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Eye-Gaze Tracking Analysis of Driver Behavior While Interacting With Navigation Systems in an Urban Area

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Research Overview

- **What This paper study**
  - Analyzed the eye-gaze tracking of drivers while interacting with portable navigation systems
  - Find out how drivers are affected when the location and size of the navigation system changes.
  - Suggested that larger, closer-positioned displays are safer

Portable Navigation
Source: https://m.media-amazon.com/images/I/81Wr6LIKGgL._AC_SX679_.jpg

- **What I Study**
  - Finding the optimal position of the wheel loader's sub-display by analyzing eye movement data.

➢ **Therefore, I considered the results of this paper to be helpful in discussing the results of my own research.**

KOMATSU WA475-10
from https://www.komatsu.eu/en/wheel-loaders/wheel-loaders/wa475-10

Introduction

- **On-board vs. Portable Navigation Systems**
  - Traditional on-board navigation systems are built into the car.
  - Portable navigation systems can be moved
    - which can affect how drivers interact with them.

On-board Navigation

Source: https://jpn.pioneer/ja/carrozzeria/carnavi/cybernavi/img/main.jpg

Portable Navigation

Source: https://m.media-amazon.com/images/I/81Wr6LIKGgL._AC_SX679_.jpg

- **Why is this Study Important**
  - There are safety guidelines for on-board navigation systems.
  - But there are no guidelines for portable navigation systems.
    - we don't know the safest way to use these systems while driving.
- **Purpose**
  - Understand how drivers interact with portable navigation systems.

How to Evaluate

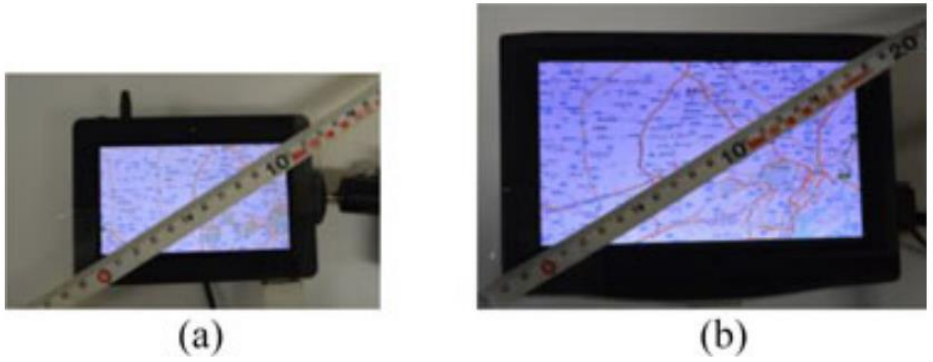
- **Eye-Gaze Tracking**
  - Eye-gaze tracking analyze where people look.
  - It uses cameras and Infrared rays to record gaze direction.
  - It helps understand how drivers interact with these systems.
  - **Calculated parameters**
    - Glance frequency : How often participants look at navigation system
    - Glance time : Amount of time spent looking at the navigation system
- **Subjective evaluation**
  - Drivers rated acceptability, safety, and fatigue for the different conditions.
  - They rated these aspects on a five-level scale.

➢ Based on the above parameters, investigate the impact of different size and location of the navigation system on driver behavior.

Apparatus

- **Moving-based DS**
  - It can move in six directions, just like a real vehicle.

- **Navigation Systems**
  - Two types of navigation systems were used
    - Portable system (MapFan Navii)
    - On-board system (Carrozzeria).
  - Both systems showed a 2-D map and travel information.
- **Display Sizes**
  - The portable navigation system had two display sizes
    - 4.3 inches and 7 inches.
  - The on-board navigation system only had a 7-inch display.

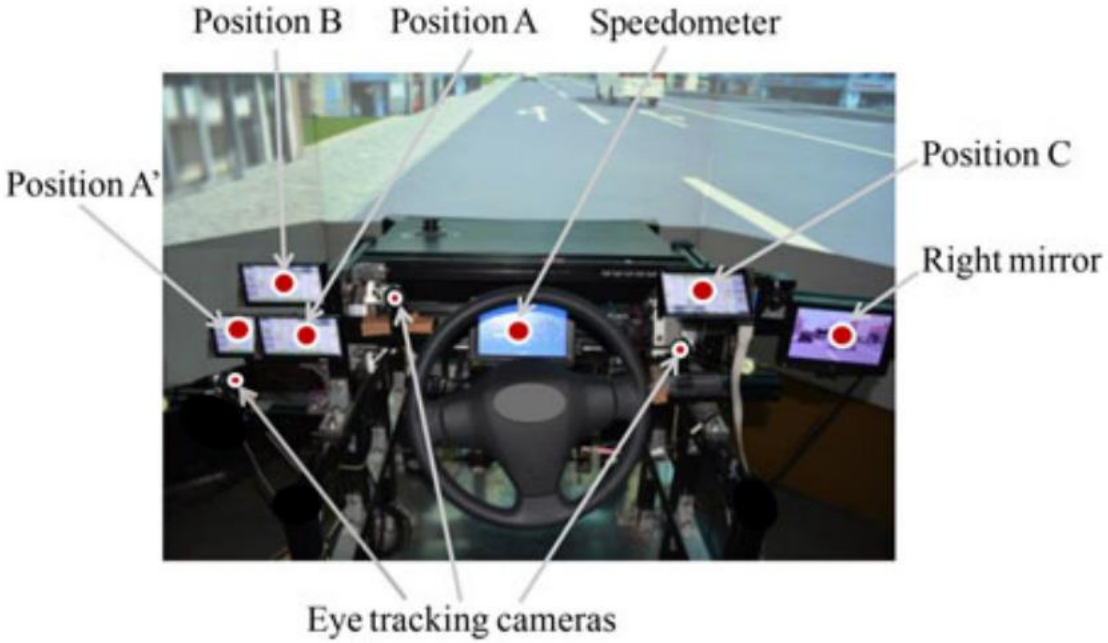


(a) (b)

Physical sizes of the (a) 4.3- and (b) 7-in displays.

Experimental Design

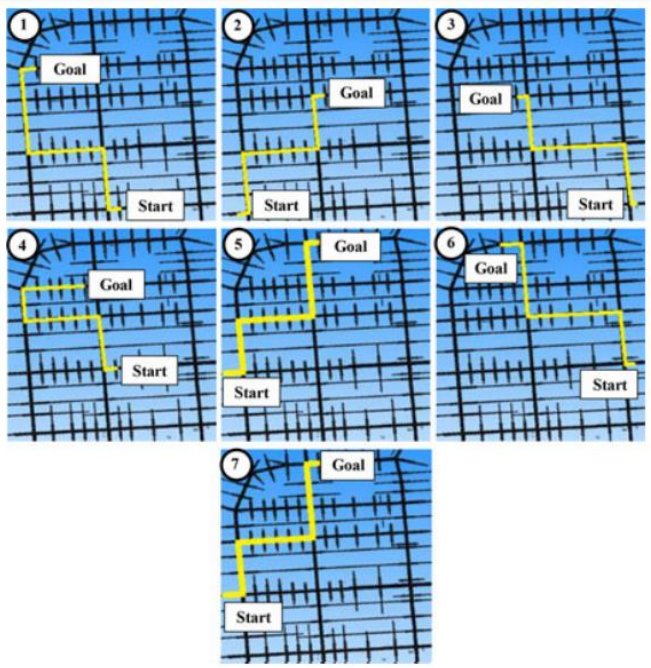
- **Display Positions**
  - A’: on-board navigation system.
  - **3 positions of the portable navigation**
    - A: right side of the built-in navigation position.
    - B: the top of position A.
    - C: the right and upper side of the dashboard.
  - Visual angle
    - A: 43, B: 44, C: 26 [deg]



- **Experimental Conditions**
  - The study had 7 experimental conditions.
    - 2 display sizes (4.3 and 7 inches) × 3 positions (A, B, C).
      + On-board navigation system(7inch, A’)

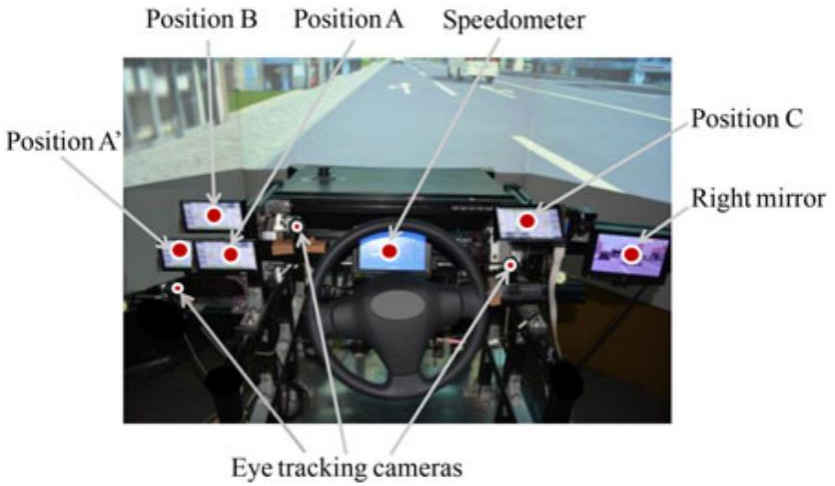
Participants

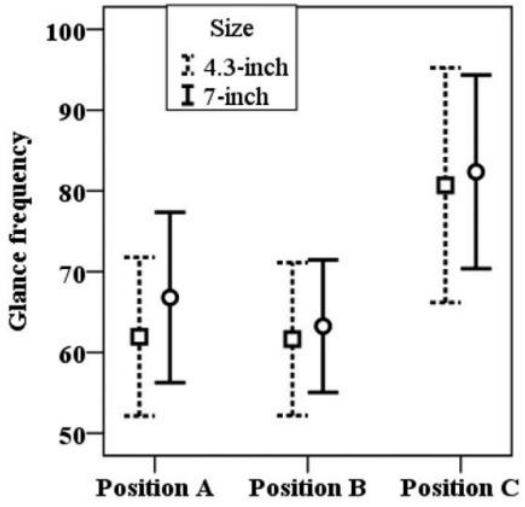
- **Participants**
  - 20 people (men and 4 women)
    - Their ages ranged from 22 to 54 years.
  - All participants had valid Japanese driving licenses.
    - They had been driving for an average of 16.4 years.
    - Their average driving frequency was twice a week.
- **Procedure**
  - Participants drove seven different routes with different destinations.
  - They were not allowed to manually operate the navigation system.
  - They only interacted with the system visually to get the correct traffic route.



Results : Eye-Gaze Tracking

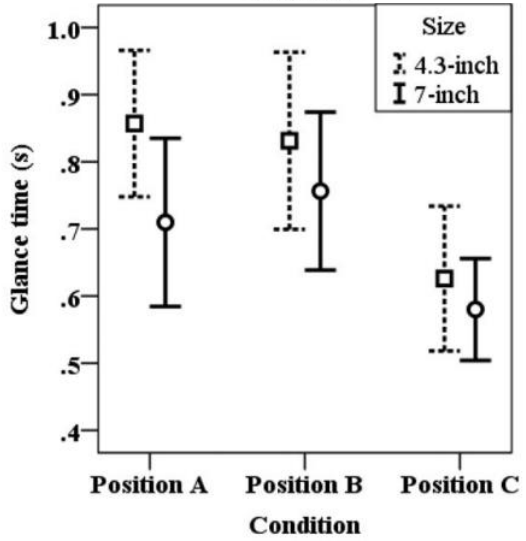
- **Display Position**
  - Near position (C) led to
    - Higher glance frequency
      - B < C (p = 0.006)
    - Shorter glance times
      - C < A & B (p = 0.001)





➢ It is considered that A & B are safer than C

- **Display Size**
  - A smaller display size resulted in longer glance times.
    - 4.3 inch > 7.3 inch (p = 0.02)

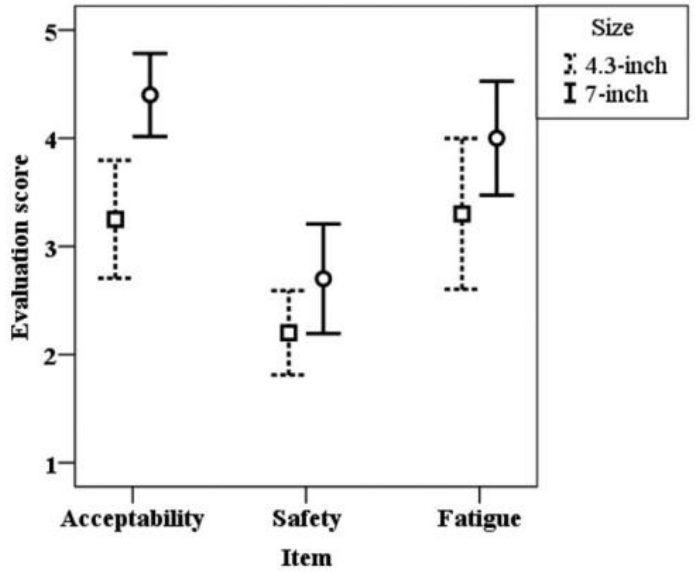


➢ A displays placed in a distant position (A & B) or small-size portable display may increase visual distraction

Results : Subjective Evaluation

- The five levels of evaluation score were:
  1 = very low, 2 = low, 3 = average, 4 = high, and 5 = very high.

- **Display Size**
  - The small-size portable display received lower scores for acceptability and fatigue.
    - 4.3 inch indicates significantly lower acceptability than 7 inch (p = 0.001)
    - 4.3 inch indicates significantly lower fatigue than 7 inch (p = 0.005)

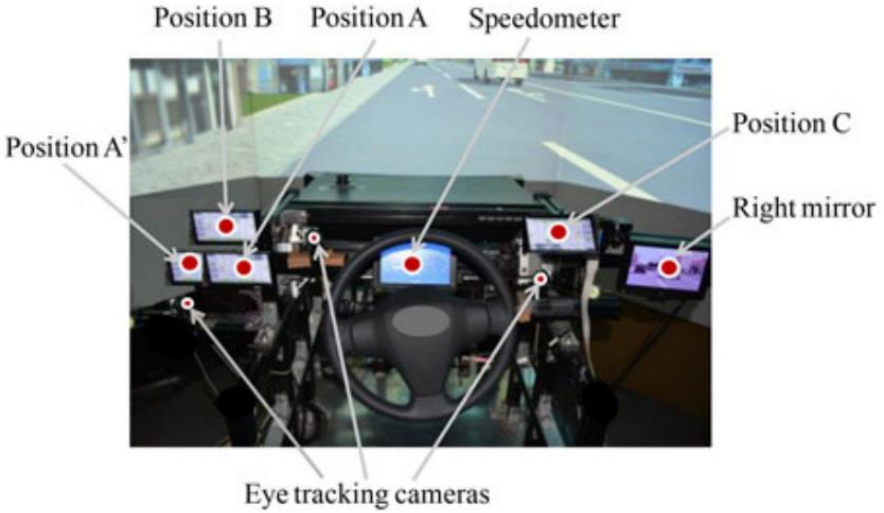


◆ **Why fatigue score is higher when using 7 inch**

- ➢ Glance frequency was relatively higher for the 7-in display than for the 4.3-in display
- ➢ Which means High frequency of glance increases fatigue.

Discussion

- **Effect of display position**
  - Display positions make
    significant difference in the driver's eye movement.
  - Even though all display locations
    met the guidelines for **in-vehicle display systems**
  - **Especially,** longer glance time may result in
    the driver taking their eyes off the road and an increased risk of collision.



- **Differences of traffic rules**
  - This study was conducted for the right-hand driving on the left side of the road in Japan.
  - There is little difference in the eye-gaze tracking behavior
    when the left-hand driving on the right side of the road
  - the results of this study may be referenced for wheel loader's sub-display

Conclusion

- **What the Study Find**
  - The study found that the size and position of portable navigation displays significantly affect driver's eye-gaze behavior.
  - A smaller display size can lead to longer glance times, which may increase visual distraction for drivers.
- **About User Experience**
  - The study also conducted a subjective evaluation of the navigation systems.
  - Participants found small displays harder to use and gave them lower scores for acceptability and fatigue.
- **What can be used for**
  - The study provides insights that can help in creating guidelines for portable navigation systems.
  - These guidelines can improve both safety and user experience.