Accounting for Fatigue in Systems Design and Operations: Issues and Opportunities

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Overview

- Intersection of three safety factors: fatigue, automation and distraction
  - Can “distraction” mitigate automation-induced fatigue?
- Simulator studies of automation fatigue: Surface and UAVs
  - Impact on subjective state, behavioral alertness and trust in automation
- Extent of the problem
  - Driver/operator limitations in effective fatigue management
- Secondary task solutions
  - Mixed effects of media use
- Safety implications

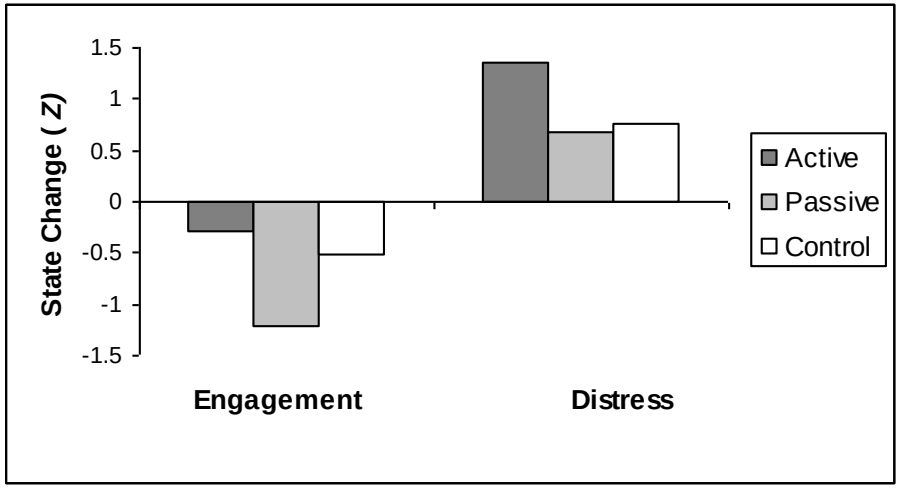
Convergence of Multiple Safety Threats

- Fatigue
  - Task-induced fatigue and workload regulation
  - Distinct from sleep loss and circadian effects
  - Fatigue effects in short-haul trucking (Friswell & Williamson, 2008)
- Distraction
  - Phone use and more (Strayer & Drews, 2007)
  - But can secondary tasks counter fatigue?
- Automation
  - Aims to help – but loss of situation awareness (Young & Stanton, 2007)
  - Source of fatigue
  - The driverless vehicle

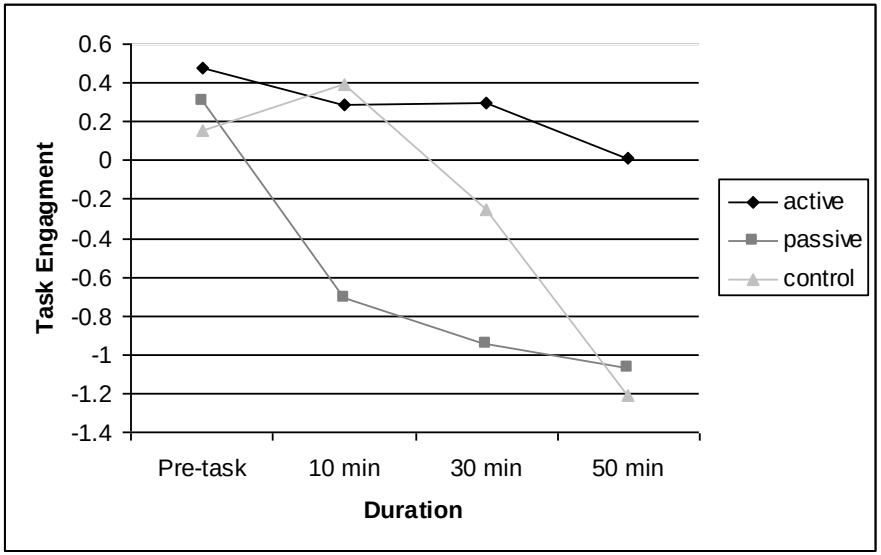
Automation Provokes Rapid Disengagement

(Saxby et al., 2013)

Overall state change



Loss of engagement over time

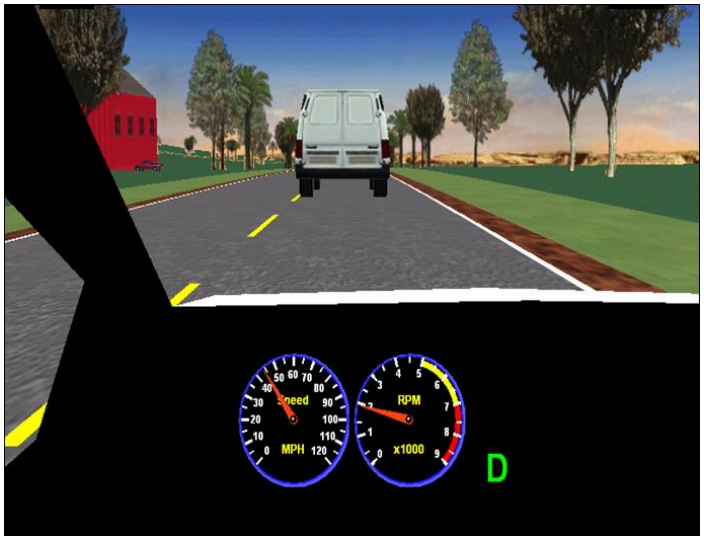


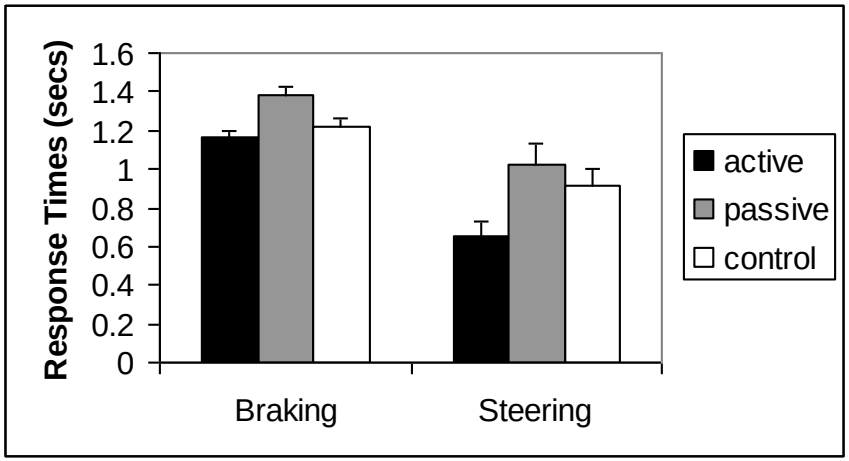
Active fatigue: wind gusts

Passive fatigue: full automation

Automation Provokes Loss of Alertness
(Saxby et al., 2013)

- Emergency event at end of drive: van pulls out
- Measure braking and steering response times (averaged across duration)
- Slowest braking and steering response times in passive fatigue condition





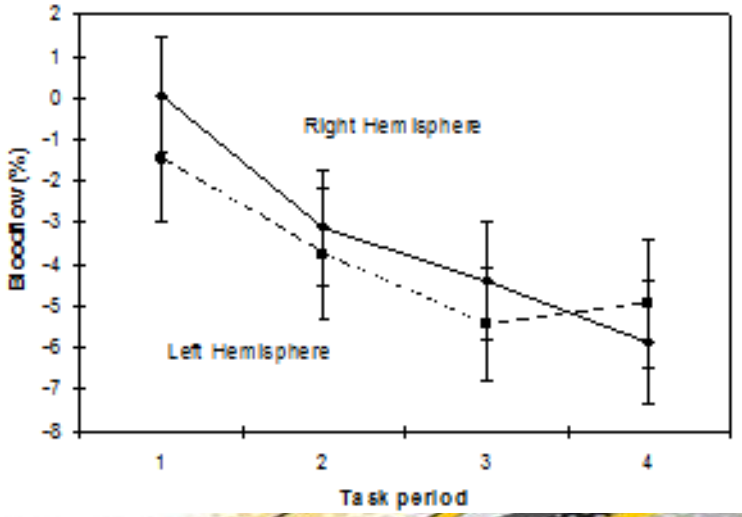
Active fatigue:
wind gusts

Passive fatigue:
automation

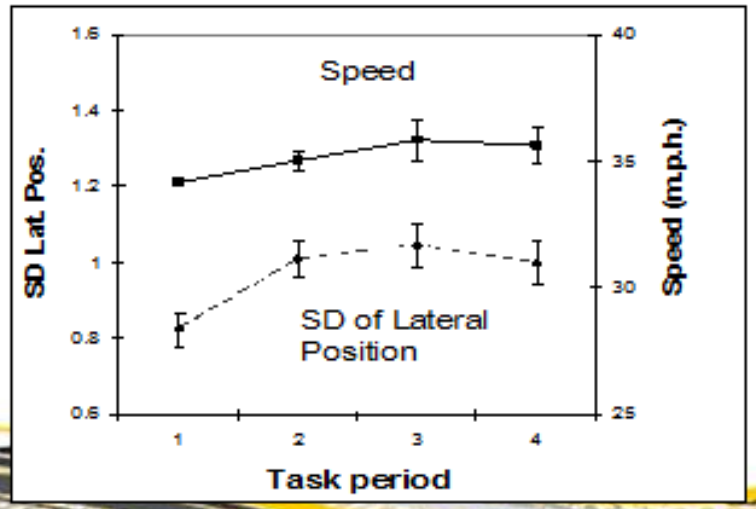
Brain Metabolic Changes

- Cerebral bloodflow velocity (CBFV)
  - Measured using transcranial Doppler sonography
  - Decline closely parallels vigilance decrement in performance (Warm et al., 2012)
- Simulated driving: Concurrent changes in CBFV and performance (Reinerman et al., 2008) over 36 min

CBFV

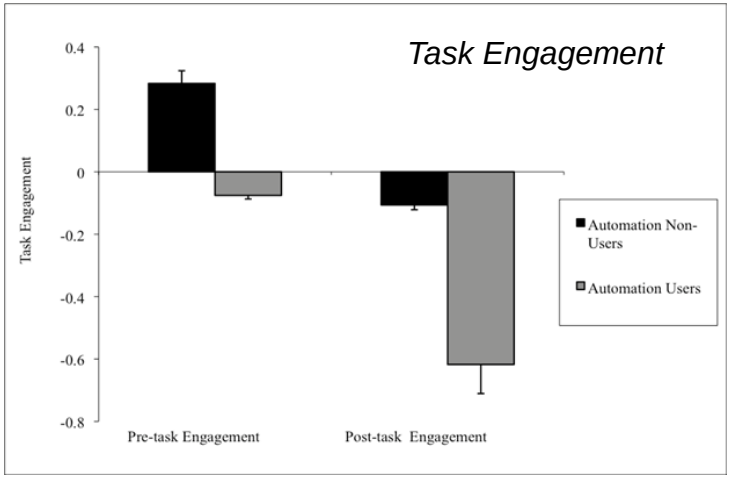


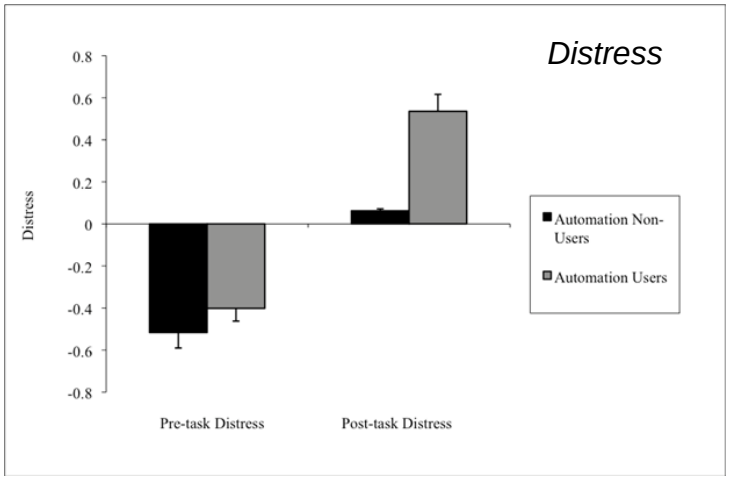
Performance



Control over Automation Does Not Mitigate Fatigue
(Neubauer et al., 2012a)

- Participants can choose to use full automation, for 5 min periods
  - Compare automation users (N=44) and non-users (N=49)
  - Pre-drive subjective engagement predicts greater automation use
  - Automation users show greater increase in post-drive distress (vicious cycle?)

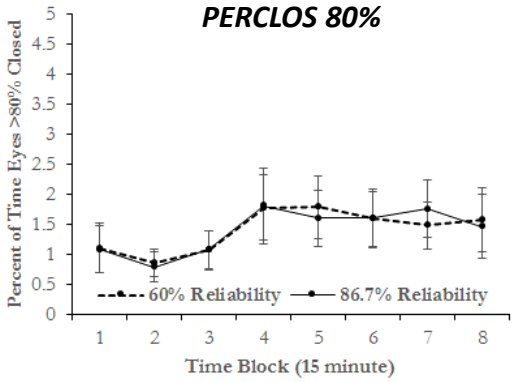


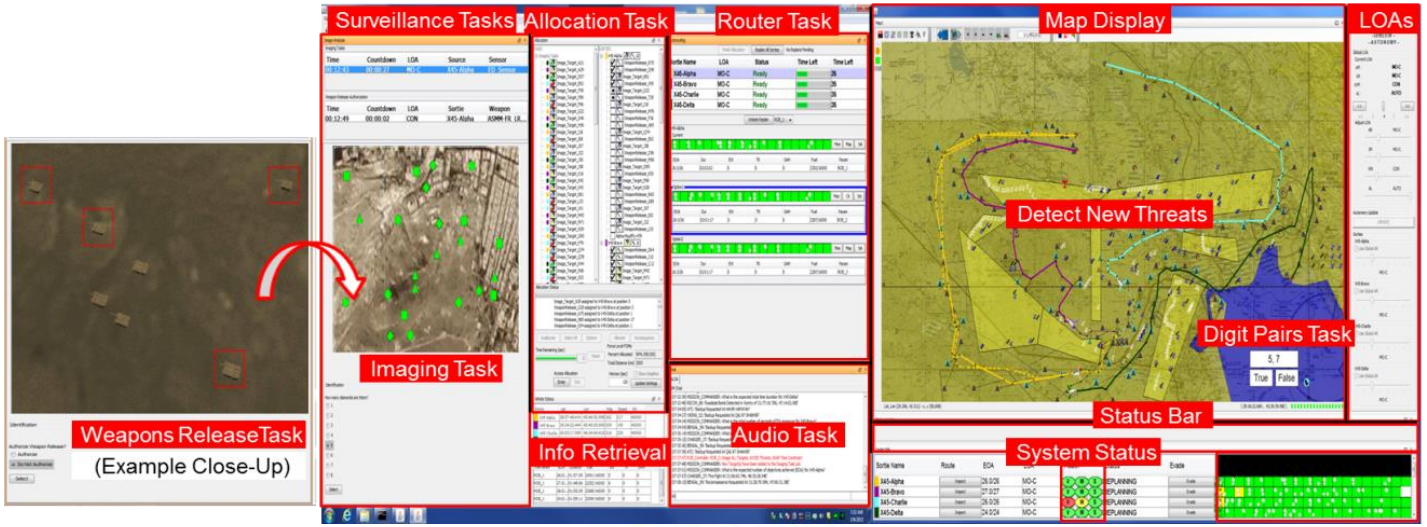


Fatigue in UAV Operation
(Lin et al., 2016)

- Adaptive Levels of Automation (ALOA) multi-UAV simulation, with embedded surveillance tasks
- Configured for monotony
- 2-hour run effective for fatigue induction:

  Subjective and eyetracking metrics

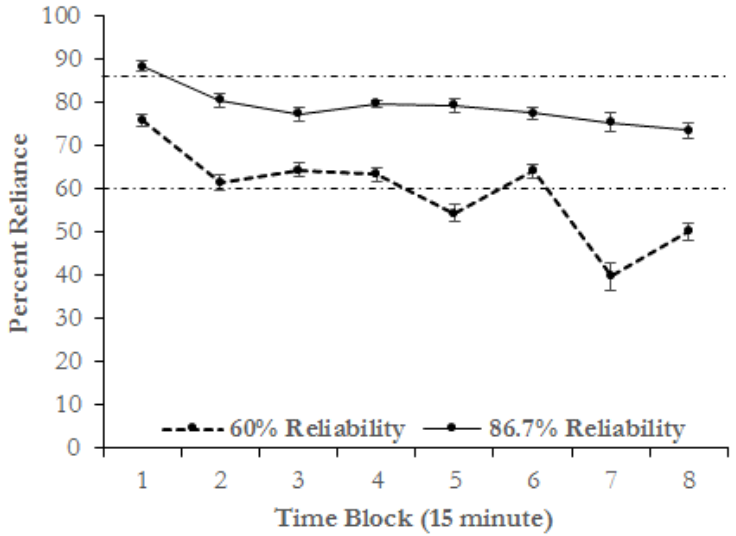




Operators Do Not Use Automation Effectively

- Automation helpful for difficult surveillance task
- Operators increasingly neglect automation over time: task-shedding?

Reliance: % of trials on which automated recommendation followed

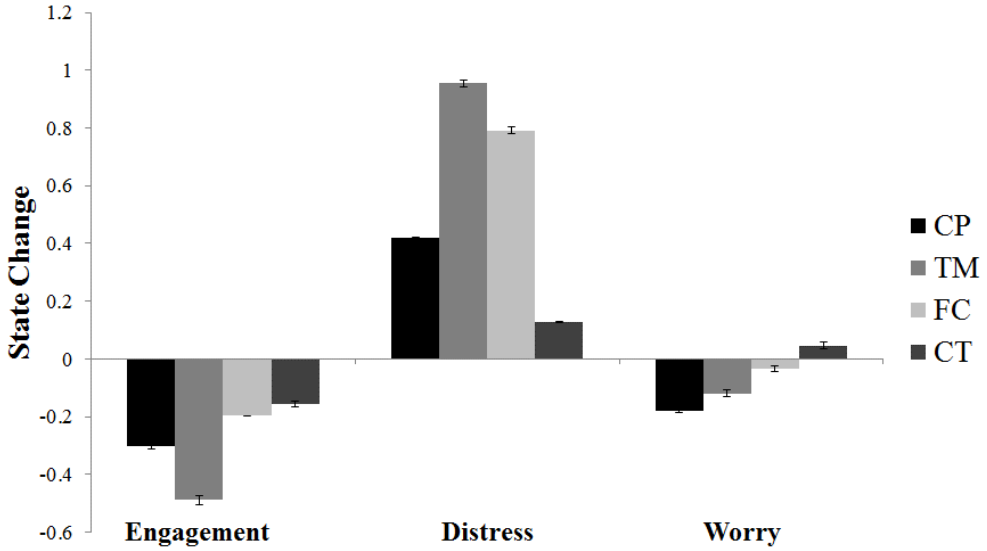


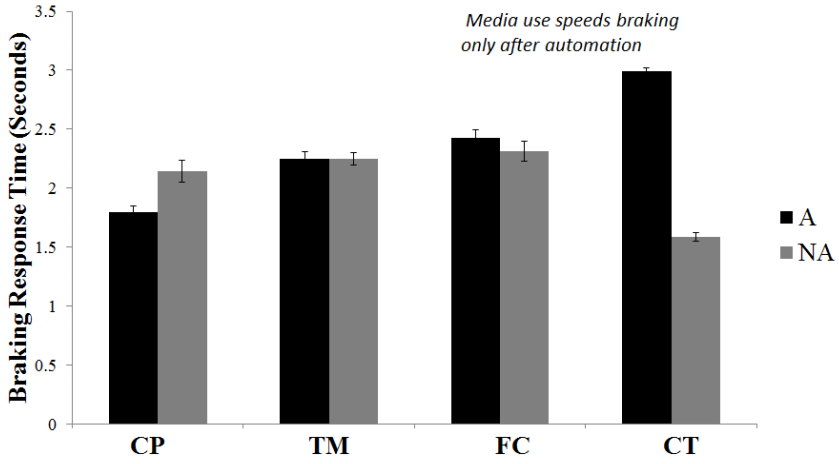
Surface Vehicles: Distraction and Fatigue

- Does media use during period of automation counter automation fatigue?
  - Text and speech inputs
  - Text and voice outputs
  - Some scope for choice
- Outcome measures
  - Subjective stress and fatigue
  - Response time to post-automation emergency event
- Study 1
  - Response to cellphone text messages: text or speak back
- Study 2
  - Response to voice messages: speak back

Responding to Texts is Stressful but Enhances Alertness

- *Texting elevates distress and lowers engagement; speech to a lesser extent*
- *Texting and speech slow emergency response after normal driving; speed response after automation*



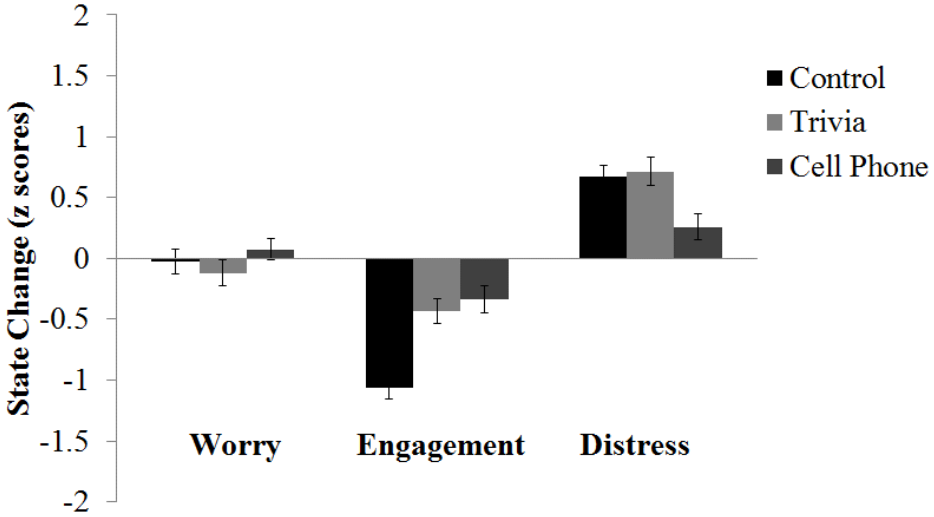


CP = Phone TM = Text FC = Choice CT = Control

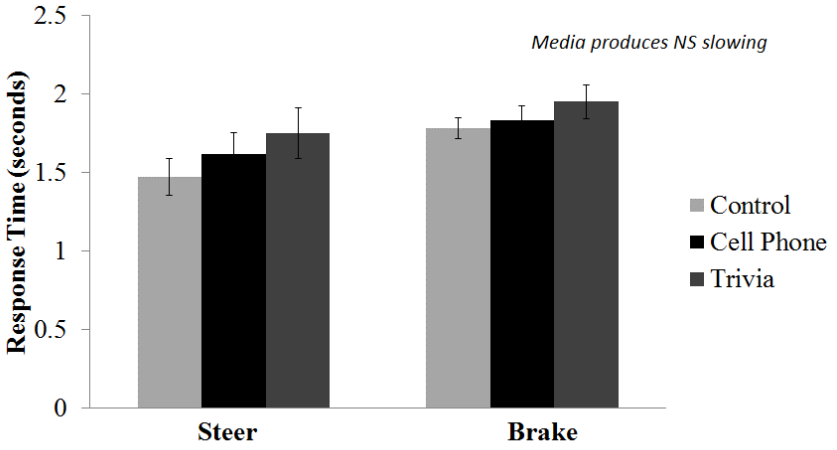
A = Automation NA = No Automation

Responding To Voice Is Engaging But Does Not Raise Alertness

- *Cellphone and trivia mitigate loss of engagement*



- *Cell phone and trivia have no effect on response time, irrespective of automation*



Implications for Countermeasures

- Perils of automation
  - Even short intervals of automation are hazardous due to passive fatigue
  - Don't trust the driver to manage automation
- Secondary tasks: Distraction or countermeasure?
  - Verbal response to texts during automation enhances alertness
    - Unclear whether this is a viable countermeasure
  - Trivia game play has similar effects to phone conversation
    - Again, some way to go to practical benefits
- Other solutions
  - Diagnostic monitoring
  - Training solutions
  - Situational exercises to promote adaptive coping