A Smart Driving Smartphone Application: Real-World Effects on Driving Performance and Glance Behaviours

Presented by: Dr Stewart A Birrell

Authors: S Birrell, M Fowkes, P Jennings

Introduction

- Research shows IVIS can be distracting
  - However many aim to actually increase driving safety, efficiency, comfort or convenience
- What is unknown is if these IVIS have any measurable positive effect in the real-world
  - If they do what is the effect on distraction
- Aim of this study is to address both these issues by reporting on a comprehensive field trial using an in-vehicle Smart driving advisor

What is Smart Driving?

Green Driving Behaviours

- Planning ahead to avoid unnecessary stopping and help maintain a constant speed
- Smooth, positive acceleration
- Use engine braking for smooth deceleration
- Use moderate engine speeds and a uniform throttle for steady speeds

Safe Driving Behaviours

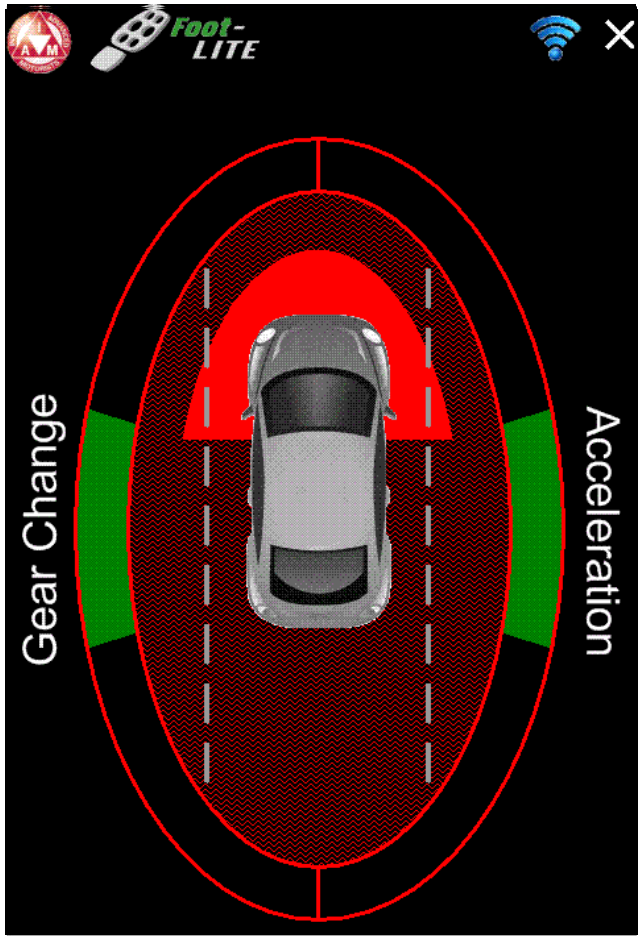
- Obey speed limits
- Maintain a headway (gap between you and the car in front) of two seconds
- Be mindful of your vehicles position within your lane

Foot-LITE Smart Driving Aid

- Real-time Smart driving advice offered in-vehicle via smartphone application
- Safety and fuel efficiency advice together on a single, integrated, adaptive interface
- Developed according to Ecological Interface Design principles (EID)

Foot-LITE Smart Driving Aid

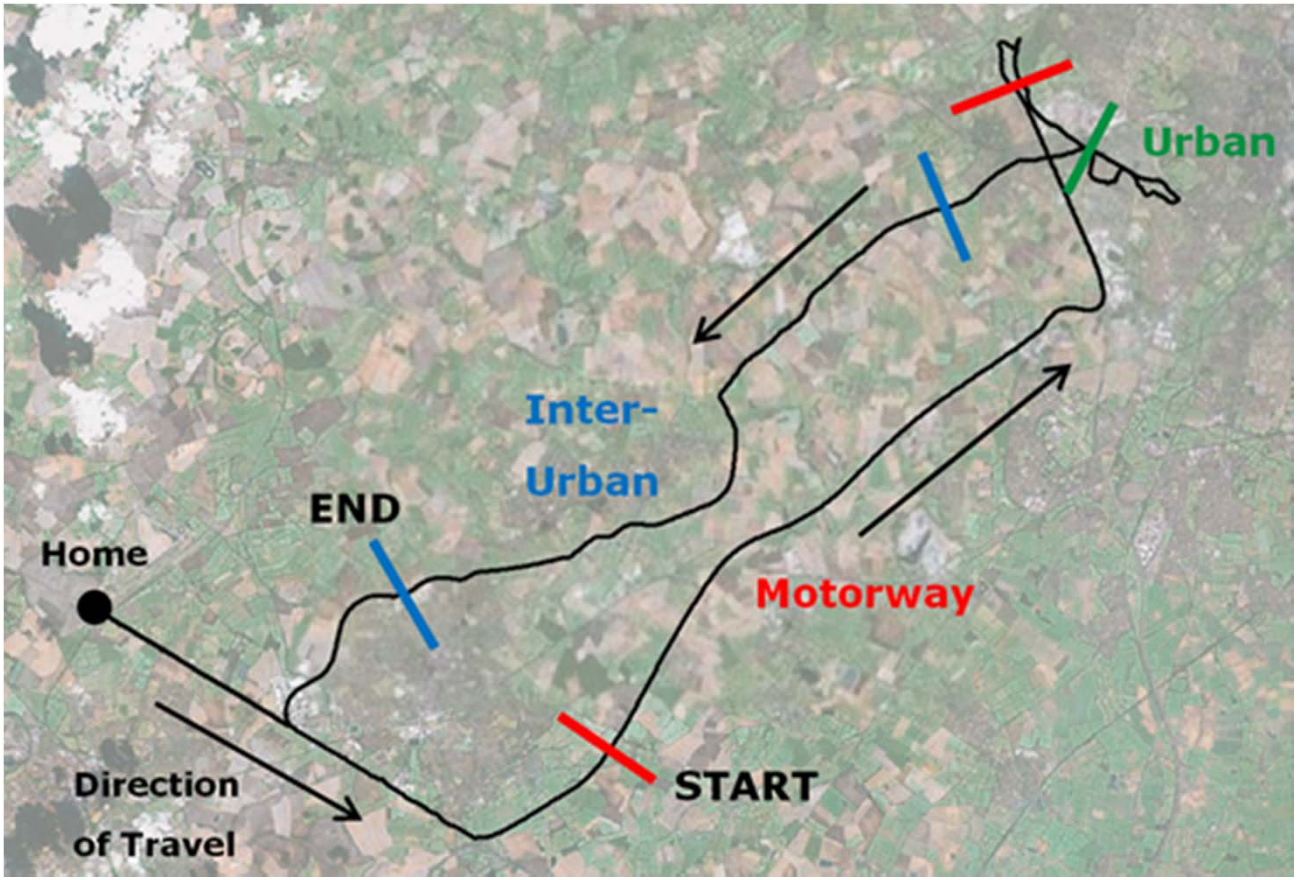
- Naturalistic representation of driving environment
- Groups related information
- Intuitive use of colour
- Direct perception of safety critical events
- Spatially linked, i.e. change up when accelerating
- Provides positive feedback



UK Reg Des: 4017134-41

Driving Scenario

- 1.25 hours, 64.5 km, mixed driving route



Participants

- Driving Performance
  - 40 (30 male, 10 female; mean age 41.9 ± 11.6)
- Glance Behaviour
  - 15 (10 male, 5 female; mean age 39.4 ± 12.9)
- Members of staff at the trial management company

Trial	Subset	n	Age		Driving Experience	
			Mean	SD	Mean	SD
Driving	Group	40	41.90	11.64	22.03	11.74
Performance	Male	30	42.33	12.28	22.60	11.94
	Female	10	40.60	9.10	20.30	11.24
Glance	Group	15	39.40	12.95	19.07	12.52
Behaviour	Male	10	39.64	14.89	19.55	13.36
	Female	5	38.75	6.60	17.75	11.53

Data Collection

- Data collected by two logging methods

RaceTechnology GPS
and Video Data Logger

Foot-LITE

Data Collection – Foot-LITE

- Smartphone application
- Adapted Lane Departure Warning Camera
- Bluetooth OBDII adapter
- GPS module on Smartphone
- Accelerometer in data processing unit

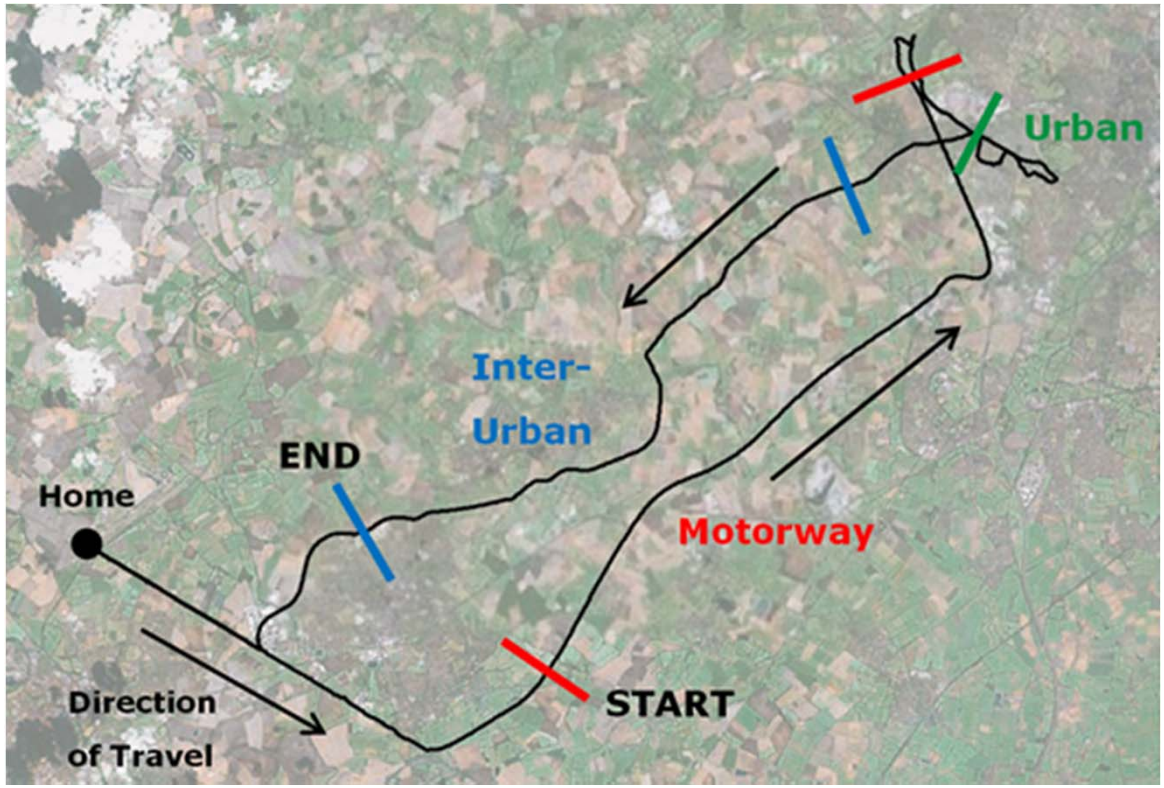



Data Collection – RaceTech

- GPS data logger at 20 Hz
- Accelerometer and Gyroscope at 100 Hz
- Four internal camera (1 x HD, 3 x SD)
- Fuel consumption via internal trip computer

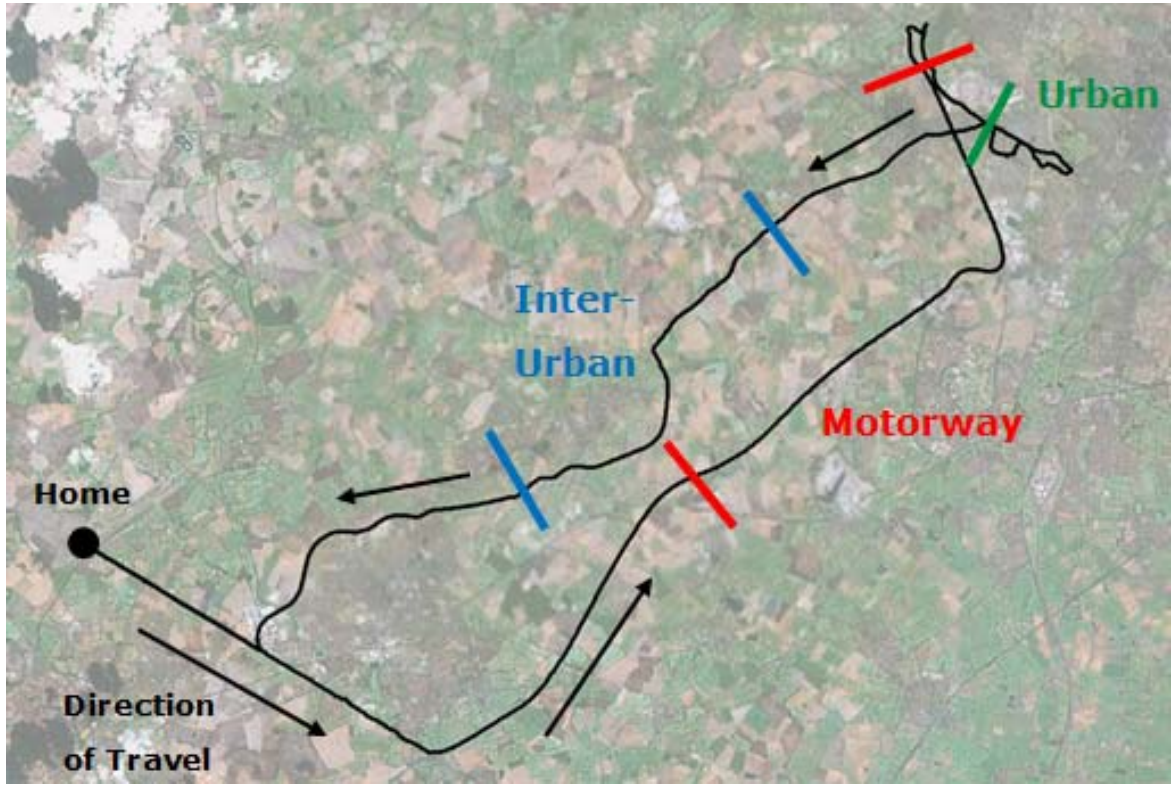
Data Collection

- Driving Performance evaluated over a 50 minute section – Start to End

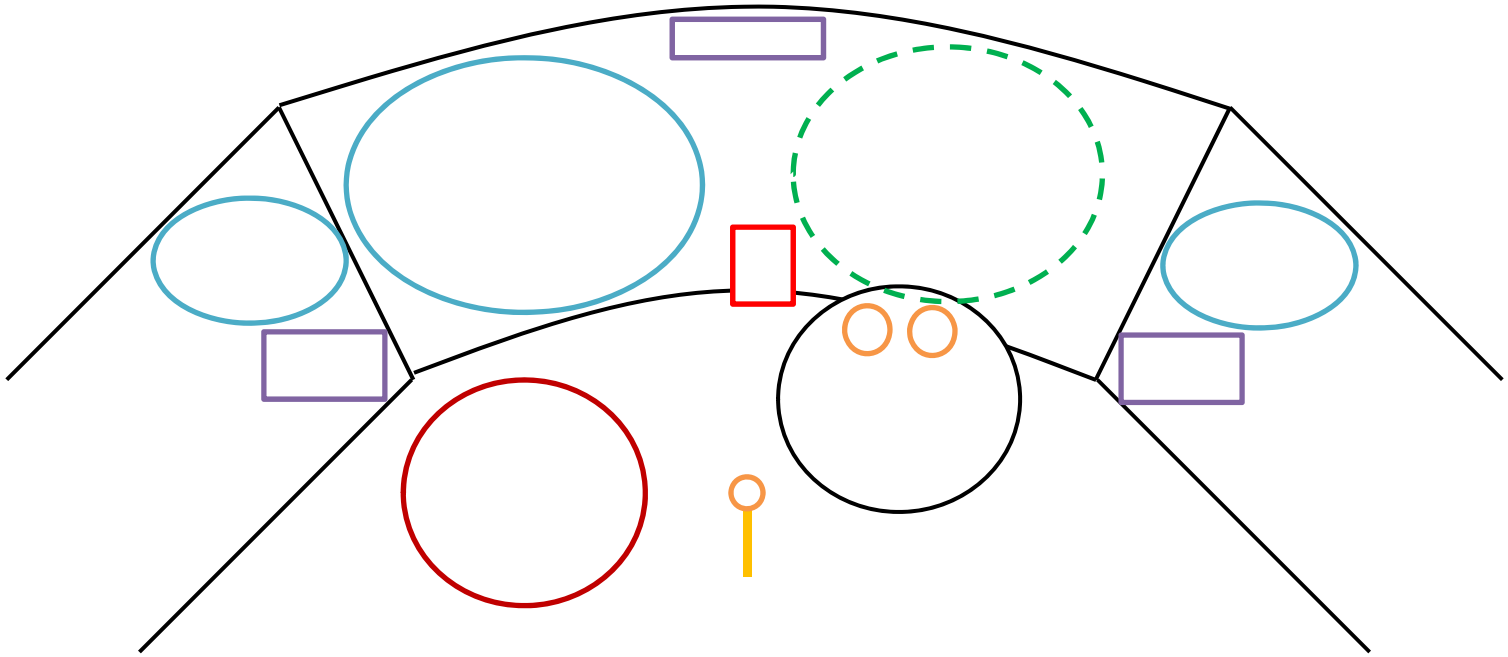


Data Collection

- Glance Behaviour evaluated over 3 x 8 minute sections which were combined



Glance Locations



Green = Centre

Blue = Off-Centre

Purple = Mirrors

Red = IVIS

Dark Red = Other & Experimenter

Orange = Driving Equipment

Experimental Conditions

- Two study conditions were adopted
  - Control: No Smart driving advice offered
  - Experimental: Smart driving advice offered via the in-vehicle Smartphone application
- Conditions were counterbalanced
- Same driving scenario completed both times
  - Separated by one week, but on same day / time

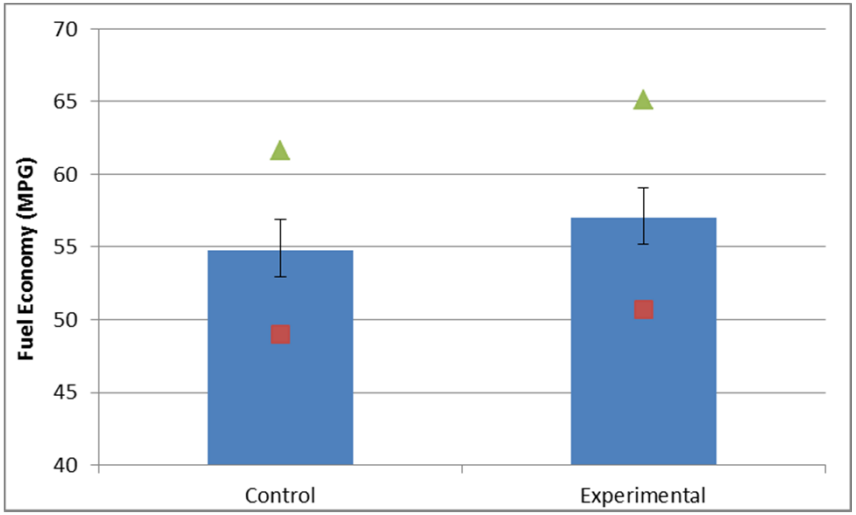
Dependent Variables

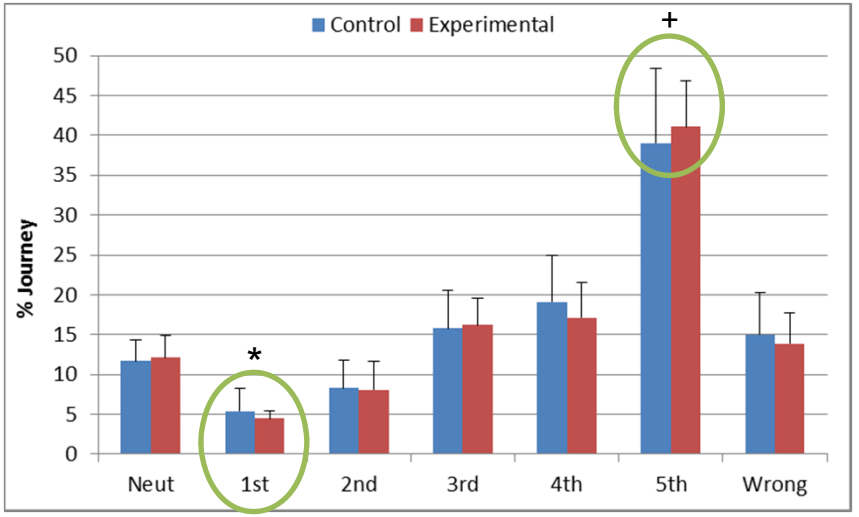
- Driving Performance
  - **Time headway:** continuous (s) and % journey under 1.5 s
  - Number of **lane deviations**
  - **Engine speed** (RPM) and **load** (%), throttle position (%)
  - **Current** and **ideal gear** position, % time in each gear
  - **Vehicle speed** (mph) and **journey time** (s)
- Glance Behaviour
  - **Glance frequency:** absolute and percentage of glances to certain locations
  - **Glance duration:** average, max and percentage of time spent at each location, number of glances greater than 2 seconds

Results

Driving Performance – Green Driving

- Significant increase in fuel economy of 4.1%
- Primarily due to improvement in gear change behaviour (↓ 1st and ↑ 5th)
  - ↑ in mean engine load, ↓ maximum RPM

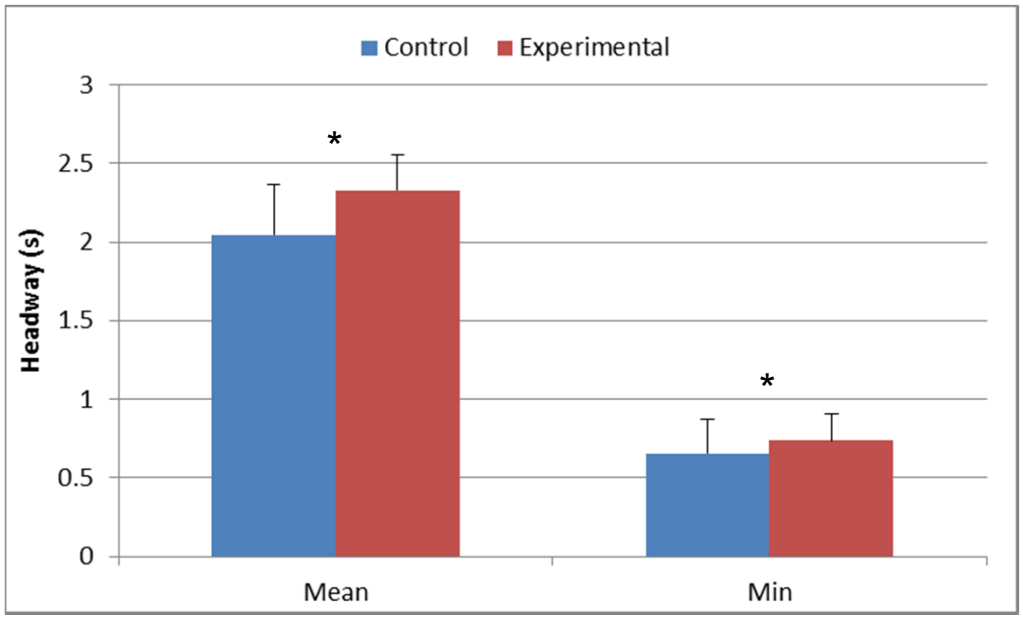




Results

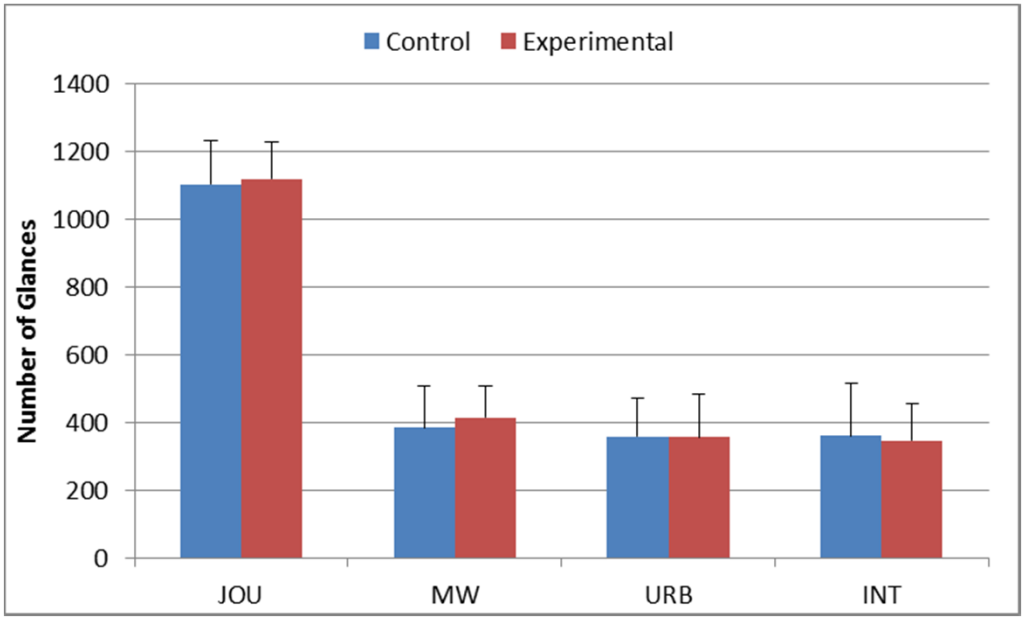
Driving Performance - Safety

- Increase in mean headway over the entire journey, a decrease in minimum headway
- Significant decrease in time spent < 1.5 s



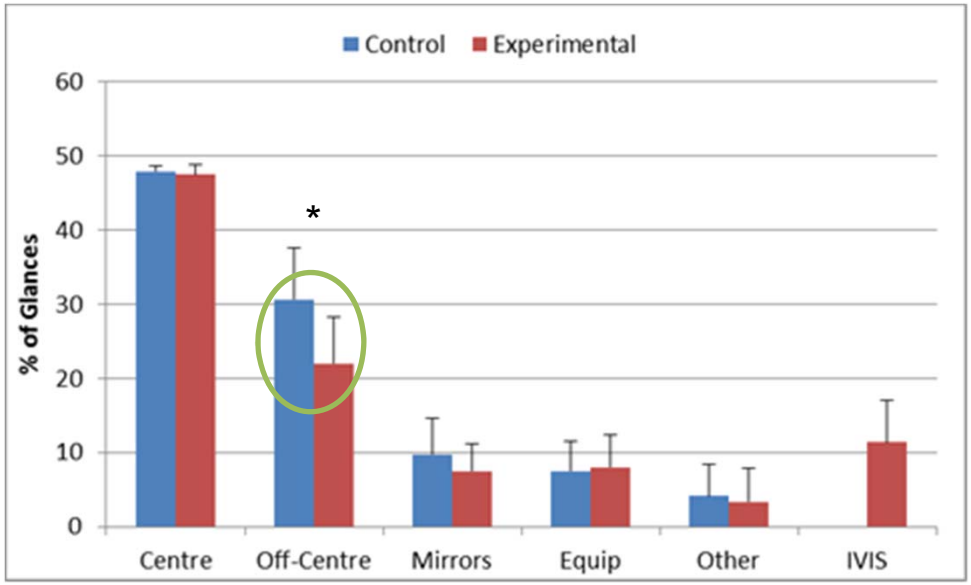
Results – Glance Behaviour

- Approx. 1100 glances to different locations were made over the combined journey
  - Only 15 more glances were made in Exp.



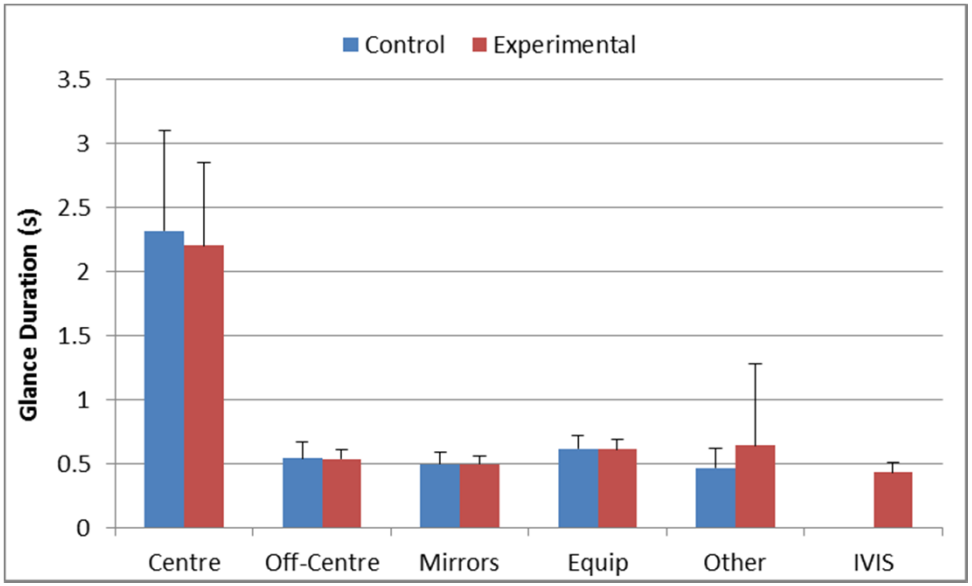
Number of Glances

- Glances to the Smart driving aid accounted for 11.74% (or 129.4) of the total number of glances
- A significant reduction in glances Off-Road was seen to compensate for this observed increase



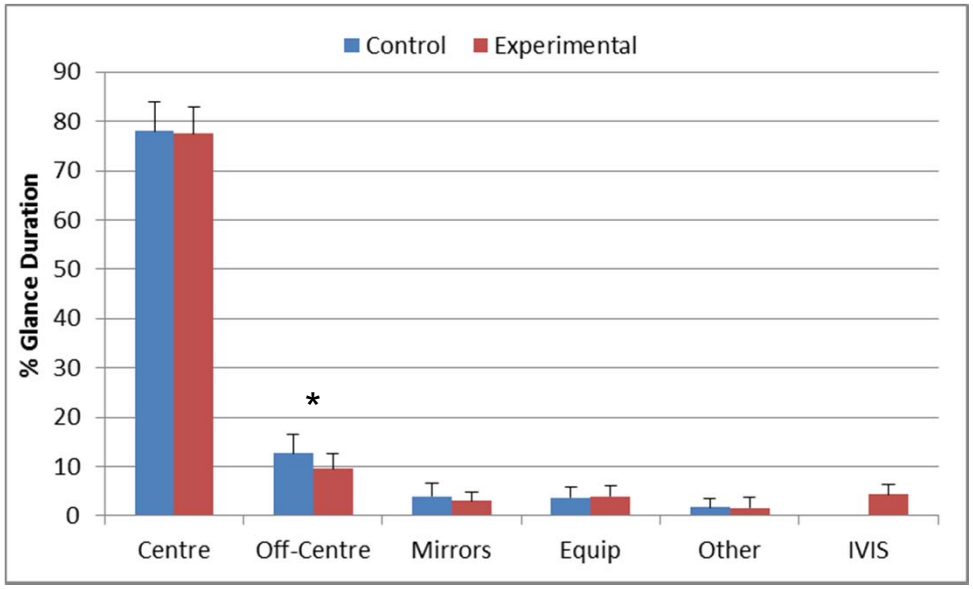
Glance Duration

- No differences to mean glance durations occurred as a result of using the Smart driving aid
- Mean glance duration to the IVIS was 0.43 seconds
  - The lowest of all the categories recorded
- Glance durations to the Driving Equipment averaged 0.61 s, mirrors 0.49 s



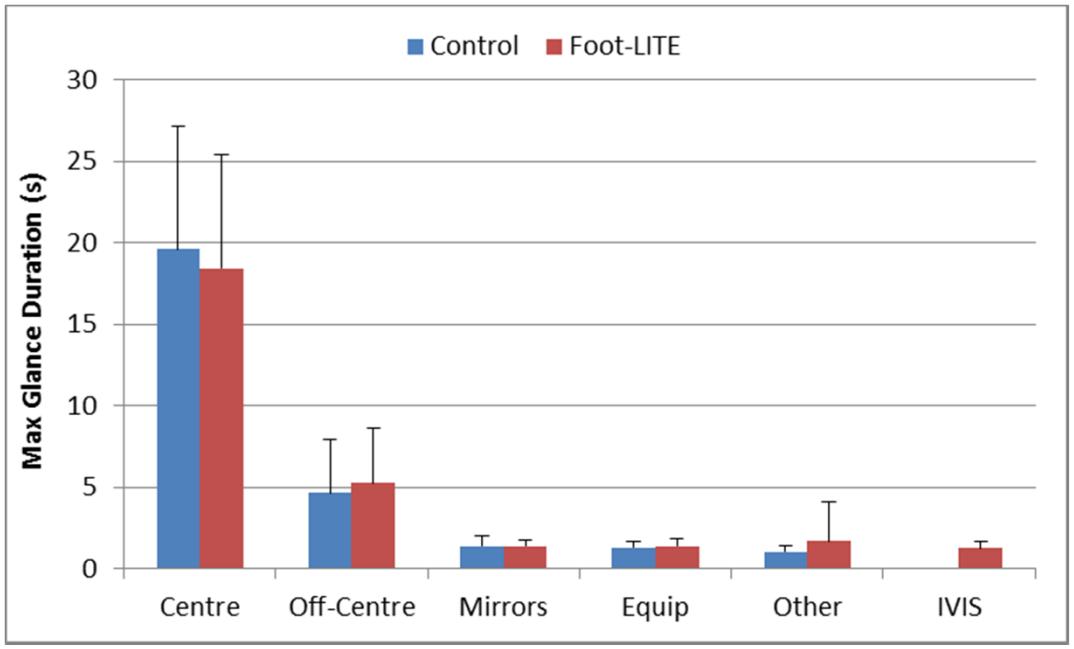
Percentage Glance Duration

- 4.3% of the drive was spent looking at the system
- 'Off Centre' reduced significantly when using the Smart driving aid, from 12.7% to 9.5%
- No differences to Mirrors, Driving Equipment or Other



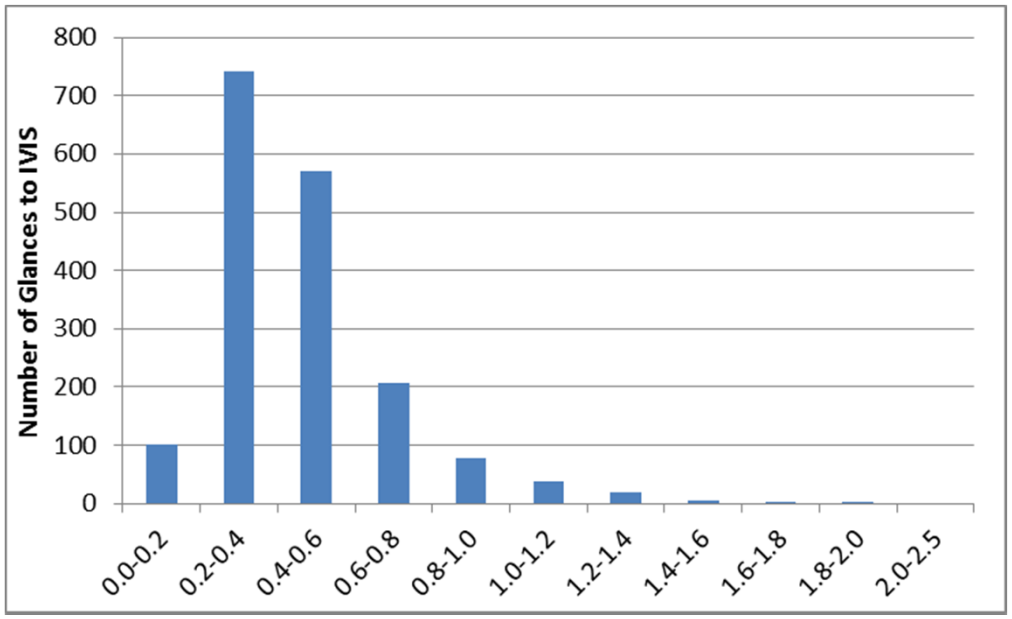
Maximum Glance Duration

- Max glance durations to areas other than the road were all around 1.4 seconds
  - To the IVIS was lowest recorded at 1.28 s

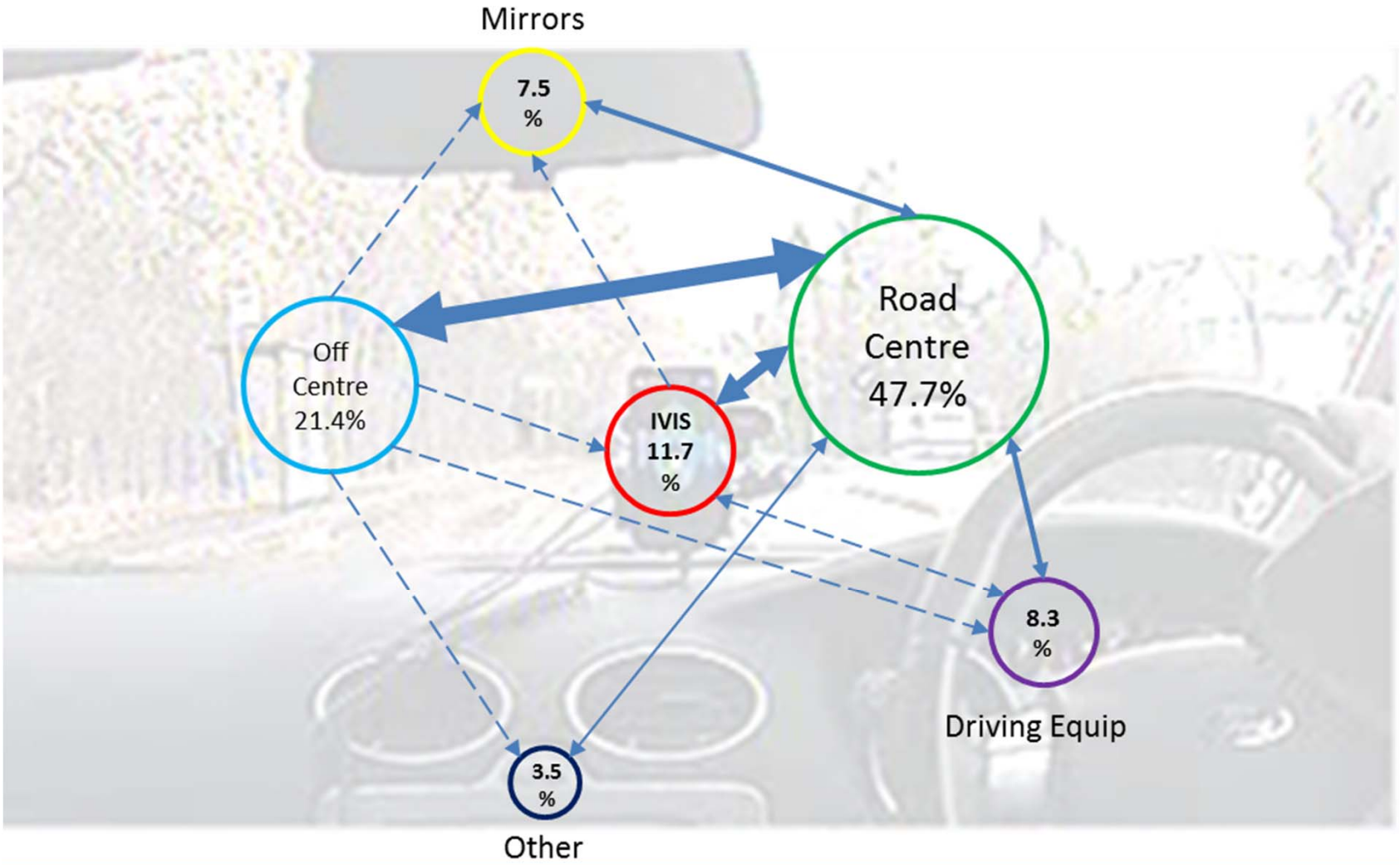


Glances of >2 Seconds

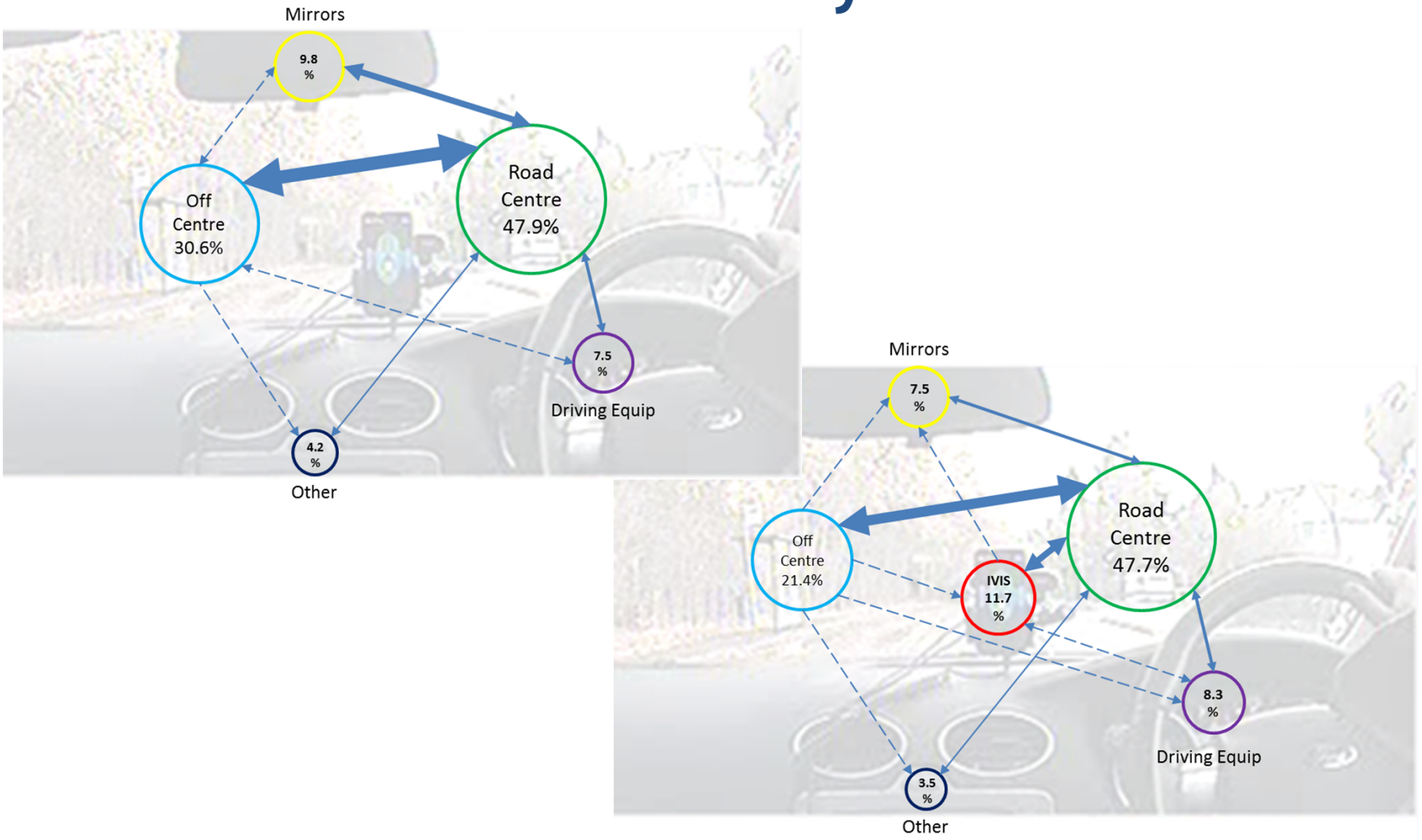
- No glances of greater than 2 seconds were made to the Smart driving aid by any of the 15 participants during the 24 minutes of the driving scenario selected for this analysis
- Approximately 75% of the glances to the IVIS were short glances, between 0.2 and 0.6 seconds



Glance Analysis



Glance Analysis

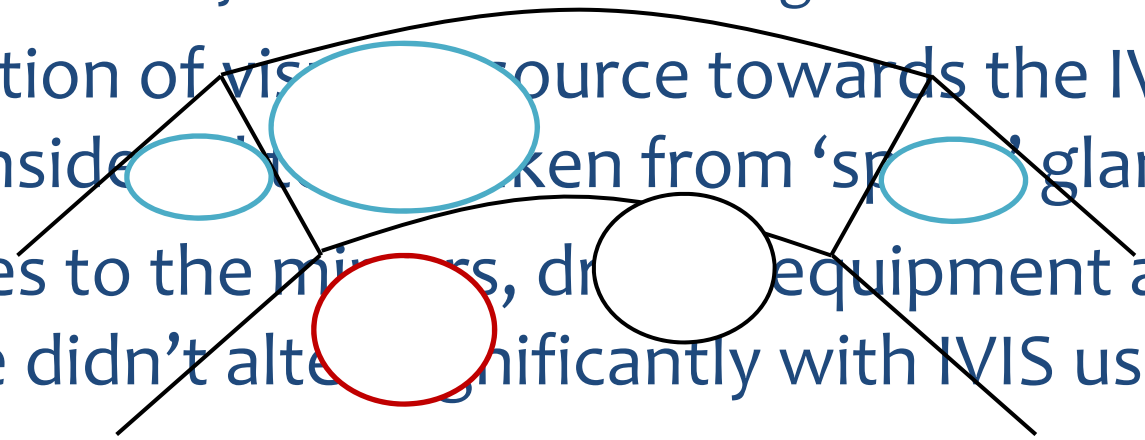


Summary
Glance Behaviour

- 11.7% of all glances made in the experimental condition were to the Smart driving system
- Mean glance duration was 0.43 seconds
- With drivers spending 4.3% of the 24 minute analysis period looking at the IVIS
- Average maximum glance duration was 1.28 s
- With no glances to the IVIS being greater than 2 s, i.e. within the NHTSA guidelines

Conclusions
Glance Behaviour

- Drivers may have 40 – 50% '*spare*' attentional capacity during driving (Hughes and Cole, 1986; Green and Shah, 2004)
- Study proposes that spare glances are those from two categories – 'Other' and 'Road: Off Centre'
  - Contain glances that may not be considered safety or operationally critical to the driving task
- Allocation of visual resource towards the IVIS could be considered taken from 'spare' glances
- Glances to the mirrors, driving equipment and road centre didn't alter significantly with IVIS use



Thank you for listening

Any Questions?

Dr. Stewart Birrell
BSc (Hons), PhD
Senior Research Fellow

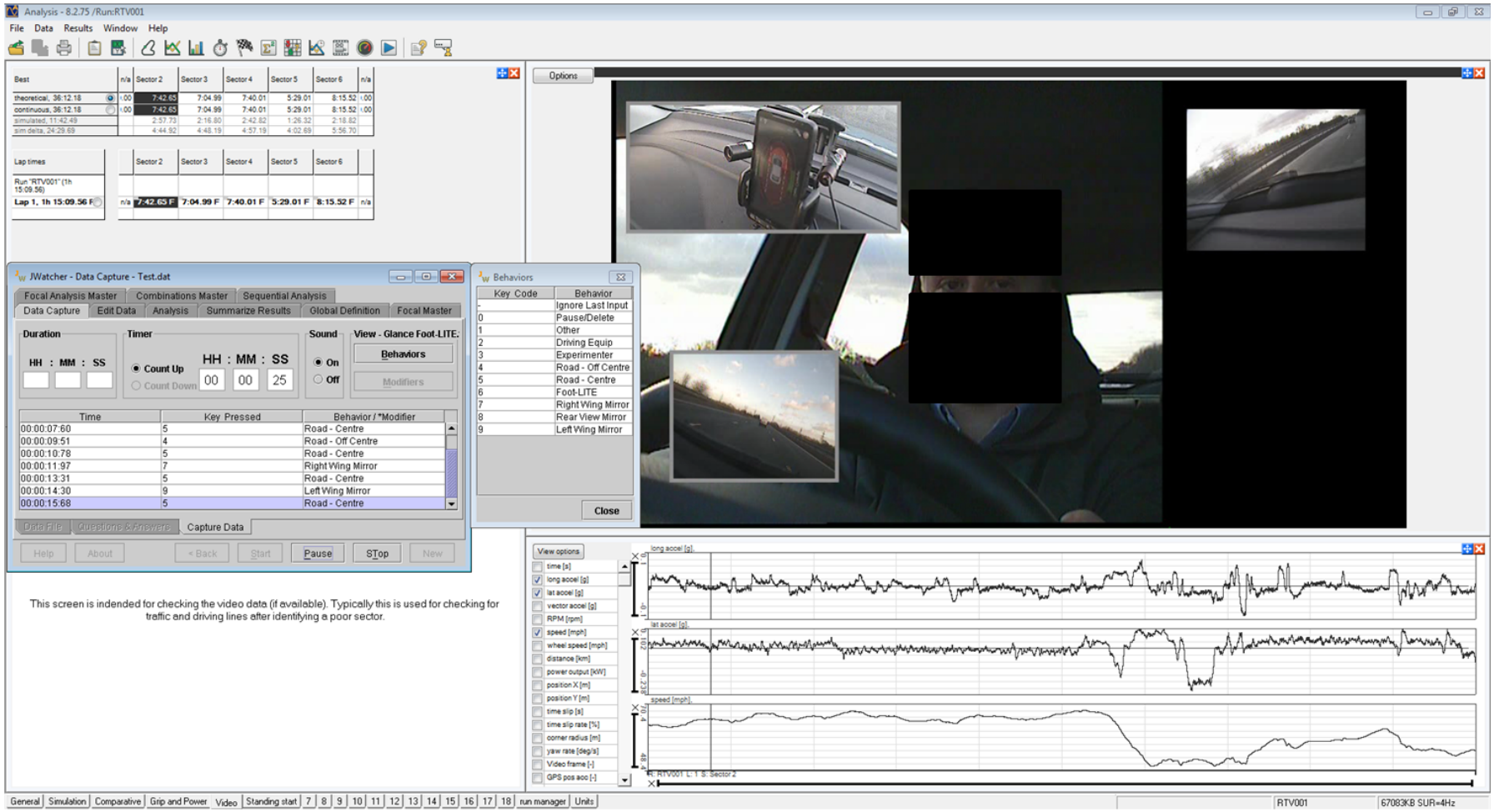
Email: s.birrell@warwick.ac.uk

International Digital Laboratory
The University of Warwick
Coventry CV4 7AL UK
Tel: +44 (0)24 7657 3752
Web: www.wmg.warwick.ac.uk

Video Methodology

- Manual Analysis of Video Files
  - Video collected was stored as raw data files
  - Pilot trials revealed that frame-by-frame analysis was very time consuming (1-2 hours each 7 min section)
  - No automated video analysis is possible, so an alternative method was needed
- JWatcher programme selected for analysis
  - Originally developed as an observation recording programme for Behavioural Sciences
  - Behaviours could be identified and associated with specific keys on the keyboard, the time was recorded in-between these keystrokes and saved as .text files

JWatcher Analysis



JWatcher Analysis

- Pilot analysis was conducted with JWatcher
  - Showed that playing raw video files at ¼ speed was sufficient to accurately and reliably record glances
  - The glance duration as defined by ISO 15007-1:2002 was adapted slightly. For this FOT analysis a glance was identified from fixation to fixation, rather than transition to transition
  - This allowed analyst where a glance recording it, of glance duration