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Stimulating Conversation:
Engaging Drivers in Natural Language Interactions with an Autonomous Digital Driving Assistant to Counteract Passive Task-Related Fatigue

David R Large, Gary Burnett, **Vicki Antrobus**
Human Factors Research Group, University of Nottingham

Lee Skrypchuk
Jaguar Land Rover Research

Vicki.Antrobus@Nottingham.ac.uk

Overall Aim

- To measure the effectiveness of a digital driving assistant (David…'Vid'), employing natural language interactions, as a countermeasure for fatigue while driving

Fatigue

- State of reduced mental alertness
- Synonymous with 'sleepiness' (can lead to sleep)
- Impairs performance – poor decision making, delayed reaction times, driver errors
- Gradual and cumulative process
- Prevalent during monotonous, long distance and night-time driving
- Frequently cited as causal/contributory factor in RTAs
- Passive / Active Fatigue

Measuring Fatigue

- Physiological measures
  - Heart activity, skin conductance (EDA)
- Driving Performance
  - Speed maintenance, headway variability, lane keeping
- Behavioural Indicators
  - Eye activity – perclos, percent road centre (PRC)
  - Nodding/yawning etc.
- Subjective Assessment
  - E.g. Epworth and Stanford Sleepiness Scale

In-Vehicle Countermeasures

- Technological solutions (driver state monitoring)
  - Rely on physical indicators e.g. elevated blink rate, nodding, yawning
  - Driver already significantly impaired
  - May encourage greater risk taking
- Social interaction and conversation
  - Maintains alertness amongst pilots
  - *Absence* of conversation is predictor of declining physiological alertness
  - Requires second interlocutor (co-pilot)

Digital Driving Assistant

- Voice User Interfaces (VUIs) increasingly conversational
- Often embodied by digital personality
- General trend to use VUIs in cars to reduce visual/manual distraction

Overview of Study

- 23 participants (18 male; 5 female)
- Medium fidelity driving simulator
- UK motorway scenario
- Car-following paradigm
- Low feature, monotonous driving environment
  - lead car remains in lane 1 @ 68mph
- Testing between 13:00 and 16:30
  - Circadian and homeostatic influences naturally reduce alertness
  - Participants also asked to consume normal lunch and refrain from caffeine intake 3 hours prior to testing
- Two conditions (30 min drives), counterbalanced
  - With and without DDA

Digital Driving Assistant

- Engaged drivers in conversation, e.g.
  - *"I looked at your calendar and you have a meeting upcoming today at 3 o'clock. Would you like me to set a reminder for your meeting?"*
  - *"It looks like you've got a few things to do on your way home this evening. You need to buy milk. Would you like me to set a reminder for you to buy milk?"*
  - *"There is congestion ahead. This may delay you by 5 minutes would you like me to direct you around the congestion? ... OK. I am calculating a reroute."*

Objective Measures

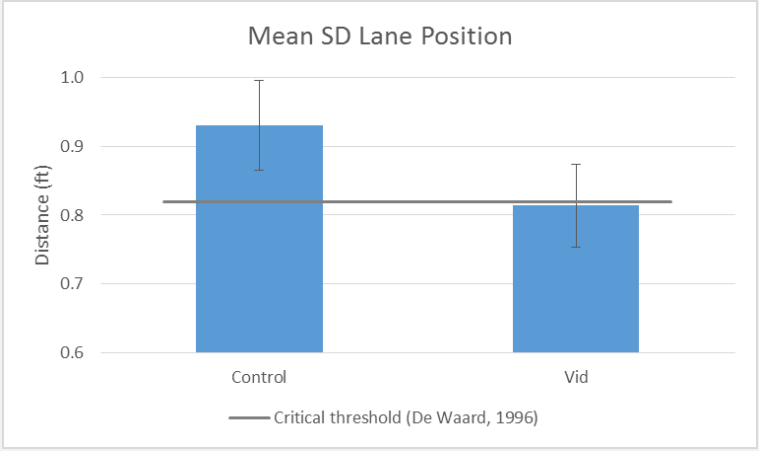
- Driving performance (STISIMv3)
  - Lane keeping, speed and headway variability
  - Response to potential hazard event
- Physiological measures (Empatica E4 watch)
  - Inter-Beat Interval / Heart Rate Variability
- Visual Behaviour (SMI 'Natural Gaze' ETG)
  - Blinks and Fixations (rate/duration)
  - Spread of visual attention (Percent Road Centre)
  - Pupil diameter

Subjective Measures

- Sleepiness ratings (pre and post drives)
  - Stanford Sleepiness Scale (Hoddes et al. 1973)
- Driver mood assessment (pre and post drives)
  - UWIST Mood Adjective Check-List (Jones 1990)
- Workload
  - NASA-TLX (Hart and Staveland, 1988)

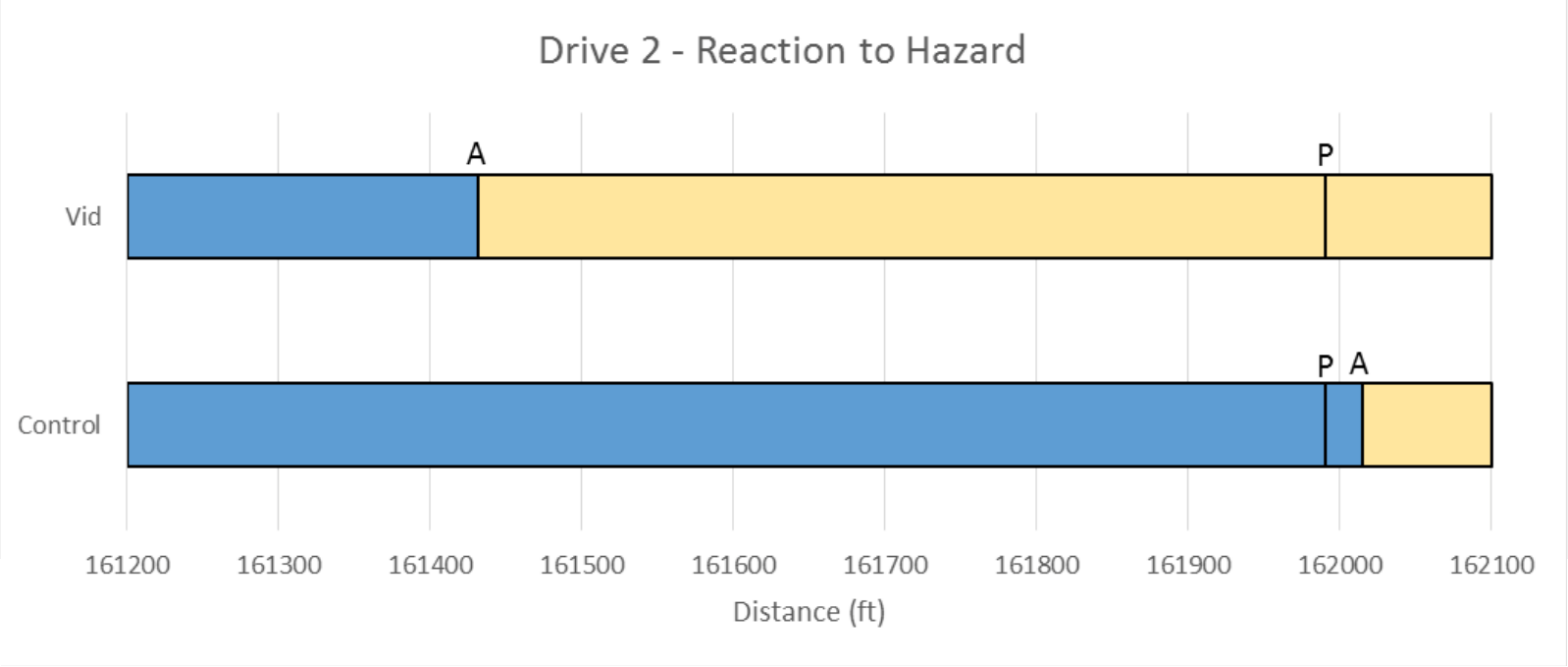
Results

- Driving Performance: significantly more variability in lateral lane position during control drive compared to Vid



Results

- Hazard Response: Earlier response to hazards in Vid condition compared to control drive
  - Drivers in the control drive had already passed the hazard before responding



Results

- Sleepiness Ratings: Sig difference in ratings between conditions
  - Participants indicated more perceived sleepiness after control drive, compared to Vid
- Driver Workload: Perceived lower workload in drivers interacting with digital assistant
- Trend toward more visual attention toward "road centre" in control drive
  - Higher concentration of gazes within road centre indicates higher levels of fatigue

Conclusions

- Social interaction enabled by a natural language digital driving assistant ('Vid') had a positive effect on driver fatigue and arousal
- However, many objective measures revealed no differences between conditions
  - e.g. Physiological indicators
- Self-report subjective measures may be biased
  - Participants often overestimate their level of alertness thereby concealing their fatigue
- Results only apply to passive fatigue
  - Interactions could add extra workload to drivers already highly-loaded (i.e. active fatigued)