations were posted on an index card below the GPS, and consisted of two street addresses and two POIs. This address entry task took the duration of the drive, and no participant finished the task before completing the drive.

Errors recorded consisted of lane deviations, crossing the median, leaving the roadway, collisions, and disobeying traffic lights/signs. The recordings were also used to track speed throughout each session. Following the third and final session, each participant was detached from the EEG electrodes and taken back into the questionnaire area. At this point, they completed the GPS usage, preference questionnaire, demographic form before being debriefed and released.

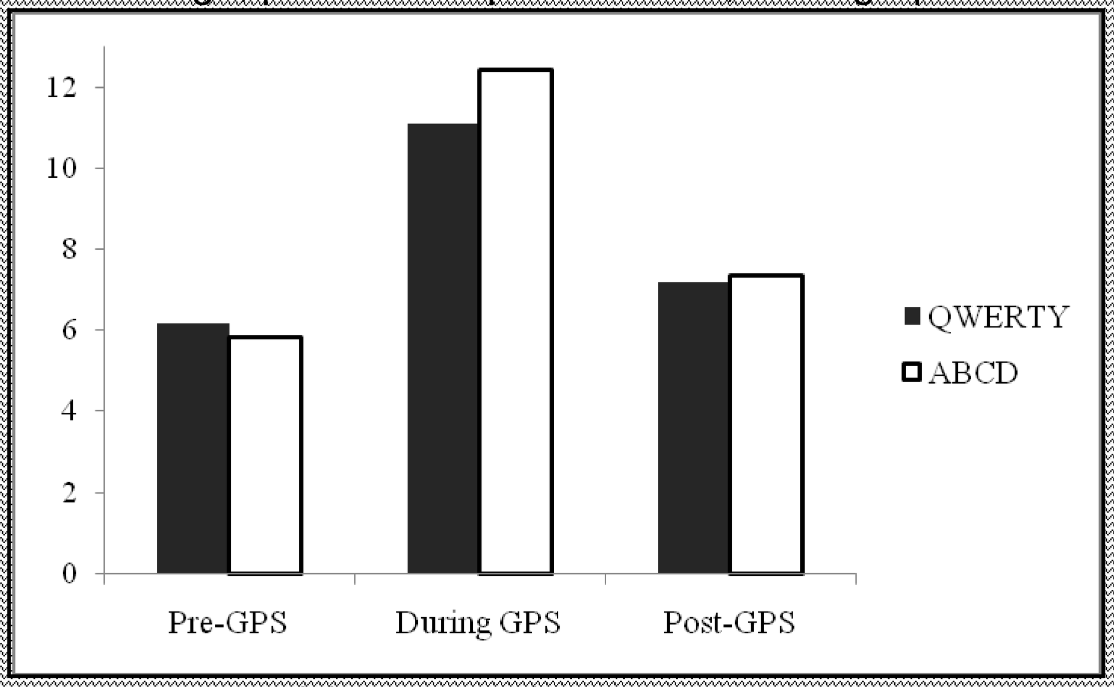

Figure 1. Total driving errors between sessions in QWERTY and ABCD groups

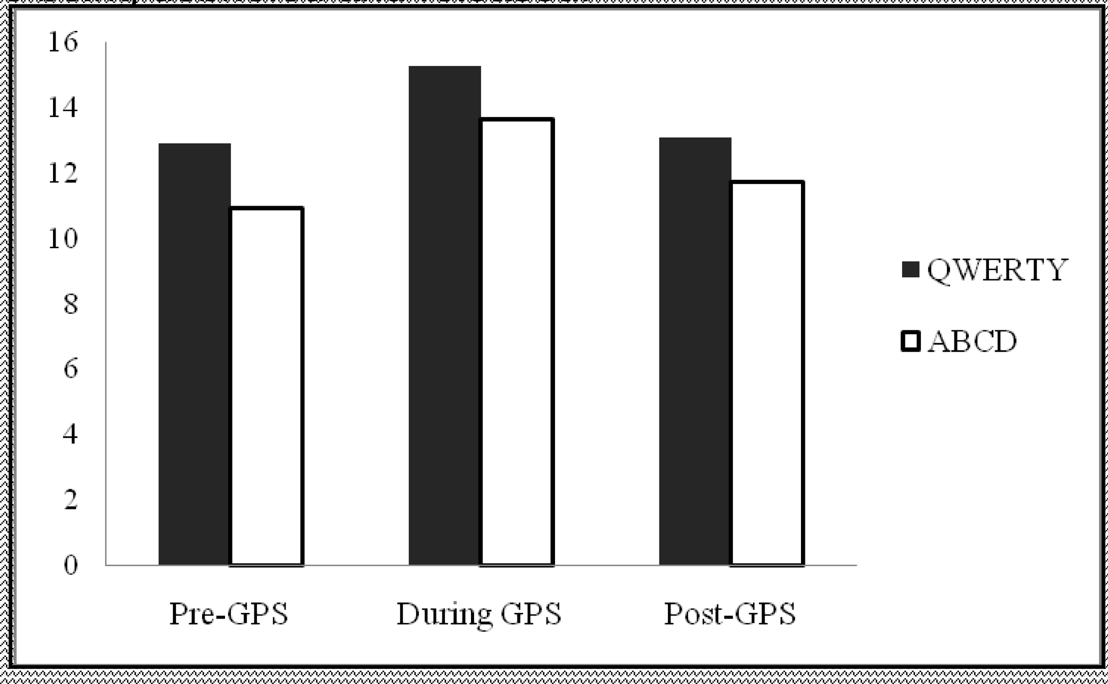

Figure 2. EEG Theta waves between sessions of QWERTY and ABCD groups.

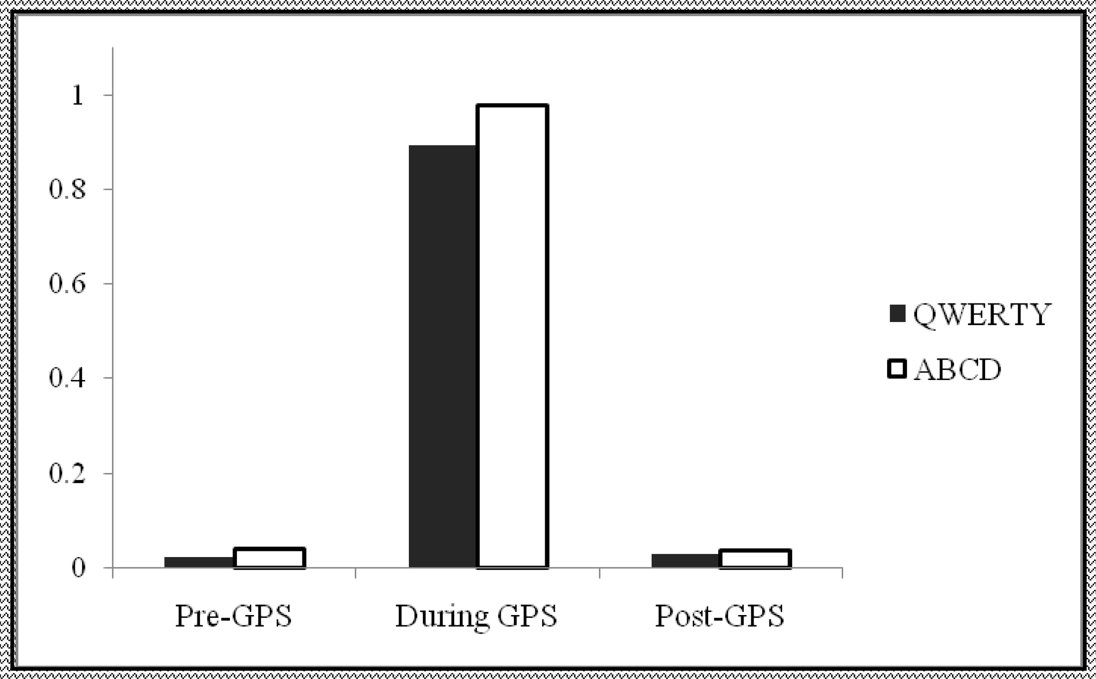

Figure 3. Eye fixation durations on GPS between sessions of QWERTY and ABCD groups.

RESULTS

A mixed design ANOVA was used to examine effects of keyboard type (QWERTY and ABCD) on driving performance. In all three measures (driving data, EEG, and eye-tracking), main effects were found for driving sessions (F (2,88) = 46.480, p = .000; F(2, 84) = 25.987, p = .000; F(2, 90) = 228.942, p = .000, respectively) with the highest level of distraction in the second session (M = 4.80; M = 5.37; M = 0.411, respectively). See Figures 1, 2, and 3. Despite high participant proficiency with QWERTY keyboards (M = 6.769) and low proficiency in ABCD (M = 1.269) keyboards (t(51) = -21.787, p = .000), no significant differences were found due to keyboard layout in any of the three. Participants who used the ABCD keyboard did report a higher perceived level of difficulty (t(50) = -1.621, p = .001), as well as a lower level of usability (t(50) = -1.662, p = .004), but this difference was not reflected in actual driving performance, EEG, or eye tracker results between groups.

DISCUSSION

The present findings support prior work showing that address entry in GPS systems has adverse effects on driving performance. Qualitative driving performance was significantly worse when participants engaged in a task than when they drove without any distraction. Our EEG results showed a significantly increased theta wave when the GPS was used. Theta wave increases have been shown to be a useful measure of concurrent level of distraction (Lin et al., 2008). Eye tracker results further supported the deleterious effects of the GPS use manipulations. Fixations on the GPS were significantly higher in the second session than in the other two sessions. These findings are consistent with existing driving research where performance was impaired during GPS address entry (Tsimhoni, Smith & Green, 2004), as well as research showing increases in glances away from the roadway (Jensen, Skov & Thiruravichandran, 2010).

The present findings clearly indicate that QWERTY and ABCD keyboards are equally distracting. This calls into question current QWERTY dominance in in-vehicle keyboards. As mentioned before, designers assume users will prefer the familiar QWERTY layout, and enjoy some level of skill transfer to this popular format (Green et al, 2004, Isokoski & Raisamo, 2000). The first assumption is in part supported by our findings; in our pre-driving usability assessment participants rated QWERTY significantly higher than ABCD. In the post-driving questionnaire, they additionally rated QWERTY as significantly easier to use. However, in that same post-driving questionnaire no significant preference for either keyboard was expressed. This may be an astute observation on the part of our subjects; QWERTY provided no significant relief from the impairment of GPS address entry. Taken together, these data suggest that the only benefits of QWERTY were subjective. Although participants rated the QWERTY to have a higher level of usability, this was not reflected in their driving performance.

These findings suggest that user preference for QWERTY keyboards is not necessarily representative of a benefit to the user in terms of driving performance. Neither keyboard is "safer" than the other, as QWERTY and ABCD keyboards were not significantly different in their impact on driving performance. The findings also call into question the belief that use of a familiar two-handed keyboard layout such as QWERTY might result in skill transfer and reduced workload for users. Further research into the phenomenon of one-handed in-vehicle keyboarding, and into the potential dangers of in-vehicle telematic devices that require it, is needed.