Task-Induced Fatigue, Operator Engagement and the Control of Attention

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Sponsors:

Overview

- Task-induced fatigue
  - 3-D model of stress states (Matthews et al., 2002)
  - Cognitive perspectives
- Task engagement and attention
  - Energy, engagement and attention: basic and applied studies
  - Applications: diagnostic monitoring
- Vehicle automation and fatigue
  - Active and passive fatigue (Desmond & Hancock, 2001)
  - Full automation impairs alertness
  - Distraction and secondary tasks
- Conclusions

Task-Induced Fatigue

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The Dundee Stress State Questionnaire (DSSQ: Matthews et al., 2002, 2013)

Scale	Example item	α	Test-retest r (6-month)
Energetic arousal	I feel... Vigorous	82	39
Tense arousal	I feel... Nervous	87	23
Hedonic Tone	I feel... Contented	88	17
Motivation (Intrinsic)	The content of the task is interesting	81	
Motivation (Success)	I want to perform better than others	87	
Self-focus	I am reflecting about myself	87	34
Self-esteem	I am worrying about looking foolish (-ve)	89	42
Concentration	My mind is wandering a great deal (-ve)	89	46
Confidence-control	I feel confident in my abilities	84	32
Cog. Interference (Task-related)	I have thoughts of... The difficulty of the problems	77	28
Cog. Interference (Task-irrelevant)	I have thoughts of... Personal worries	85	00

Three Factor Model for Subjective States

	Task Engagement	Distress	Worry
Principal scales	Energetic arousal Motivation (Intrinsic) Motivation (Success) Concentration	Tense arousal Low hedonic tone Low confidence	Self-consciousness Low self-esteem Cog. Interference (task-related) Cog. Interference (personal)

- General framework for understanding fatigue and stress in performance contexts
- Low task engagement is central to fatigue
  - Tiredness, apathy, distractibility

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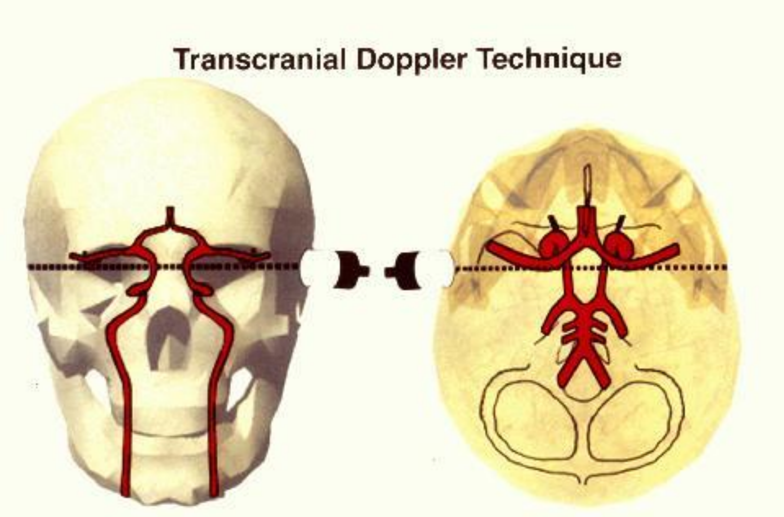
Construct Validation: Three Factors

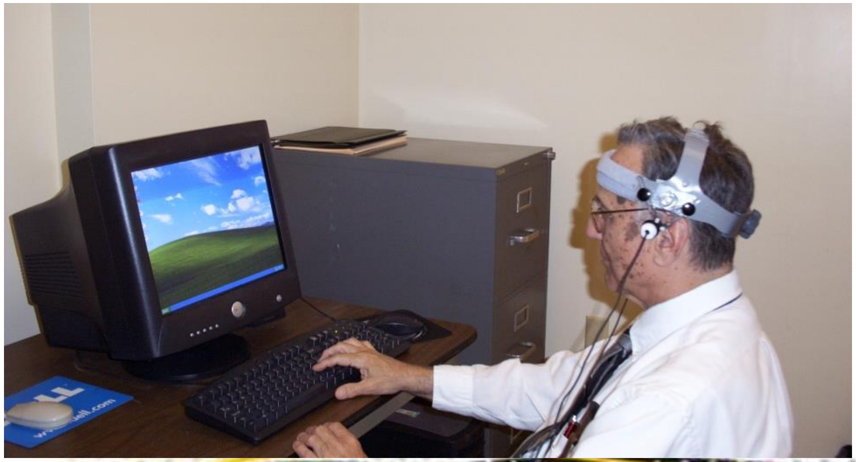
Task Engagement	Distress	Worry
Principal scales		
Energetic arousal	Tense arousal	Self-consciousness
Motivation	Low hedonic tone	Low self-esteem
Concentration	Low confidence	Cog. Interference (task)
		Cog. Interference (personal)
Appraisals		
High demands	High workload	-
High effort	Threat	
Challenge	Failure to reach goals	
Coping		
Task-focus	Emotion-focus	Emotion-focus
Low Avoidance		Avoidance
Personality		
Conscientiousness	Neuroticism	Neuroticism
Emotional Intelligence	Grit	Grit
Hardiness	Hardiness	Hardiness
		Metacognitive Style

Transcranial Doppler Sonography

Placement of ultrasound tranceiver



Use of head mounting



Cerebral blood velocity (CBFV) decline parallels vigilance decrement (Warm et al., 2012)

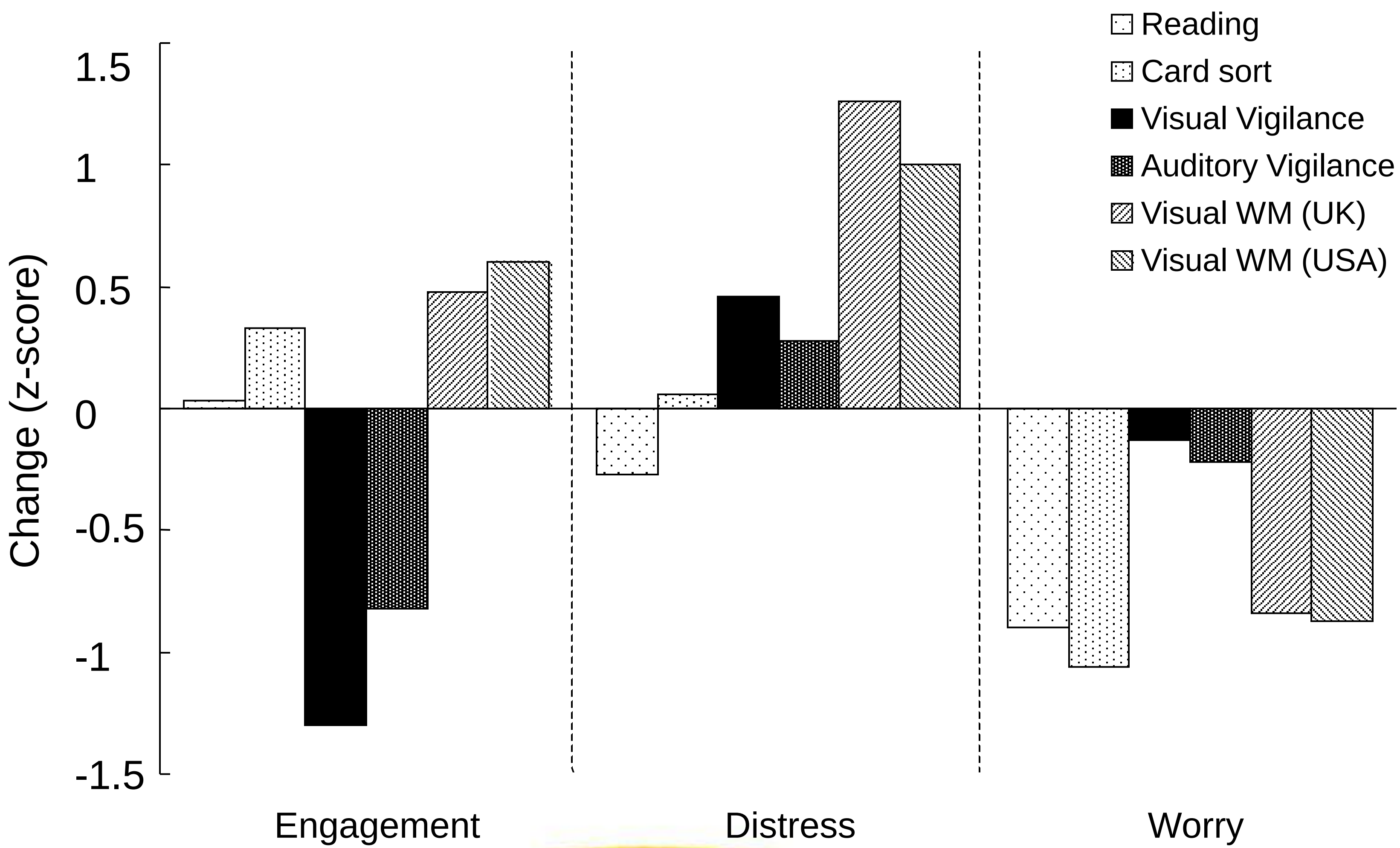
Task Engagement Correlates with Cerebral Bloodflow Response (Matthews et al., 2010a)

- *Method*
  - 187 subjects performed battery of three short, high workload tasks
  - Bloodflow measured by transcranial Doppler sonography
  - Subjective state and coping measured pre- and post-task
- *Task-induced responses*
  - Bloodflow increased, relative to baseline (some lateralization)
  - Task engagement constant
- *Correlations*

Assessment		Task Engagement		Task-focused coping	
		Left-P	Right-P	Left-P	Right-P
Baseline	*r*	.112	.255**	-	-
	N	172	152		
Post-task	*r*	.172	.256**	.133	.223**
(short battery)	N	172	152	172	152

**P<.01

Profiling Cognitive Tasks (Matthews et al., 2002)



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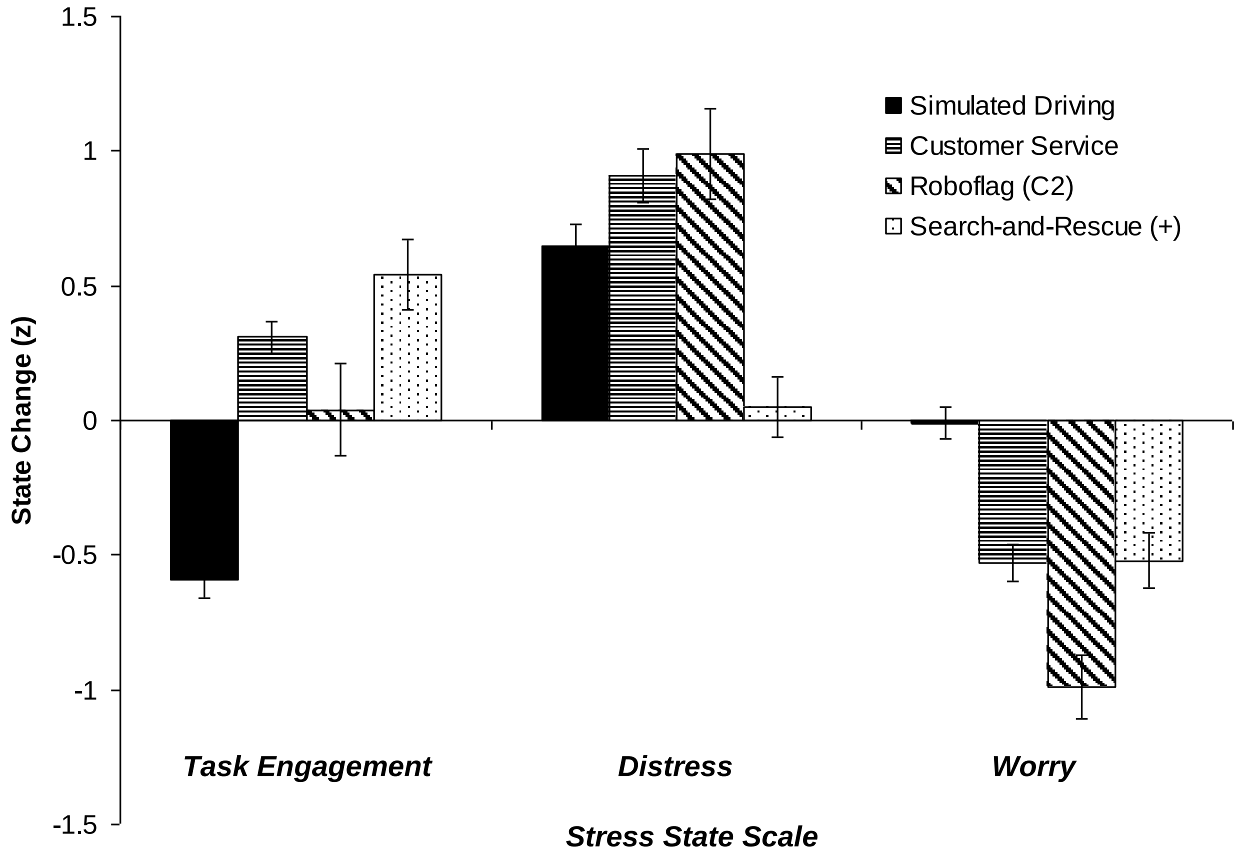
Profiling Complex Tasks



Simulated driving: Neubauer et al. (2012; *N* = 91). Customer service: Matthews and Falconer (2000; *N* = 86). Roboflag: Guznov et al. (2010; solo condition; *N* = 50). Search-and-rescue: Kustubayeva et al. (2012; positive feedback condition; *N* = 80).

Task Engagement and Attention

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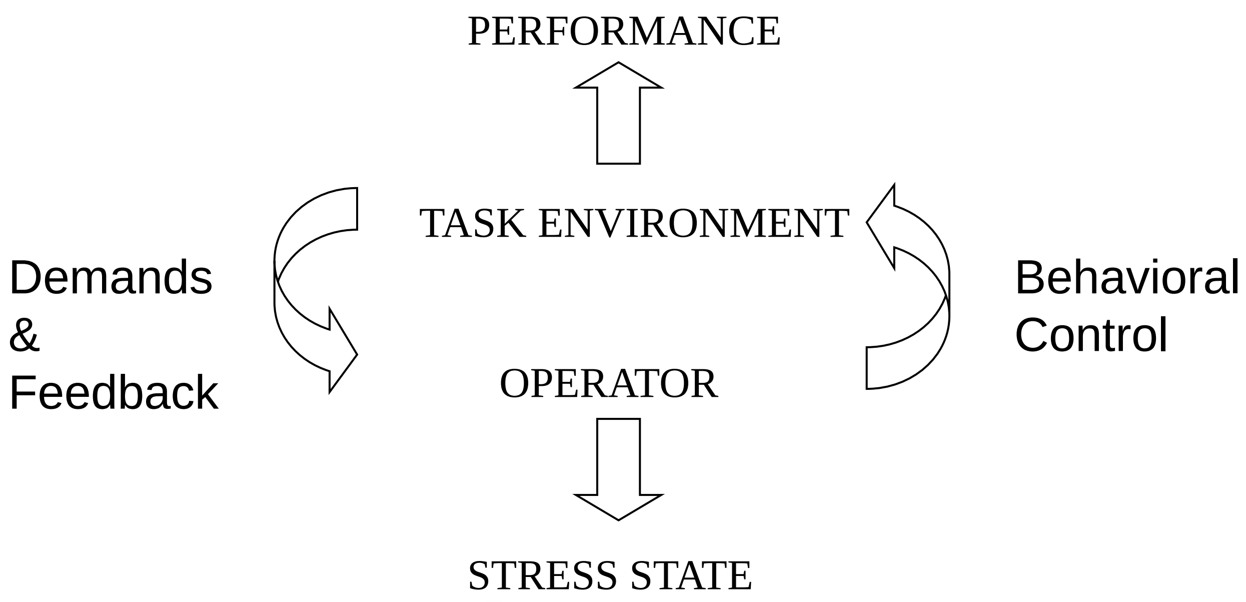
Transactional Model of Stress States and Performance (Matthews, 2001)

- Operator and task environment in dynamic interaction
  - Stress states as indices of transaction
  - Research on (1) environment effects on state, and (2) performance correlates of state



Fatigue: Cognitive Impairments

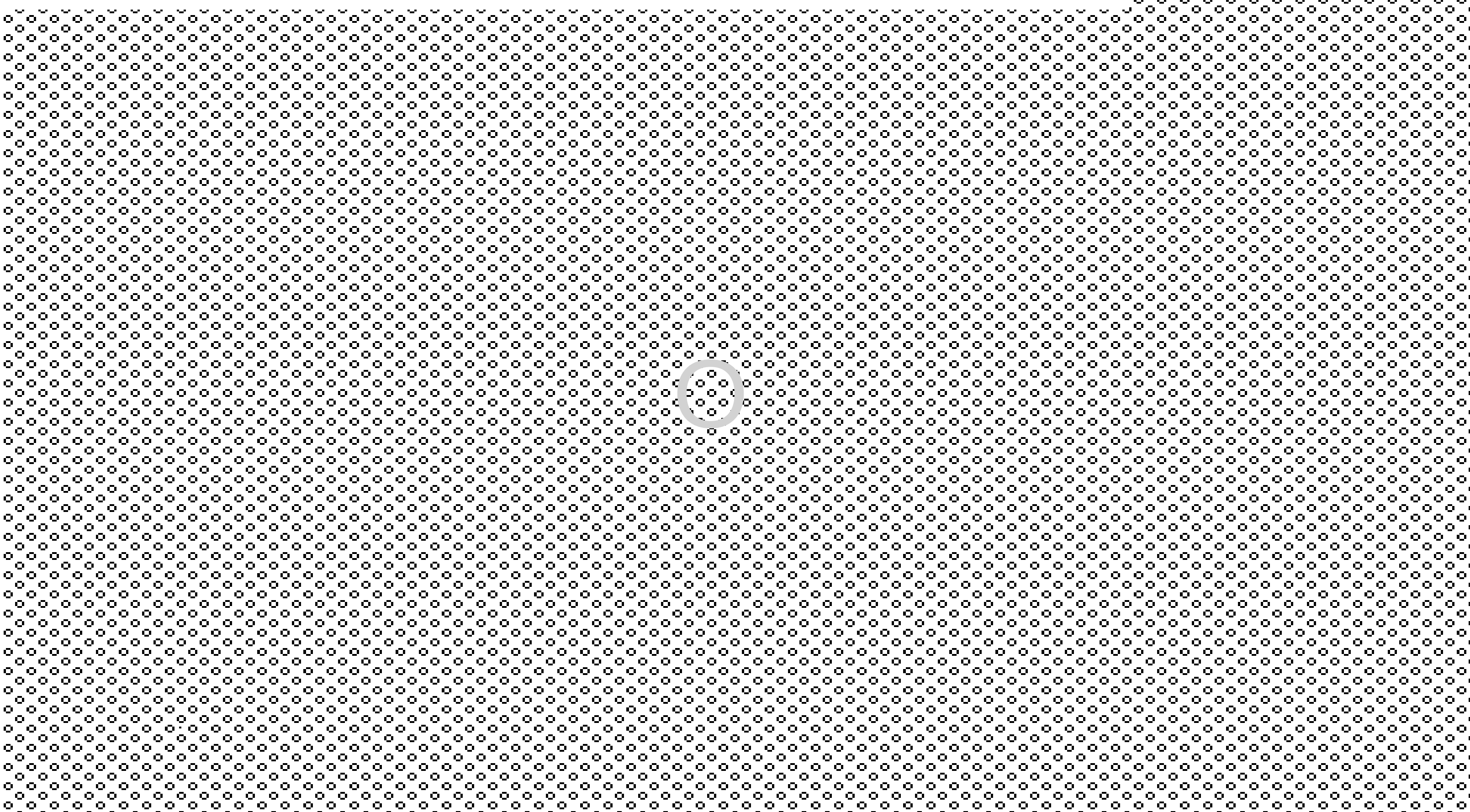
- Overload of attention
  - Low task engagement is correlated with poor vigilance and sustained attention (Matthews et al., 2010a, 2014)
  - Engagement as a marker for attentional resource availability
- Disruption of effort-regulation
  - Fatigue may influence matching of effort to task demands (Hancock & Warm, 1989; Hockey, 1997)
  - Detrimental effects of task fatigue in underload conditions (Matthews & Desmond, 2002)
- Behavioral coping
  - Choice of coping strategy may directly influence behavior (Matthews, 2001)
  - Coping may also influence state-regulation
  - Fatigue encourages avoidance at the expense of task-focus

Task Engagement and Attention

- Reliable correlations between task engagement and performance on demanding attentional tasks
- Vigilance tasks appear to be especially sensitive to variation in engagement (Matthews et al., 2010b)
  - Only if task is high in attentional demands
  - Supports resource theory interpretation
- What is the mechanism?
  - Biological: engagement as a marker for brain systems (e.g., DA)
  - Information-processing: engagement as a marker for attentional resource availability
  - Strategic: engagement as a marker for task-focused coping and voluntarily application of effort

Short Vigilance Task: Display

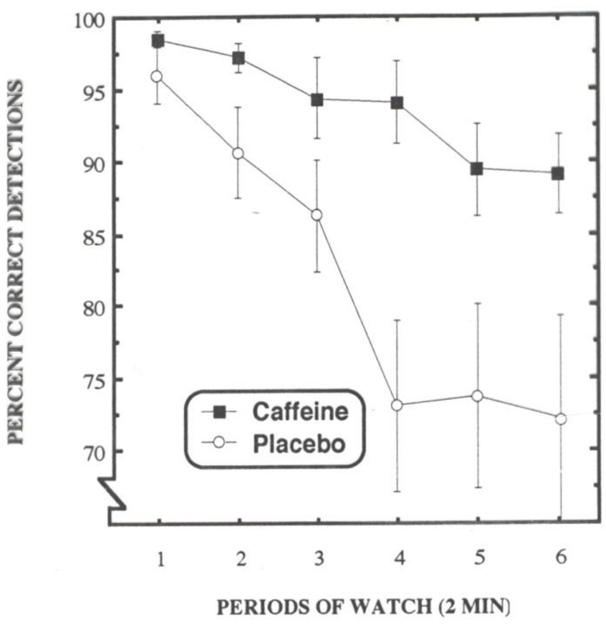
Temple et al. (2000) task: Designed to show vigilance decrement in only 12 minutes



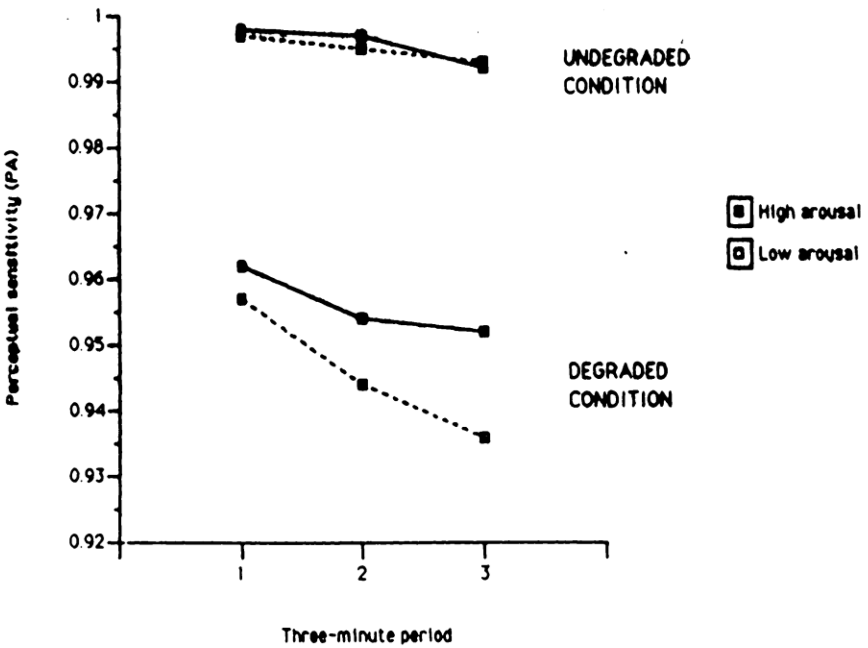
Energetic Influences on Vigilance Decrement

- Two studies of brief, high workload vigilance tasks

Temple et al. (2000). Caffeine reduces vigilance decrement



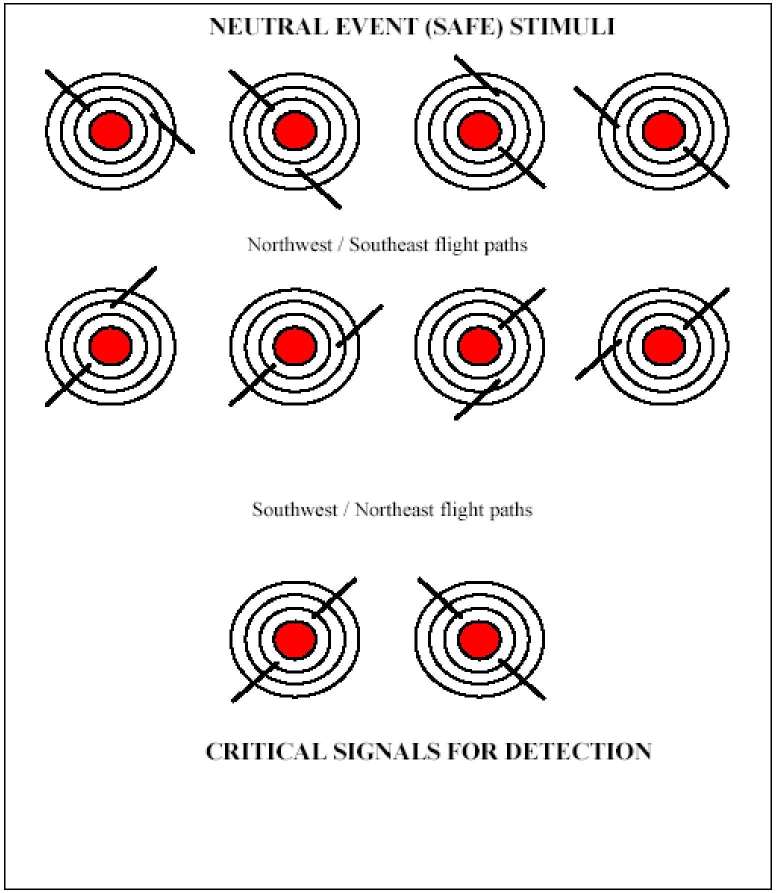
Matthews et al. (1990). Energetic arousal relates to lower vigilance decrement



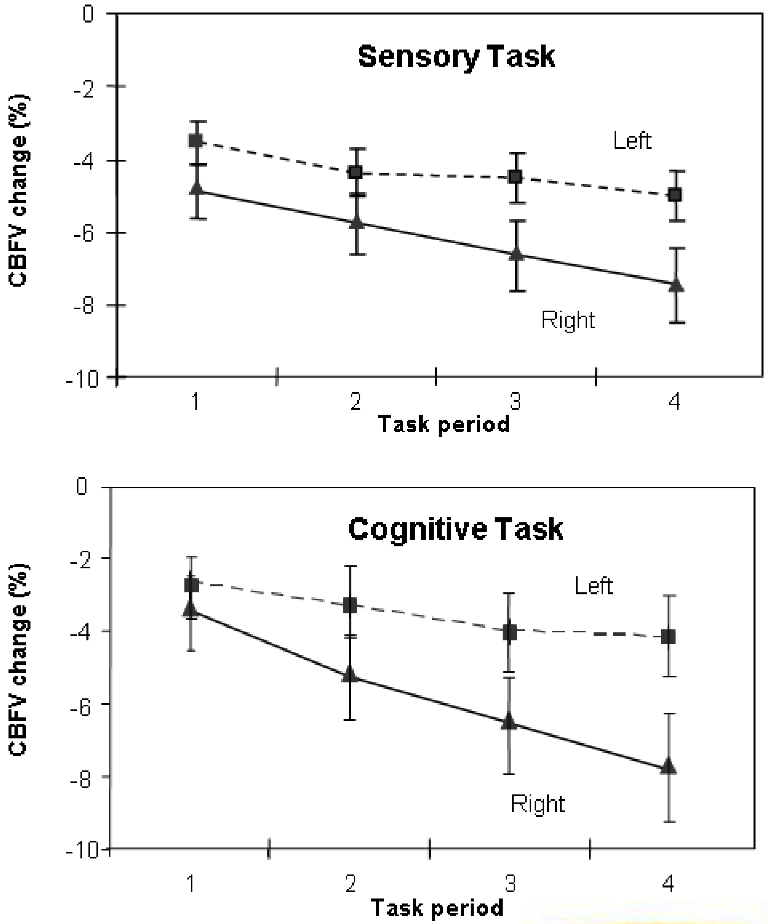
Combining Subjective and Psychophysiological Predictors (Matthews et al., 2010a)

- Comparison of cerebral bloodflow velocity (CBFV) and task engagement as predictors of performance
- Two-phase design
  - Short task battery: measure CBFV and subjective stress response (DSSQ and CITS)
  - 36-min vigilance task: either sensory (N=187) or cognitive (N=107)
  - Test whether responses to short battery predict vigilance

CBFV Study : Task Display



CBFV Declines During Vigilance



- Similar declines in two different vigilance tasks – loss of resource utilization?

Task Engagement, CBFV and Performance

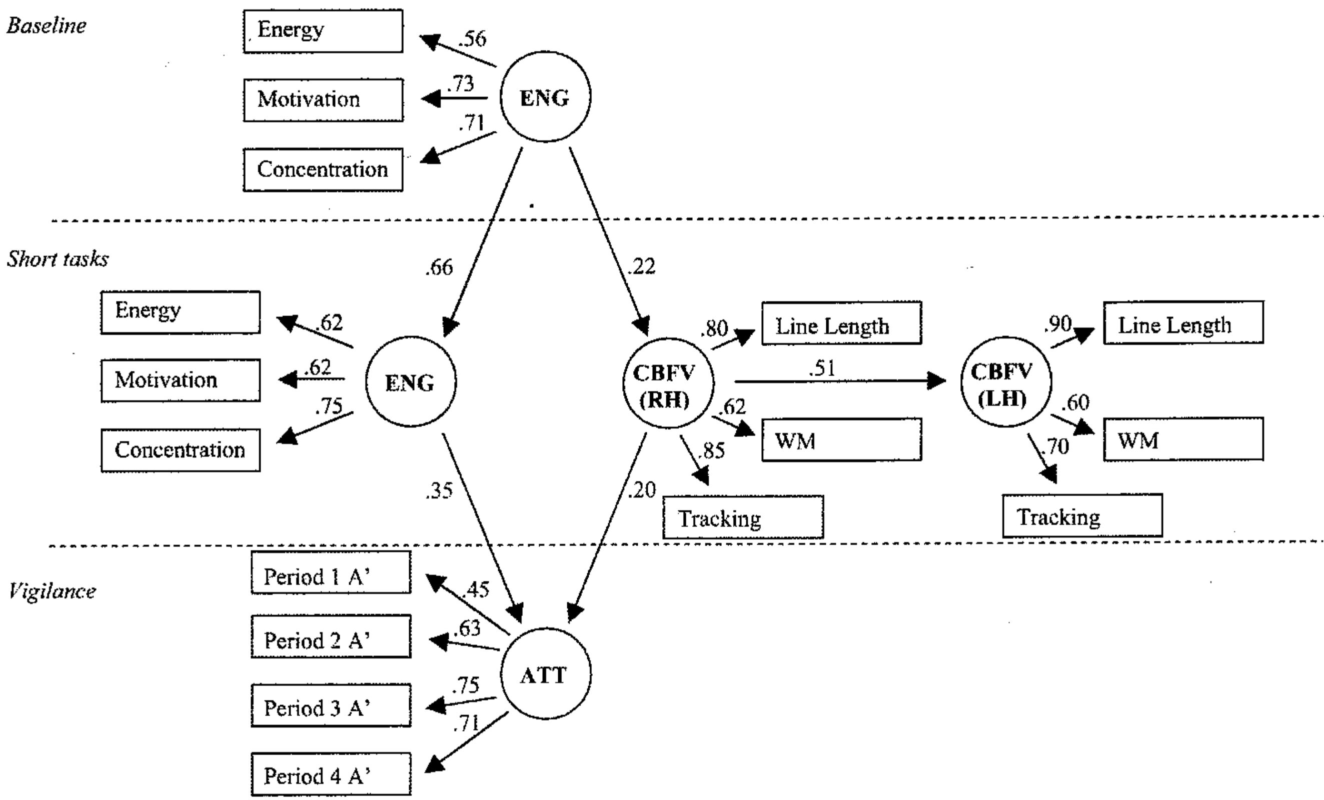


Figure 4. Latent factor model fitted to data from the sensory vigilance task. Eng = Engagement; Att = Sustained Attention; WM = Working Memory.

Stressor Effects: Cold Infection (Matthews et al., 2001)

- Design

Visit 1 — Screening and training

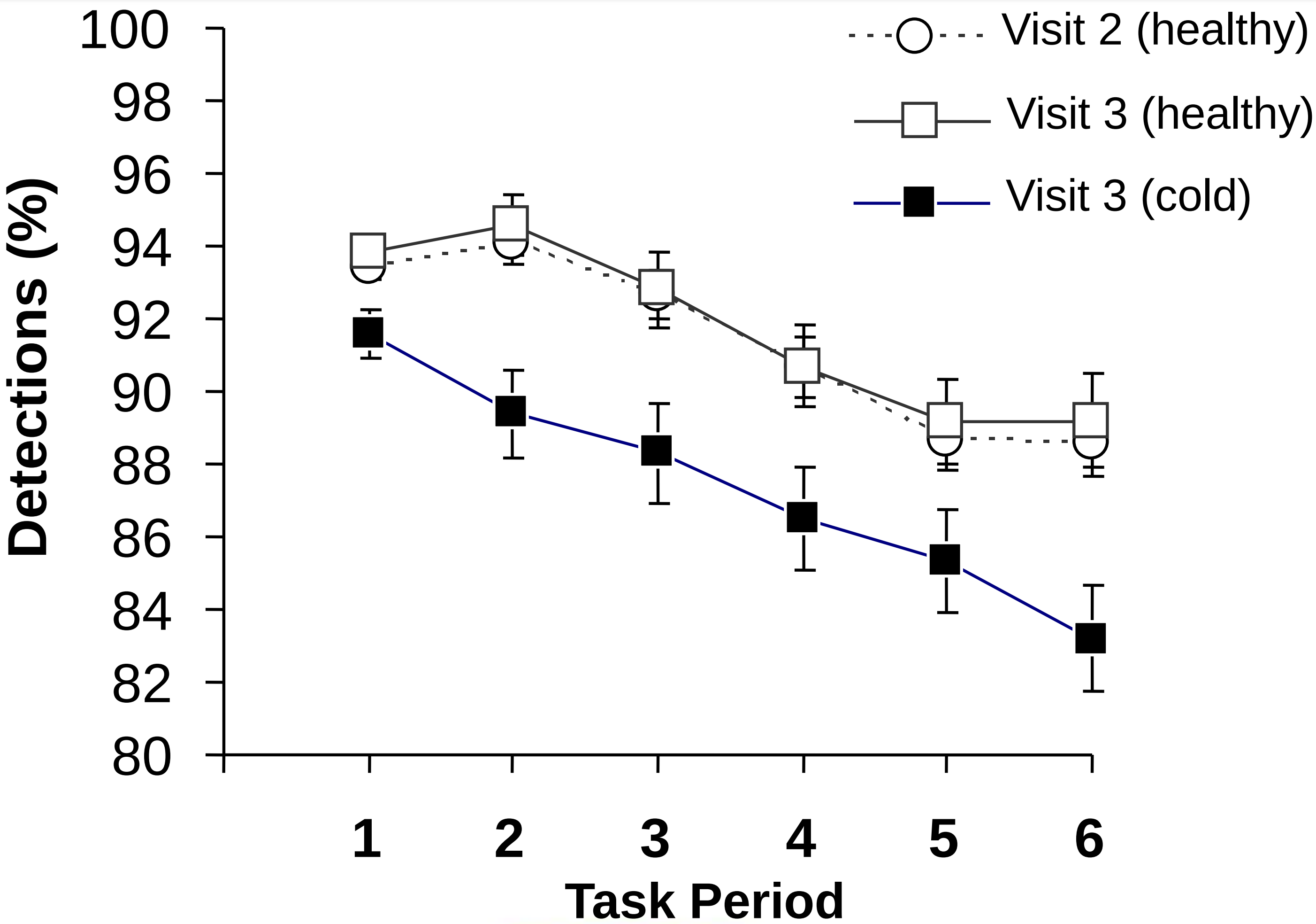
Visit 2 — Baseline performance in healthy state

Visit 3 — Cold group (*N*=95) | Healthy group (*N*=108)

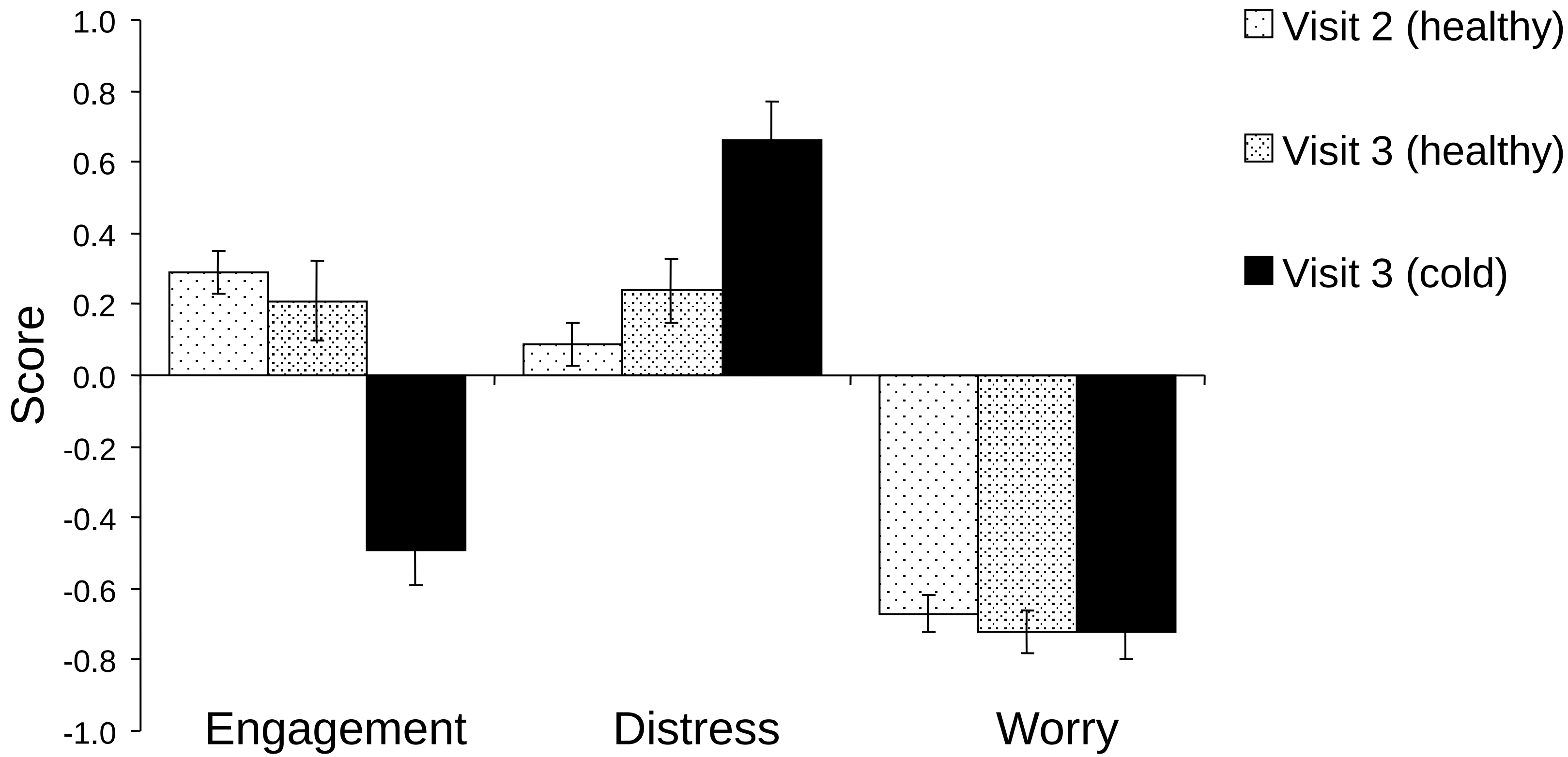
- Measures:

- Test battery of attentional tasks, including short vigilance task
- DSSQ given before and after performance

Colds Impair Vigilance



Colds Reduce Task Engagement



Task Engagement Mediates the Effect of Colds

- Predicting correct detections from cold status, test site and subjective state
- Betas for predictors in the final equation:

Cold	-.09
Site	-.26**
Task engagement	.34**
Distress	-.04
Worry	-.14*

*P<.05, **P<.01

R = . 42, F(5,198) = 8.59**

Mediation of Stressor Effects II. Jet Engine Noise (Helton, Warm & Matthews, 2009)

- Design

Performance of short vigilance task. Manipulations of:

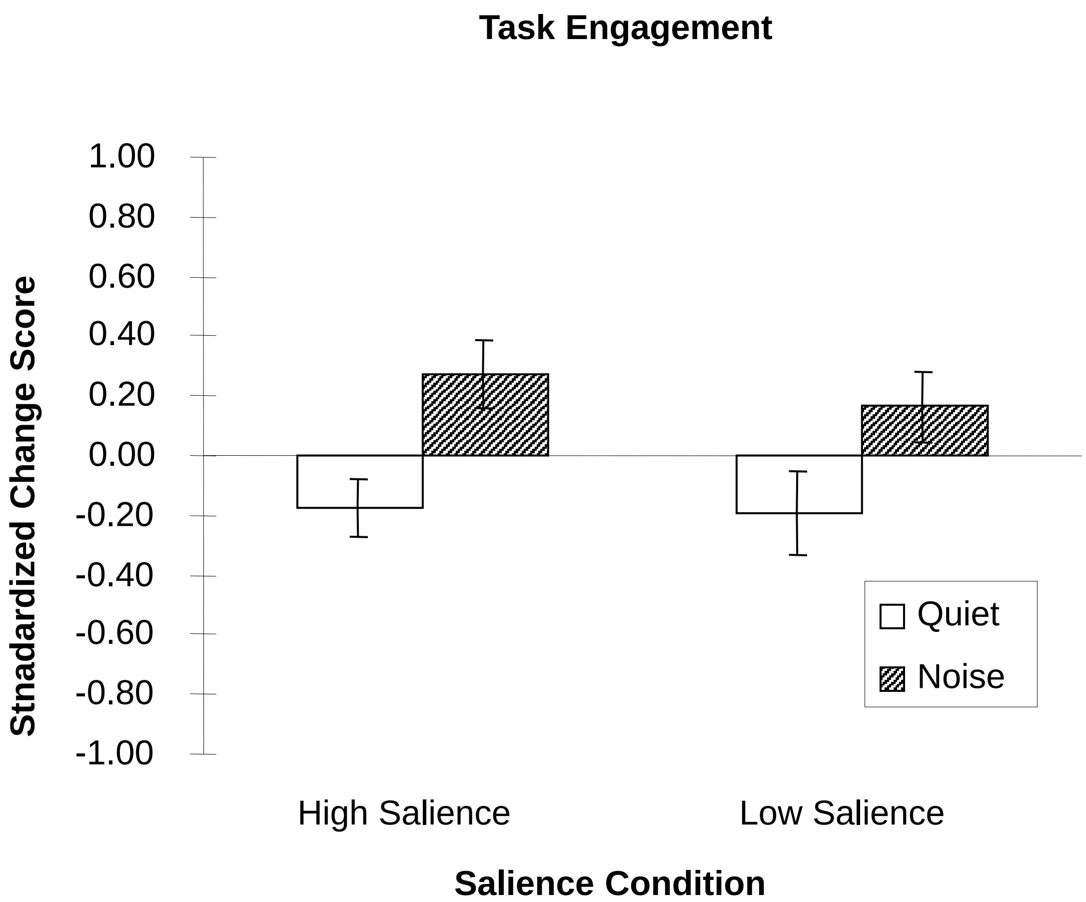
  - Salience of target (high vs. low)
  - Noise (jet engine noise vs. quiet)

- Effects of noise on performance

Noise improved hit rate: 96.4% (noise) vs. 93.8% (quiet)

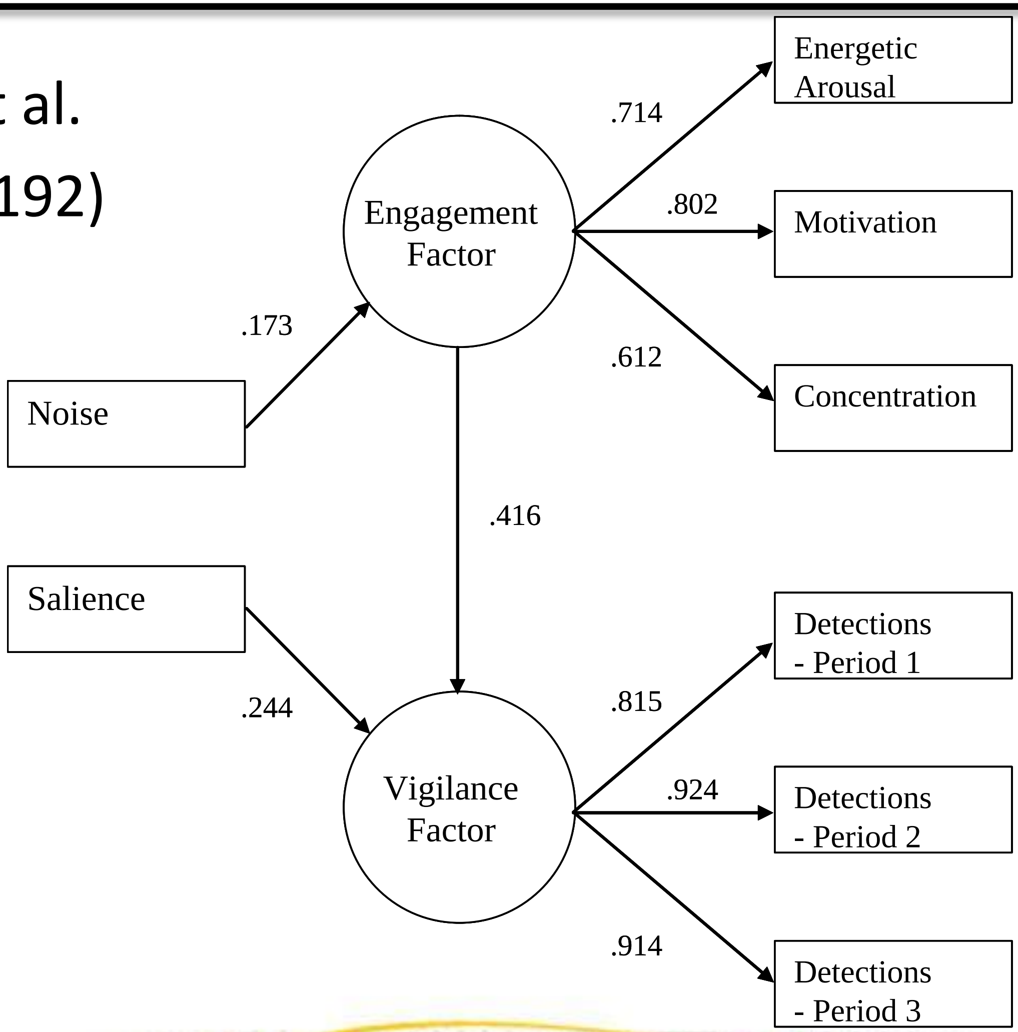
Source: Helton (2002). Unpublished doctoral dissertation, University of Cincinnati.

Noise Increases Task Engagement

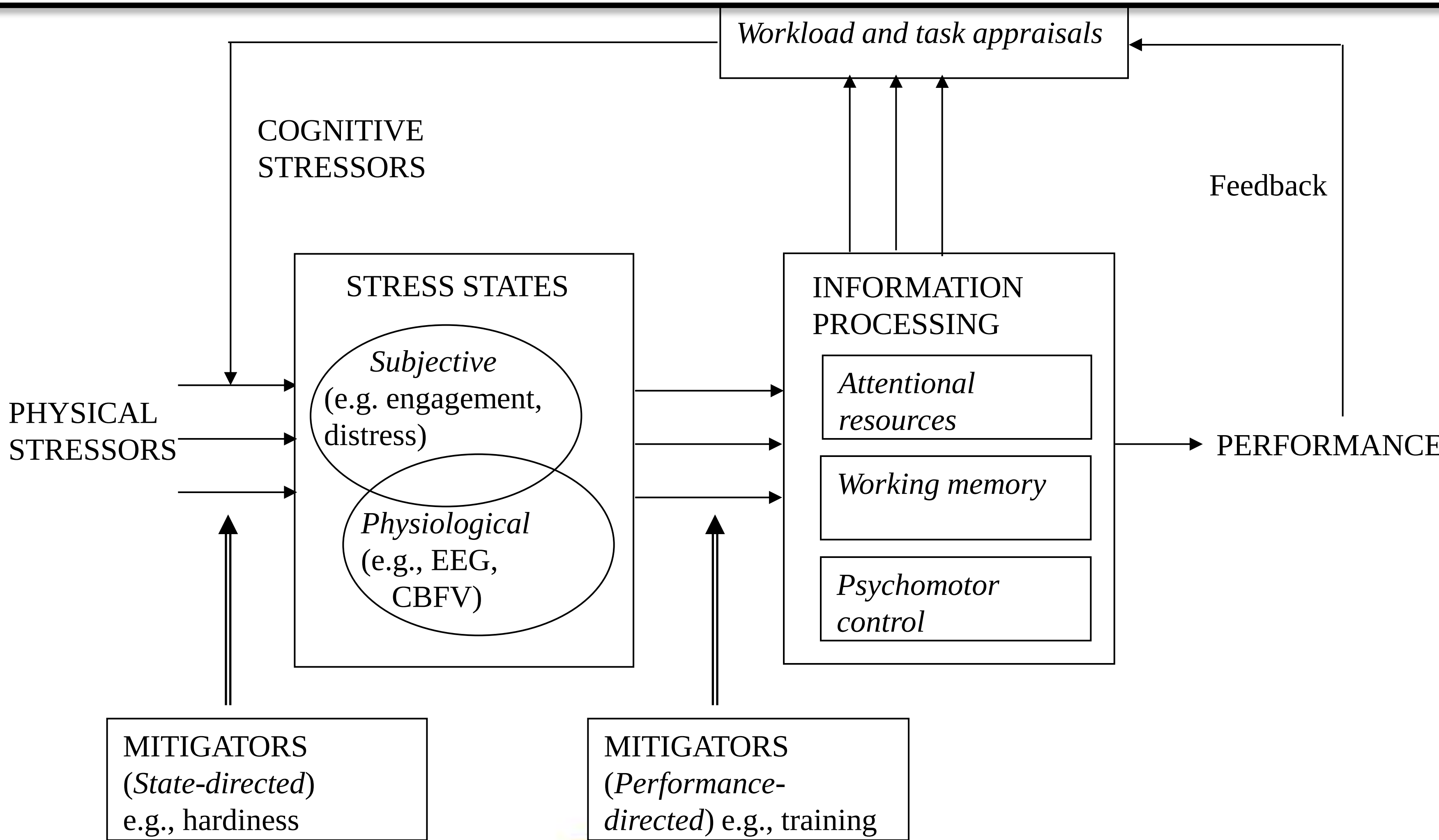


Engagement as a Mediator of Stress

- Helton et al. (2009; N=192)



A Multivariate State Model of Stress and Performance (Matthews et al., 2013)



Prediction of Vigilance in Military Context (Matthews et al., 2014)

- Vigilance and the warfighter
  - Conventional surveillance, monitoring tactical displays, operation of unmanned aerial vehicles
- Aim of study
  - Prediction of vigilance on a tactical display task, using a short battery of multiple measures
  - Test for generalization of prediction across four different task versions
- Two phase design – short vigilance task (SVT), followed by longer battlefield monitoring task

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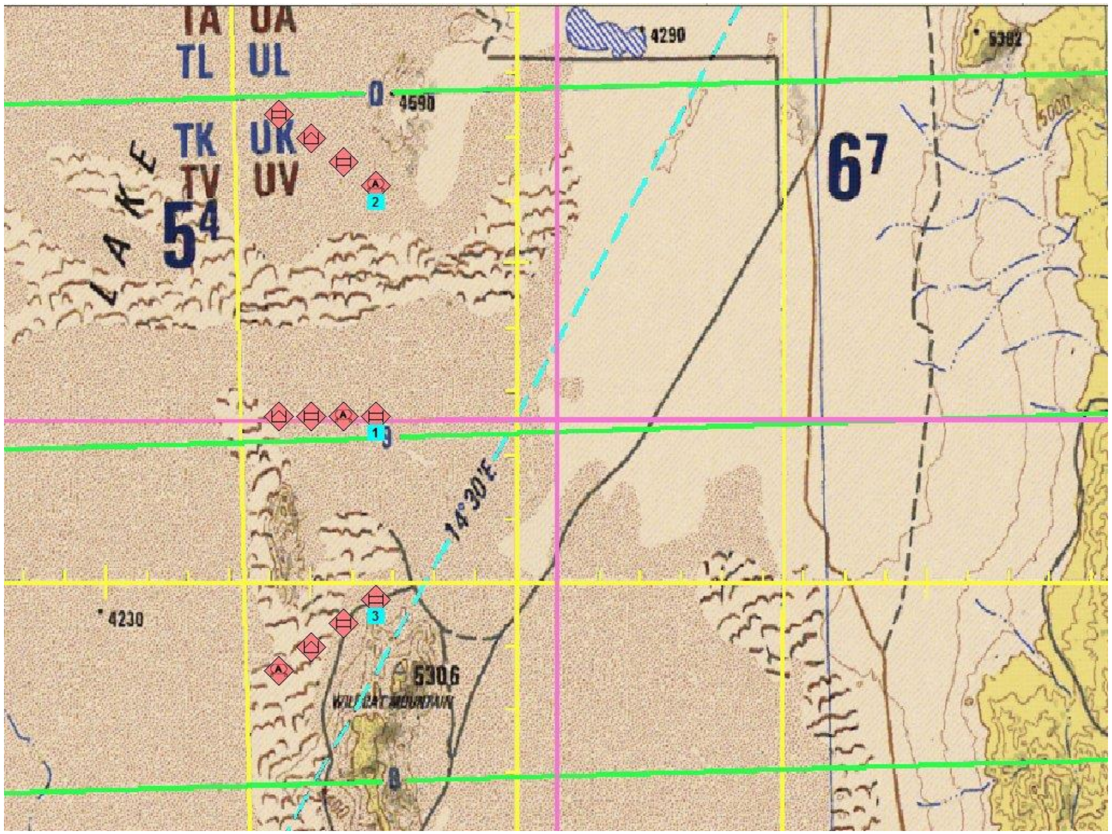
Tactical Display Monitoring Task



[Secondary task: Is vehicle 3 left of center?]

Procedure

- 462 participants (52% male; mean age 19.6)
  - Battery of personality and ETS ability measures
  - Pre-task DSSQ
  - Short Vigilance (12 min)
  - Post-task DSSQ and CITS
  - Criterion task (1 of 4: 60 min)
  - Post-task DSSQ and CITS

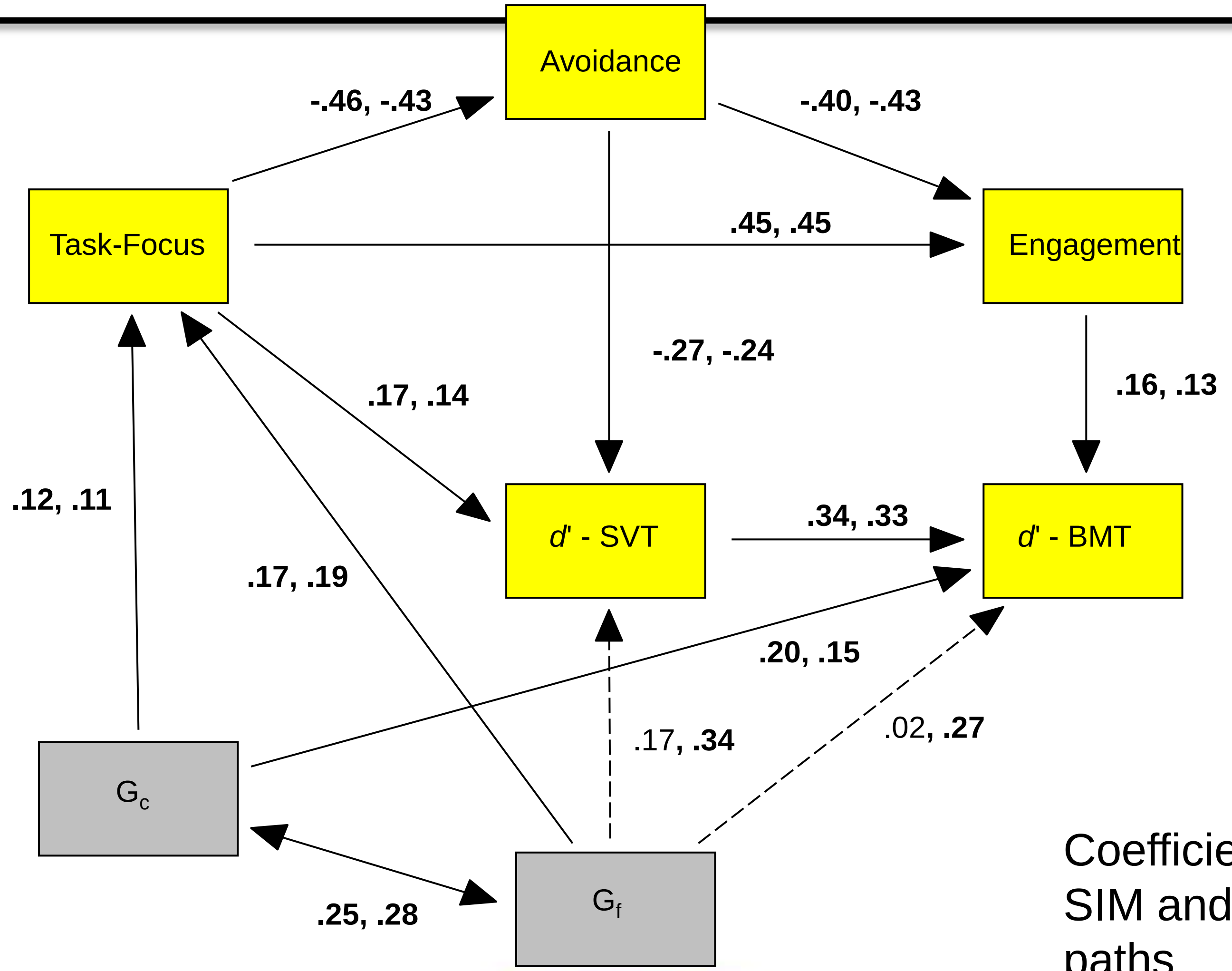
Task Engagement as a Predictor of Vigilance

- Criterion: Monitoring military tactical display (total *N* = 452)

		Simultaneous		Successive		Successive w/secondary task		Successive w/cueing	
		Mean *d'*	Dec.	Mean *d'*	Dec.	Mean *d'*	Dec.	Mean *d'*	Dec.
States (DSSQ)	Worry	-.159	-.099	-.049	-.071	-.162	.084	.048	-.020
	Engagement	**.350****	**.195***	**.221***	.055	**.271****	**.255****	**.389****	**.187***
	Distress	-.045	-.044	.037	.033	-.153	-.148	-.174	-.111
Coping (CITS)	Task-focus	**.256****	.181	**.257****	.153	**.300****	.262**	**.456****	**.206****
	Emotion-focus	**-.193***	-.130	.052	-.102	**-.233****	-.056	-.051	.102
	Avoidance	**-.252****	-.148	-.127	-.209	**-.268****	**-.244****	**-.295****	**-.214***

*$p<.05$, **$p<.01$

Path Model (Multiple Groups)



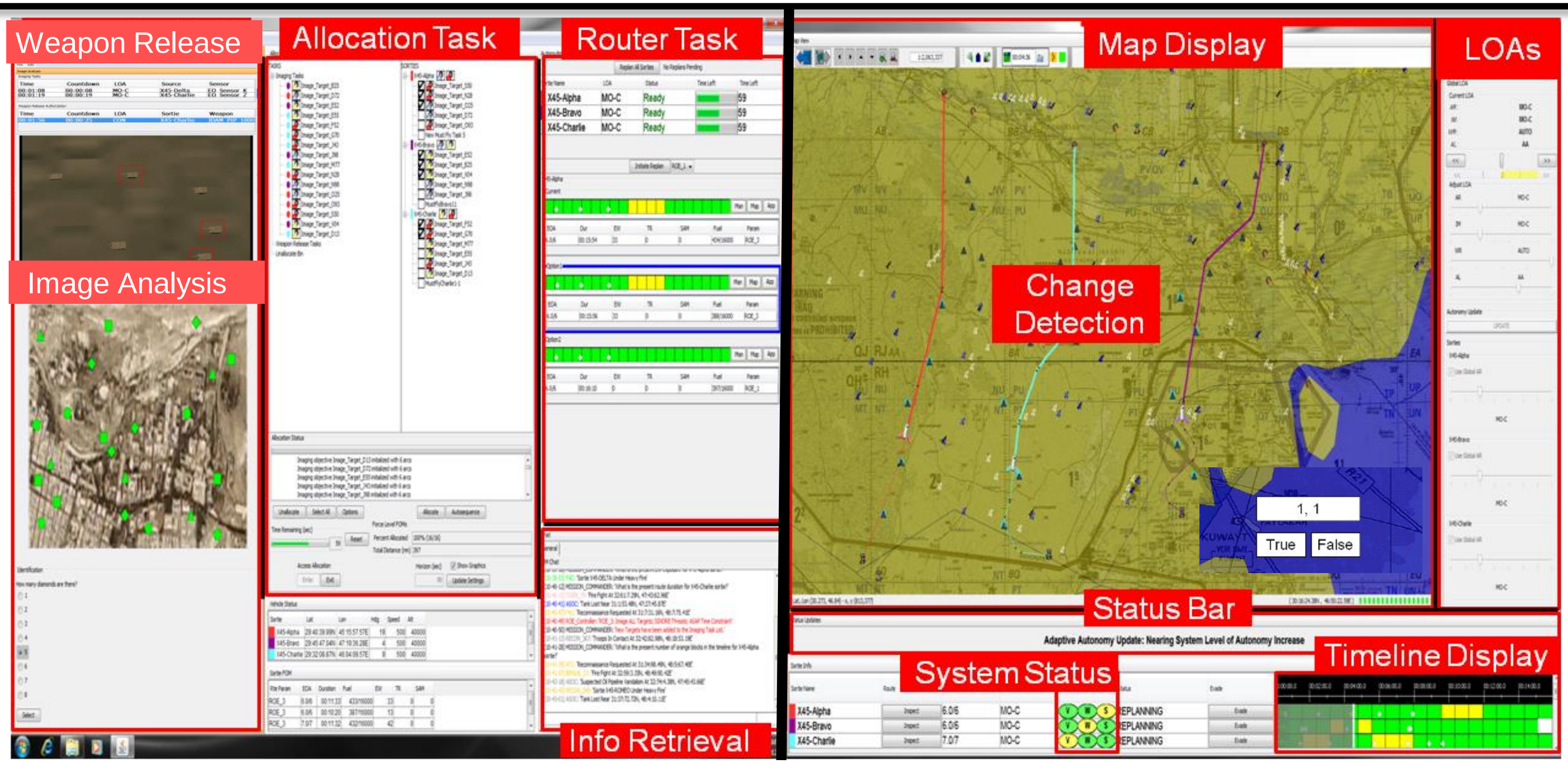
30-40% variance in criteria explained across conditions

Coefficients for SIM and SUC paths

Application to Unmanned Systems

- Multiple Unmanned Aerial Vehicle (UAV) control (Wohleber et al., submitted: N=101)
  - Control of 3 UAVs; 1-hour duration
  - Manipulations of workload and Level of Automation (LOA)
  - Engagement (and distress) predict attention on surveillance task, under high workload
- Unmanned Ground Vehicle (UGV) operation (Abich et al, submitted: N=150)
  - Attentional subtasks as vehicle moves through Middle Eastern city
  - Change detection (symbols on map display)
  - Threat detection (human figures)
  - Engagement (and distress) predict change detection

Adaptive Levels of Autonomy (ALOA) Simulation



- Multiple sub-tasks on two displays (Calhoun et al., 2011)
- Signal detection tasks embedded for primary performance assessment
- Automation manipulated for signal detection (weapon release, image analysis)
- Selected tasks used to manipulate workload

Results: Task Load and Stress

- Higher distress under high task load
  - Workload (TLX) also higher

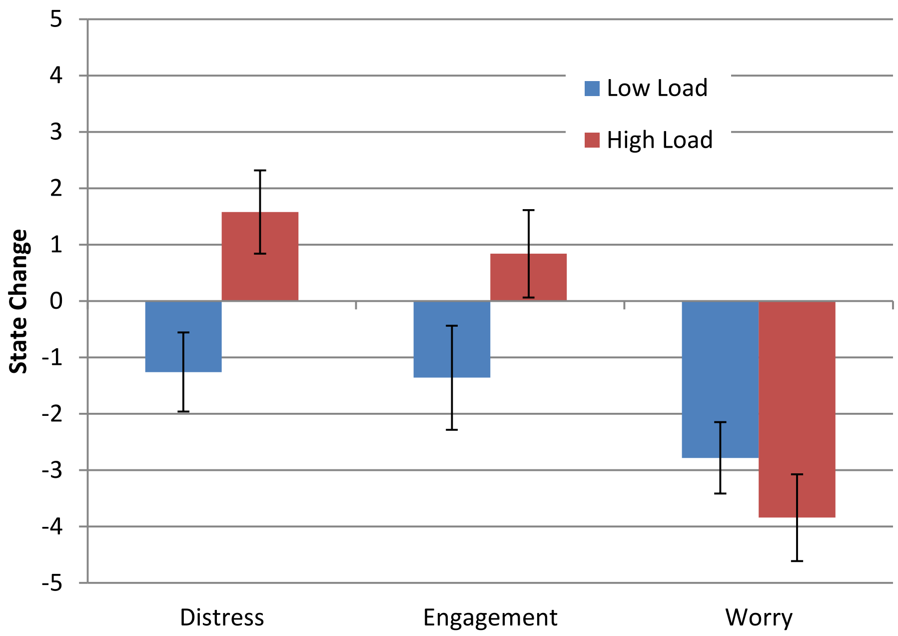
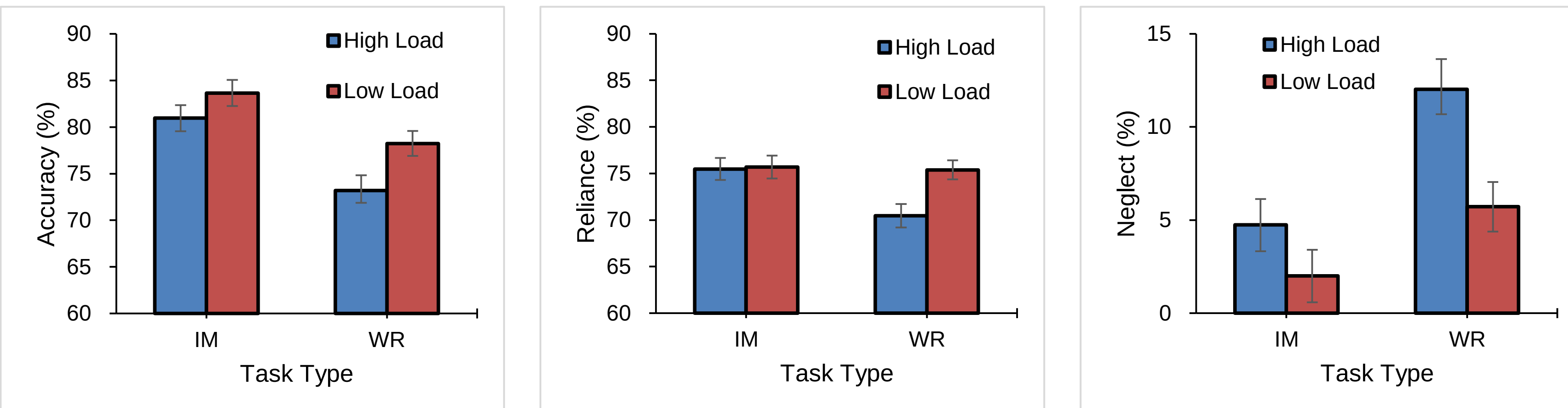


Figure shows post-task – pre-task scores

Results: Task Load and Stress

- Task load effects stronger for WR (more demanding task)
  - Lower accuracy, lower reliance, more neglect
  - Accuracy lower with management-by-consent (not shown)
  - Identifies performance vulnerability



IM = Imaging
WR = Weapon Release

Accuracy = % correct responses
Reliance = % responses follow automation
Neglect = % images (target areas) ignored

Stress State and WR/IM Performance - In High Task Load Condition

	Image Analysis			Weapon Release		
	Distress	Engagement	Worry	Distress	Engagement	Worry
Accuracy	-.33*	.14	-.29*	-.41**	.20	-.17
Reliance	-.16	.04	-.24	-.09	-.01	-.20
Neglect	.33*	-.41**	.25	.41**	-.31*	.18
*P<.05, **P<.01						

- Distress most damaging element of state
  - Due to multi-tasking requirement
- Low task engagement (fatigue) associated with neglect

UGV Sim: Workload Manipulations

- MIX testbed: Simulation of Operator Control Unit of UGV (Taylor et al., 2013)

Task type:

- Change Detection (CD) is higher workload than Threat Detection (TD)

Dual-tasking:

- Dual vs. single task performance

Correlations with Subjective and Physiological Metrics

- Concurrent/post-task metrics
  - Criteria are accuracy on change (CD) and threat detection (TD)

		EEG			DSSQ-Post		
	HRV	Alpha	Beta	Fix. Dur.	Dist.	Eng.	Worry
CD	-.258**	-.149	-.259**	.262**	-.392**	.451**	-.302**
TD	-.074	-.172*	-.154	.161	-.214**	.280**	-.247**
Note: *p < .05, **p < .01							

- Regression statistics

Criterion	Predictor Set			
	Physio (R^2)	Subjective (ΔR^2)	Final R	Adj R^2
CD	.238**	.148**	.621**	.314
TD	.095	.065*	.400	.063
Note: *p < .05, **p < .01				

- Both types of metric necessary to optimize prediction

Diagnostic Monitoring: Conclusions

- Attentional resource theory provides a framework for operator assessment
- No 'gold standard' for resources: multiple indices are needed
- Optimal prediction by combining information from subjective response, psychophysiology and cognitive performance measures
- Some variation in predictors with criterion task
- Applications to field testing

Vehicle Automation and Fatigue

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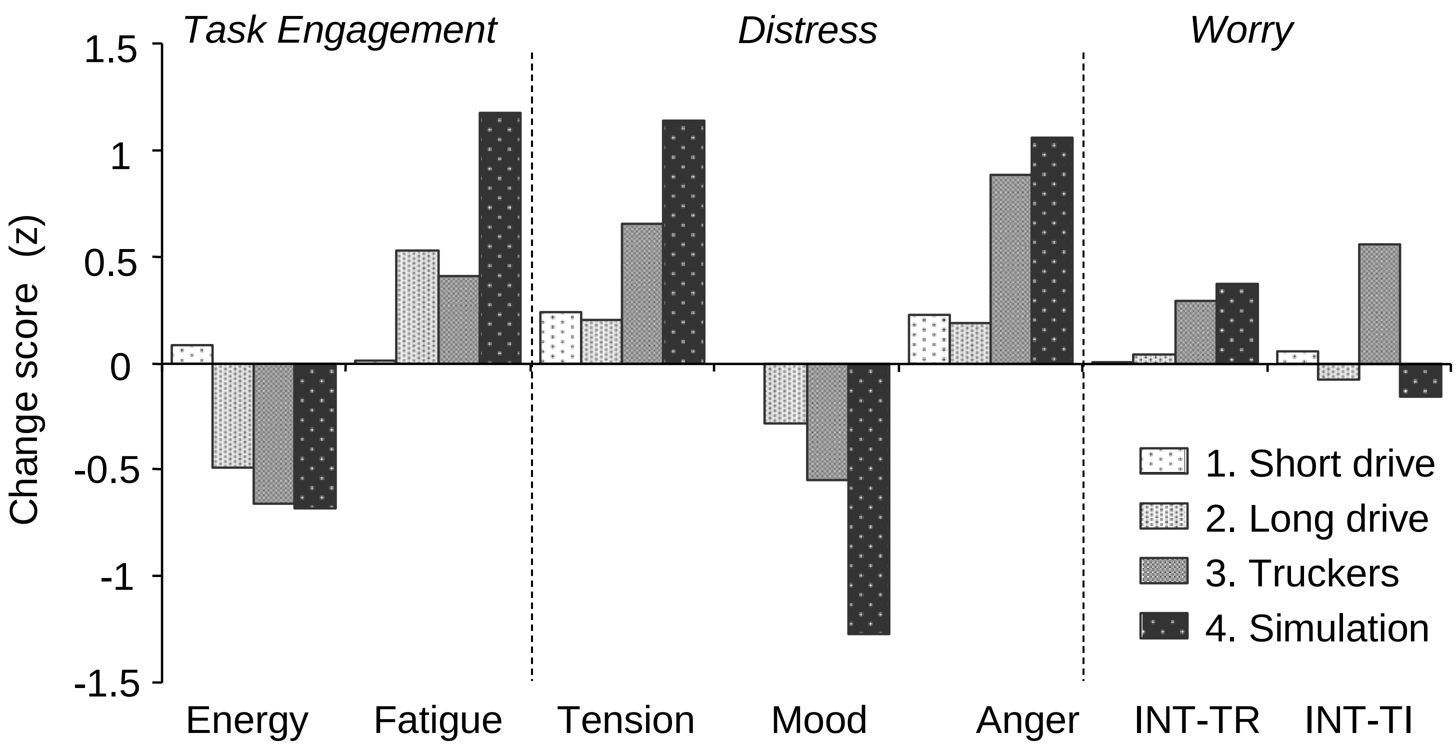
Driver Fatigue and Safety

- How is driver fatigue experienced?
  - Stress state profiling of real and simulated drives
- How does automation-induced fatigue impact alertness
  - Studies of 'active' and 'passive' fatigue
  - Response to emergency event
- How does distraction interact with fatigue?
  - Secondary tasks: danger or counter-measure?

Profiling Driver Fatigue State Responses

Pattern of state changes in four groups of drivers



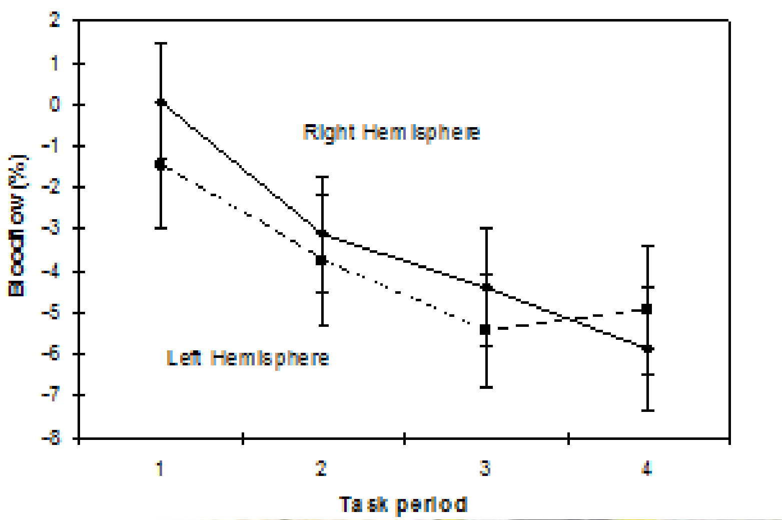
Data from Desmond & Matthews (2009); Matthews & Desmond (2002)

INT-TR = Task-related worry
INT-TI = Task-unrelated worry

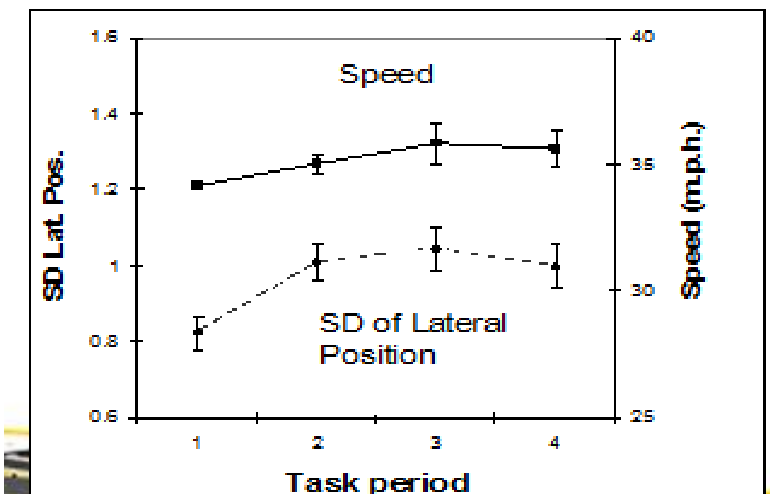
Brain Metabolic Changes

- 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

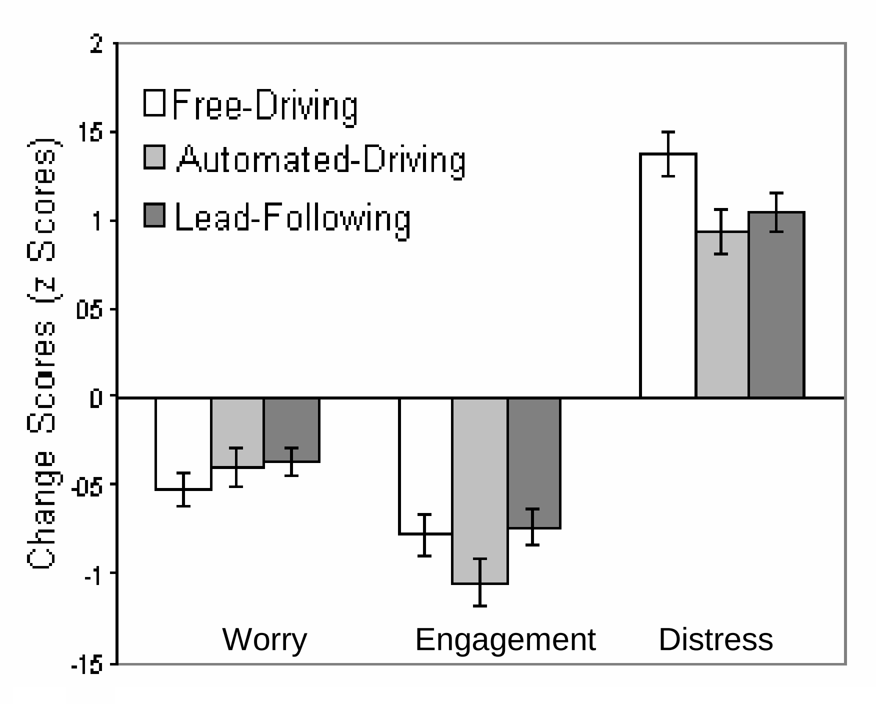


Automation

- Costs and benefits of automation
  - Intended to mitigate workload and enhance safety
  - But may generate complacency and increase willingness to engage in distracting activities
- Prolonged automation use may reduce situation awareness
  - Reaction times may increase in response to unexpected events (Young & Stanton, 2007)
- Risks of mis-regulation of automation
  - Underload may be just as dangerous to drivers as overload (Hancock & Warm, 1989)
- Fatigued drivers at risk when task demands are low
  - Extra task demands may counteract the effects of withdrawal of effort (Matthews & Desmond, 2002)

Automation and State Change

- Partial automation (speed control) reduces distress and workload, and enhances attention (Funke et al., 2007)
- Benefits from reduced need for decision
- Similar benefits from following lead vehicle



STISIM Driver Simulator

- System Technologies, Inc., STISIM Drive, Build 20802
- Westinghouse LVM-42w2 42-inch LCD monitor
- Logitech MOMO Racing Force Feedback Wheel, which includes a steering wheel capable of providing realistic feedback by means of a computer-controlled torque motor, gas and brake pedals, and adjustable car seat

Differentiating Active and Passive Fatigue
(Saxby et al., 2013, Study 1: N=108)

- Two types of fatigue (Desmond & Hancock, 2001)
  - Active fatigue: prolonged high workload and control operations (wind gusts)
  - Passive fatigue: low workload and monotony (automated vehicle)
  - Both overload and underload may threaten safety
- Experimental design
  - Fatigue manipulation (active, passive, control) x duration (10, 30, 50 min)
  - Track development of multi-dimensional fatigue states over time
  - Track cognitive processes over time
- Measures
  - State (DSSQ)
  - Appraisal (Appraisal of Life Events)
  - Coping (Coping Inventory for Task Stress)
  - Workload (NASA-TLX)

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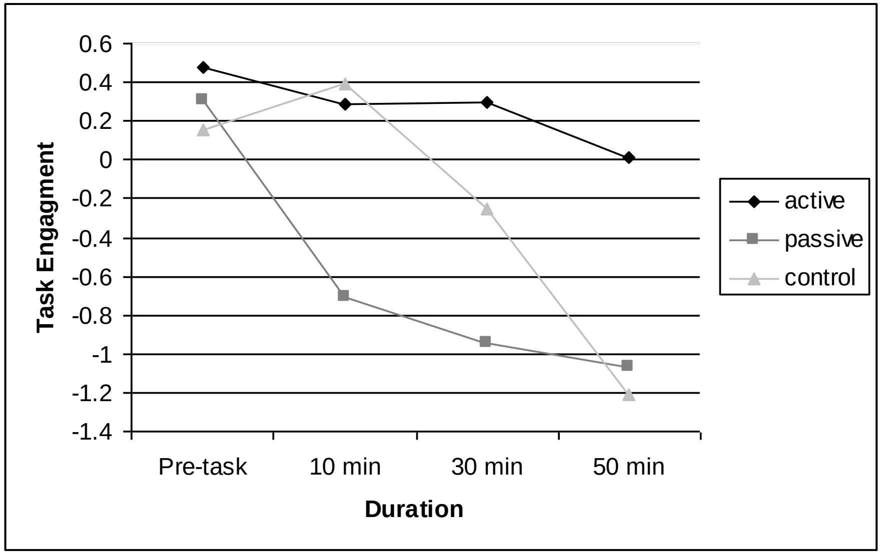
Background Scenery

Varied scenery to mitigate boredom

Changes in Subjective State

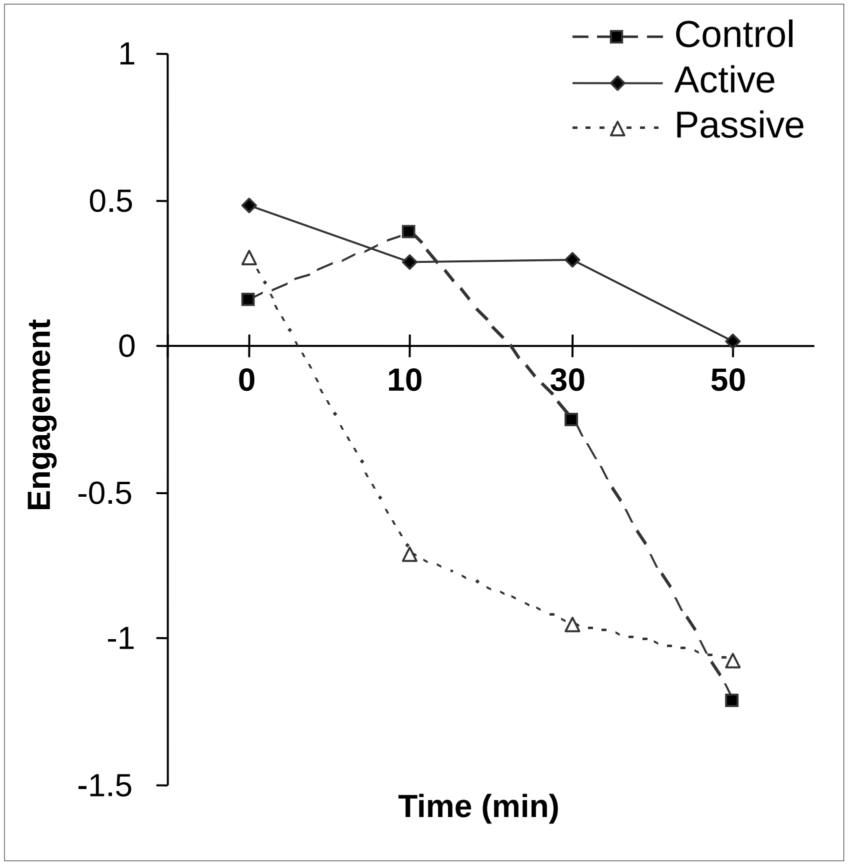
Overall state change

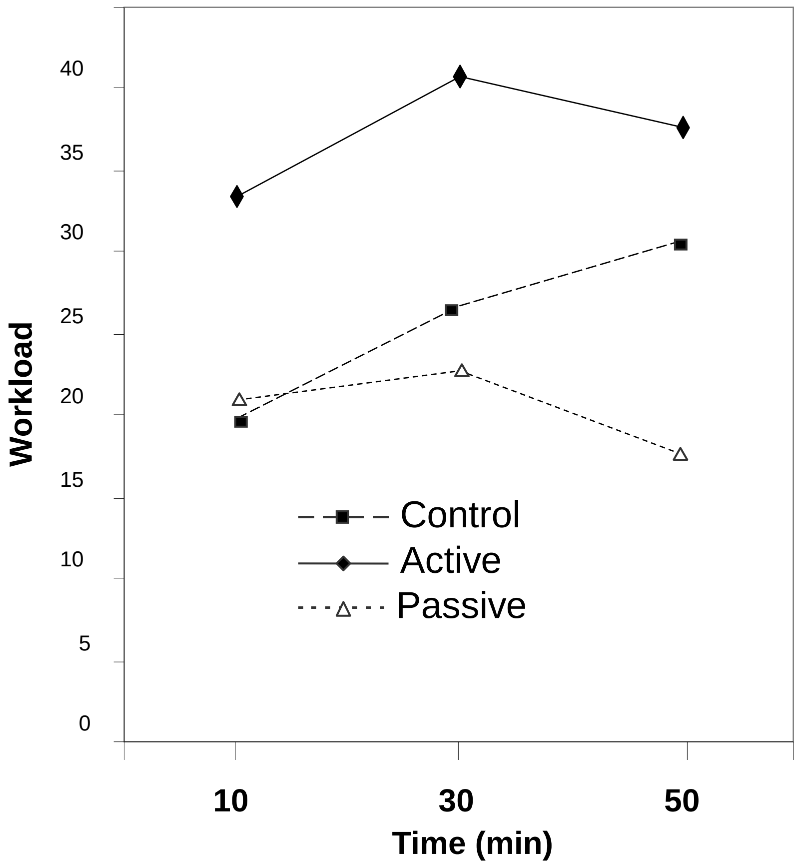
Loss of engagement over time



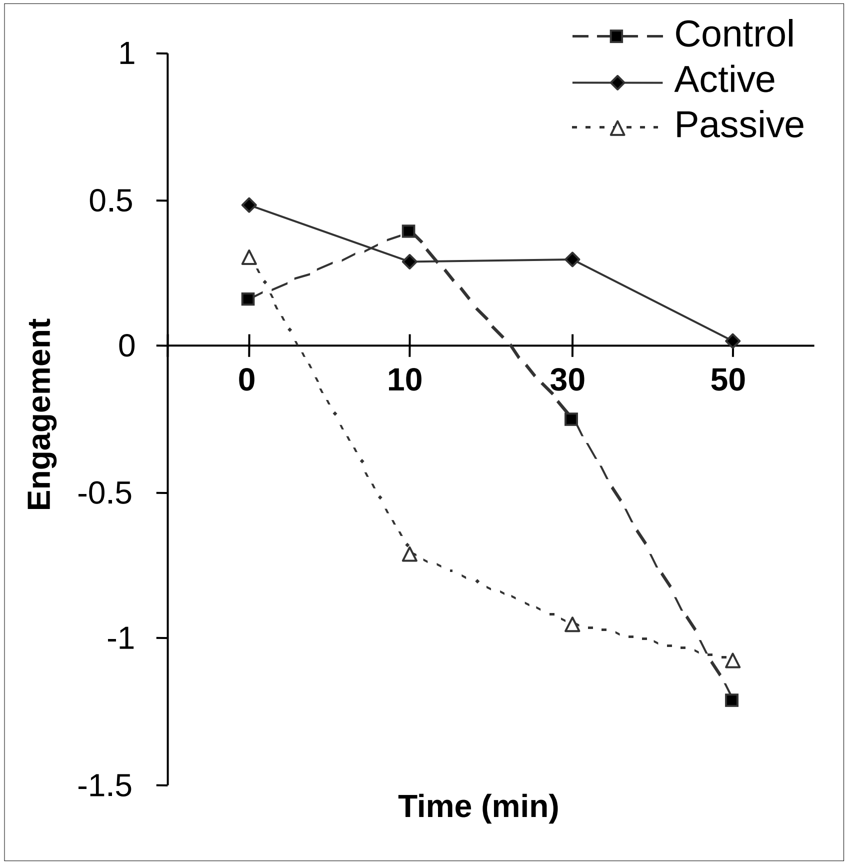
Passive fatigue produces rapid loss of task engagement

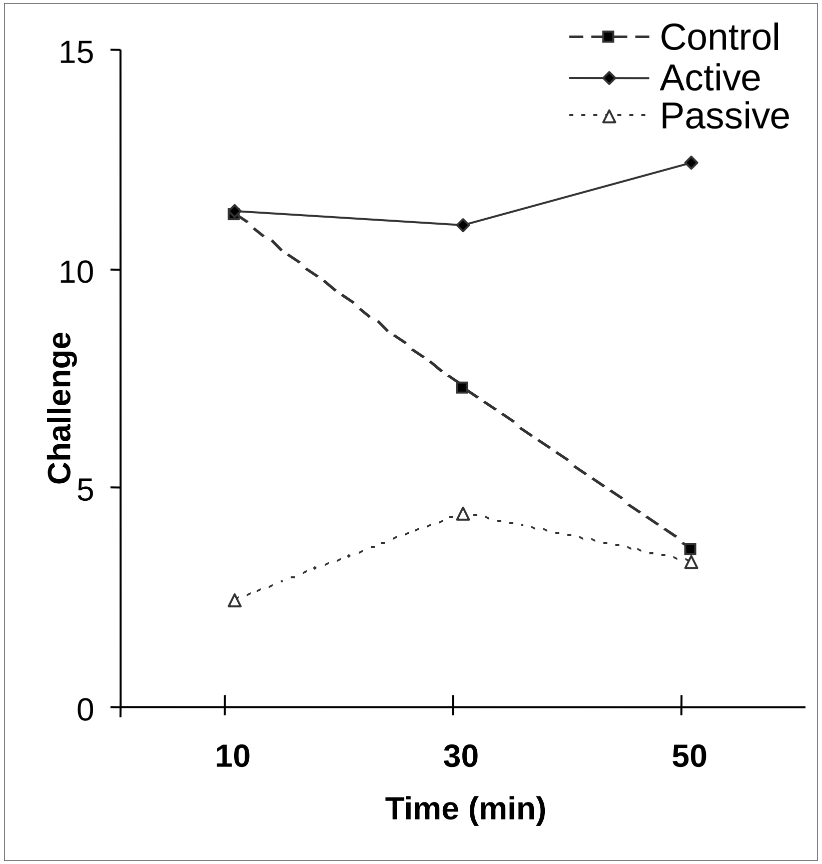
Engagement vs. NASA-TLX Workload





Engagement vs. Challenge Appraisal





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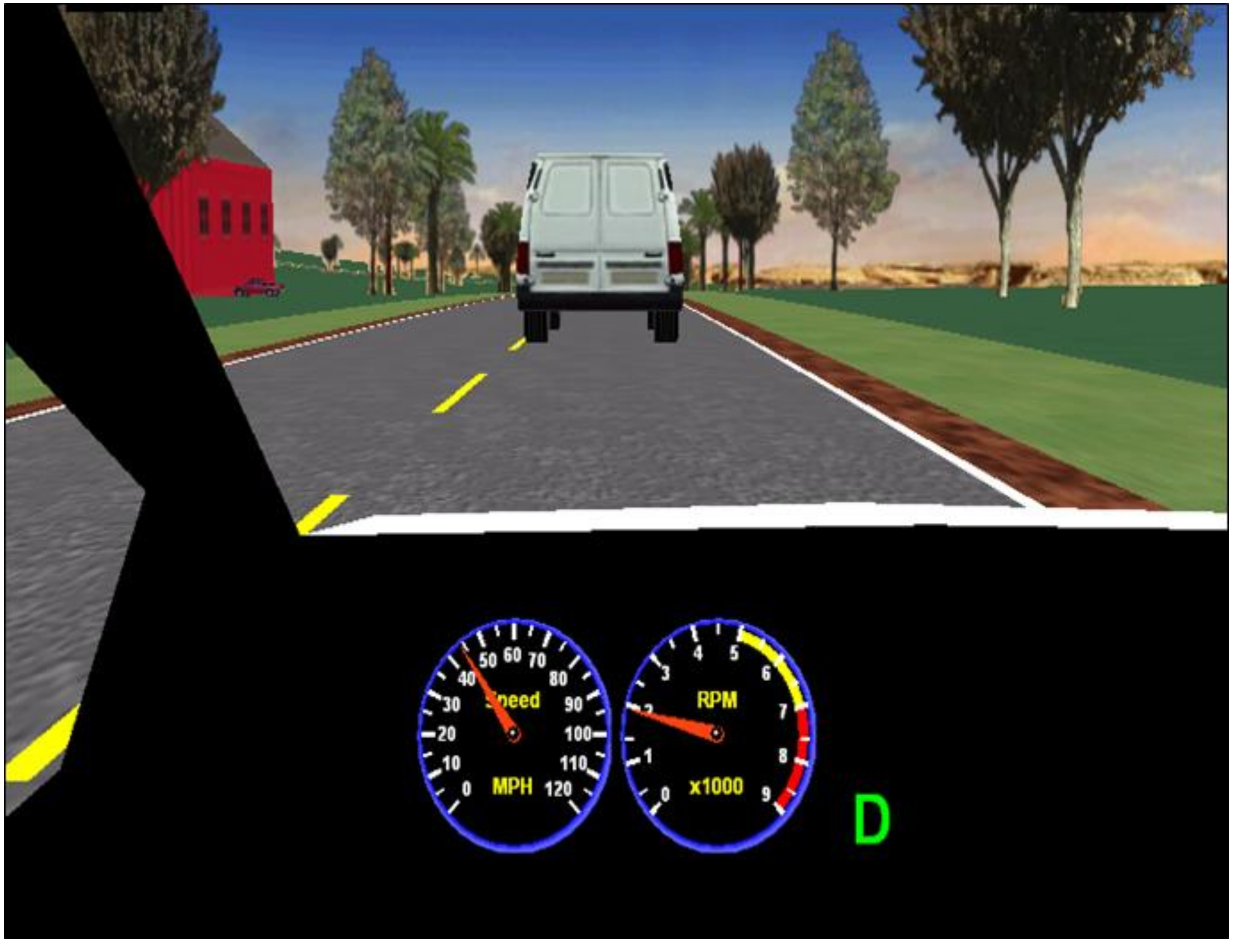
Testing Alertness

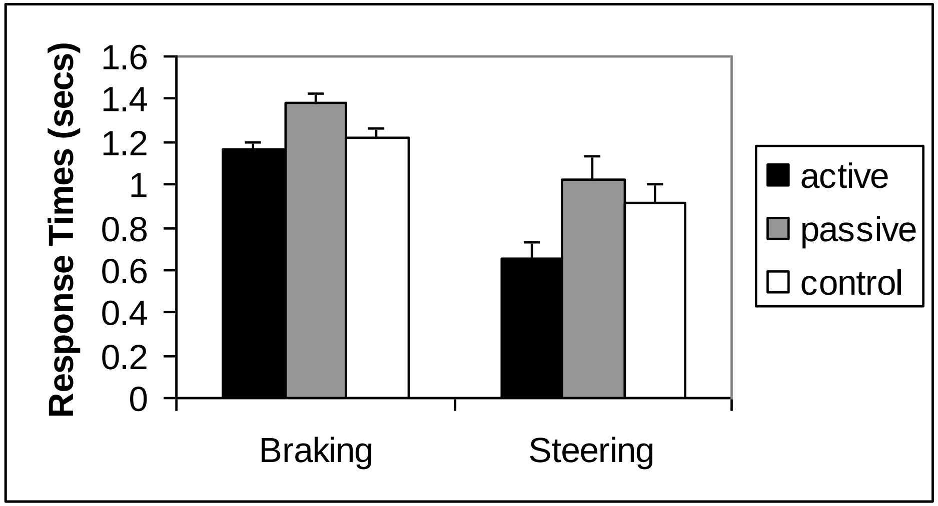


Brake or swerve to avoid crash

Performance Effects

(Saxby et al., 2013, Study 2: N=168)

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

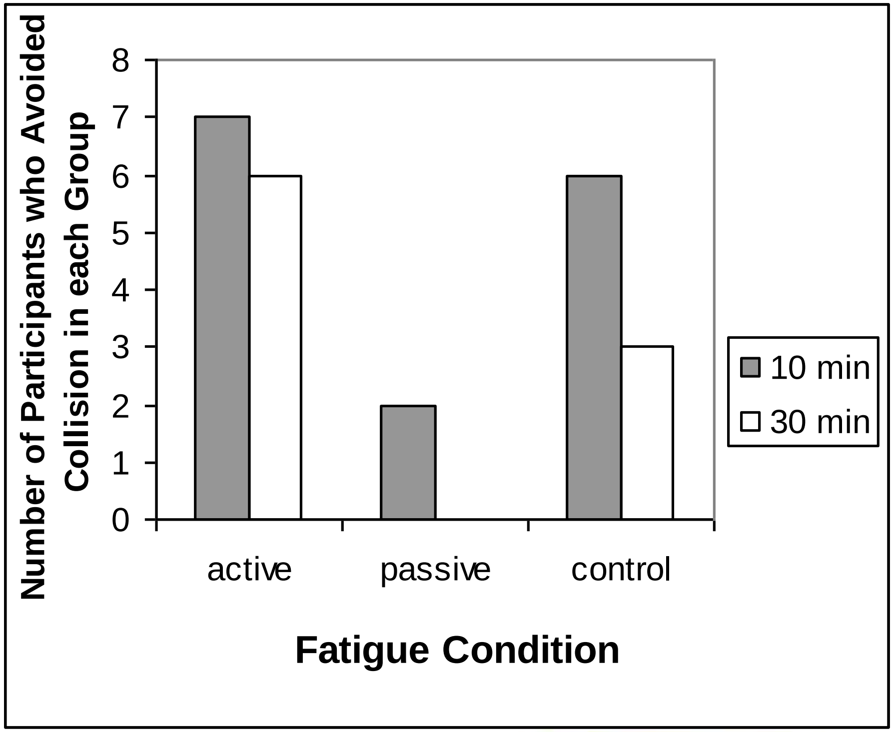


Active fatigue: wind gusts

Passive fatigue: automation

Fatigue and Crashes

- Number of drivers who avoided collision in each group
- Crash rate highest in passive fatigue condition

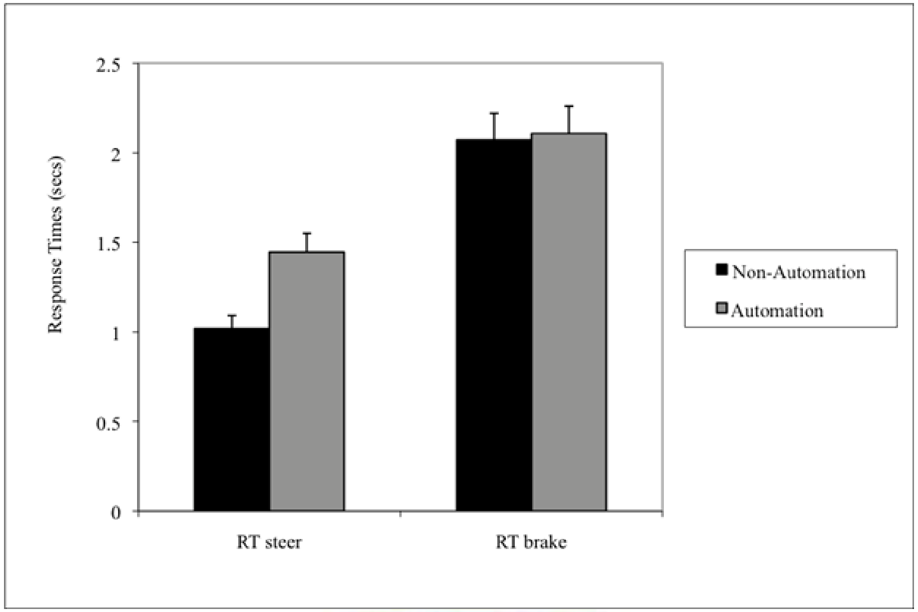


Active fatigue: wind gusts

Passive fatigue: automation

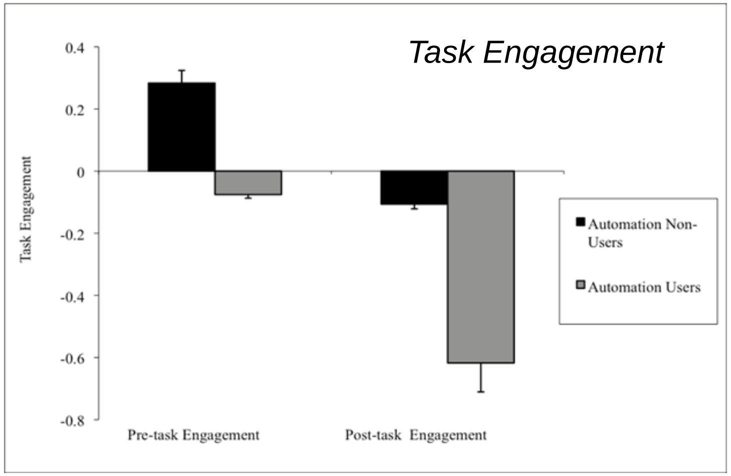
Does Voluntary Control Help?
(Neubauer et al., 2012a)

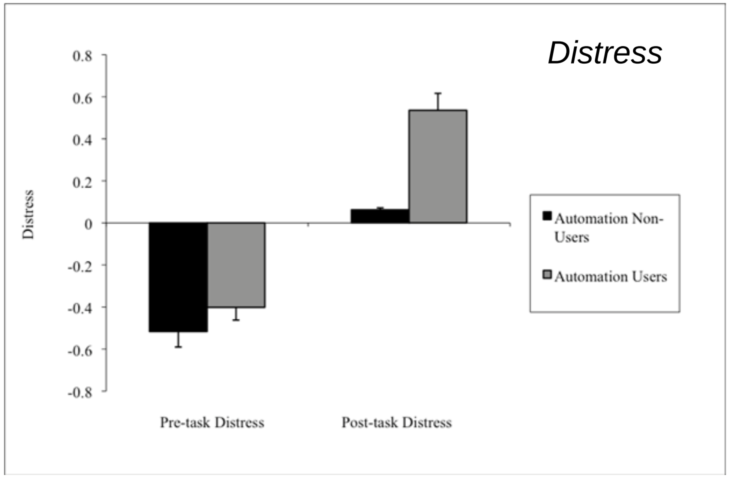
- Drivers may benefit from control over automation use
- Test of response to emergency event when drivers can choose to use automation (N=184)
- Slowed steering response in automation condition



Effects of Fatigue on Automation Use

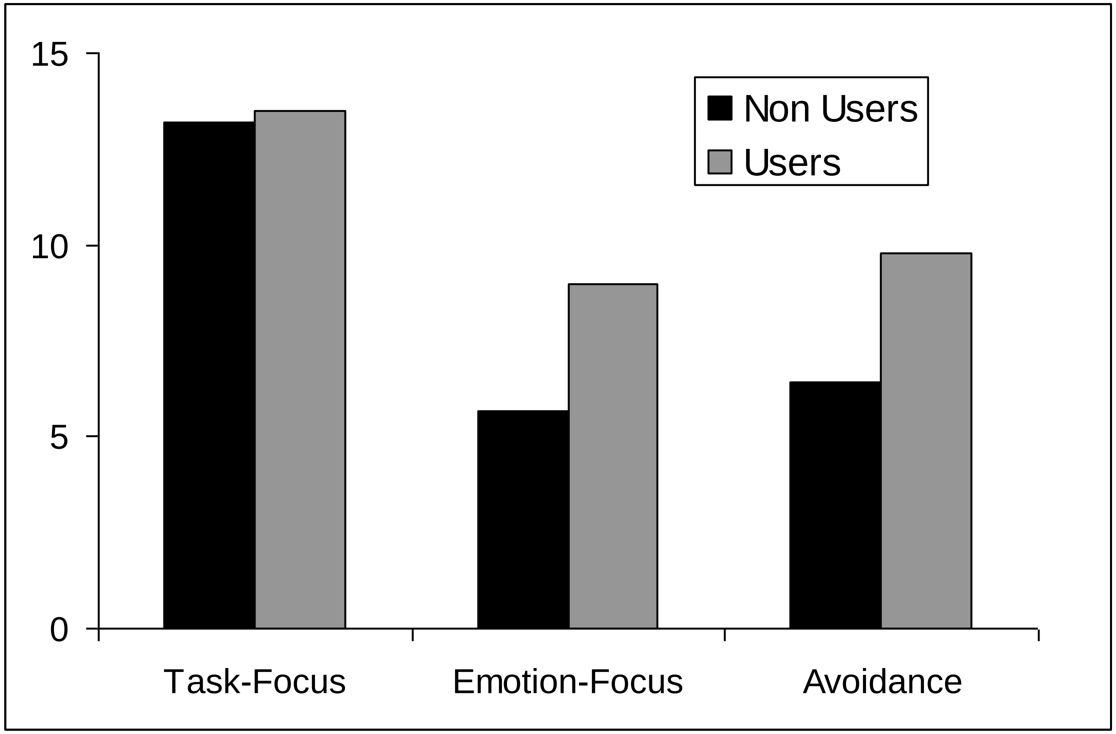
- Within the automation condition:
  - Compare participants who used automation (N=44) with those who did not (N=49)
  - Pre-drive subjective engagement predicts greater automation use
  - Automation users show greater increase in post-drive distress (vicious cycle?)





Effects of Automation Use on Coping

- Dysfunctional coping in automation users



Distraction in the Automated Vehicle

- How will use of cellphones and other media influence attention?
- Two contrary positions:

1. Fatigue tends to impair attention and increase distractibility
   - Fatigued drivers should be more vulnerable to distraction
2. Concurrent tasks improve lane-keeping during fatiguing drives (Atchley et al., 2014)
   - Cellphone use may help to maintain alertness
   - Use of trivia games to maintain alertness (Gershon et al., 2009)

"It's alright darling, I'm driving hands free."

Anecdotal Reports on Cell Phone Benefits while Driving

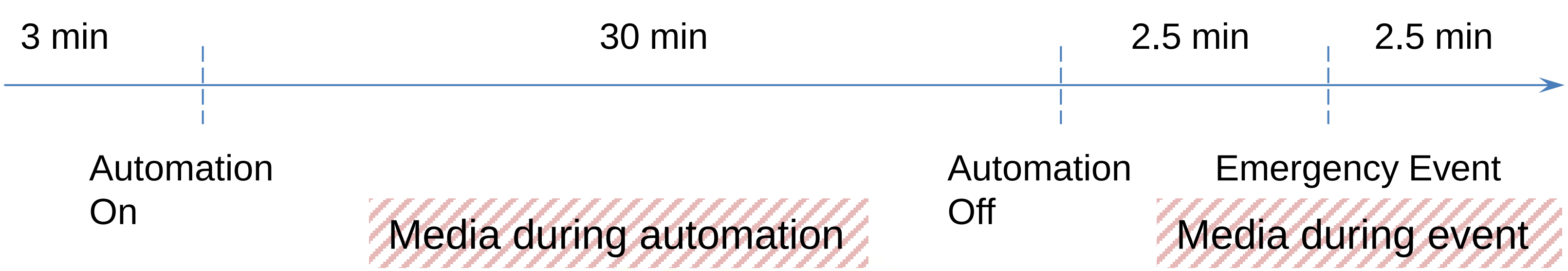
…it feels like the biggest danger to me is losing concentration in mile after mile of fairly monotonous highway….What does help me stay alert is having the occasional phone conversation…It certainly feels like being able to talk to someone is much more effective at keeping me at a safe level of awareness and alertness than rest stops, coffee, etc… (Weatherson, 2010).

Interview with Ford Motor Company (2009):

"Not only is cognitive distraction not an issue, it may actually benefit drivers in some cases."

Distraction Studies: Methodological Issues

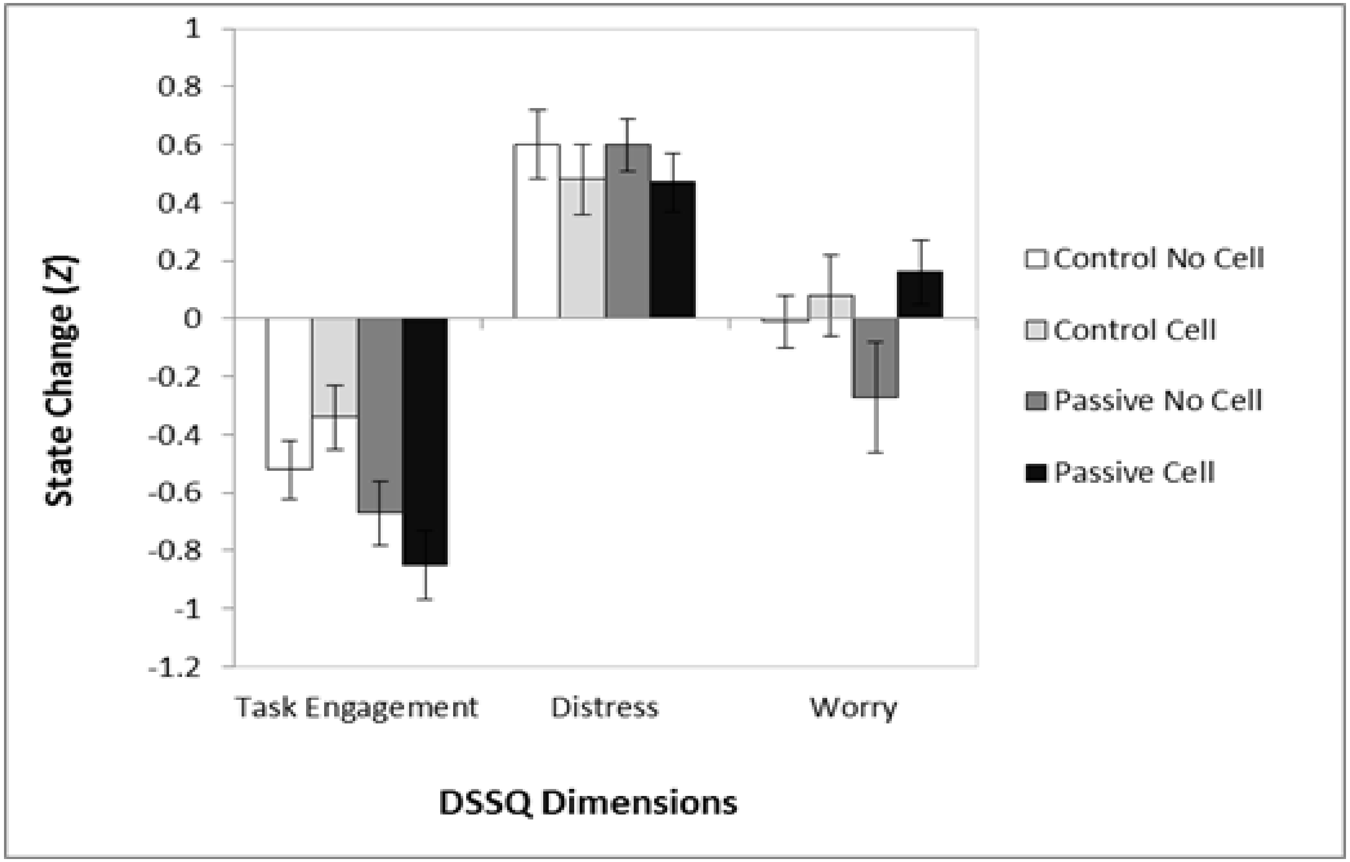
- Type of secondary media
  - Conversation, texting, trivia game
- Choice over media use
  - Mandatory or voluntary response
- Outcome measures
  - Vehicle control (SDLP), alertness to hazard
  - Subjective states
- Timing of media



Cell Phone use Following Automation

- Does cell phone elevate alertness following automation?
  - 2 × 2 design (Automation × Cell Phone)
  - 30 min drive, followed by resumption of normal control
  - Emergency event (van pulling out) during final 5 min phase
- Cell phone condition
  - conversation was initiated by the experimenter at this time (30 sec into the 5-min drive.
  - – Conversation topic was about a “close call” situation ---- methodology developed by Bavelas, Coates, and Johnson (2000)
- Emergency event at 2 min 30 sec
- The conversation was continued until the end of the drive

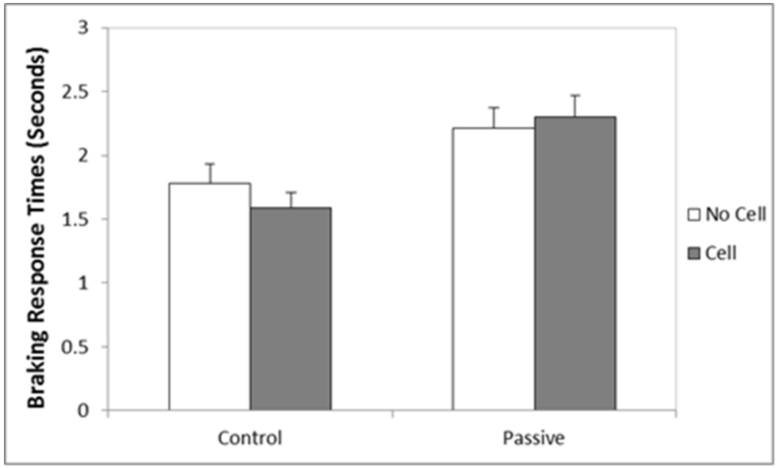
Effects of Passive Fatigue and Cell Phone Use on Subjective State

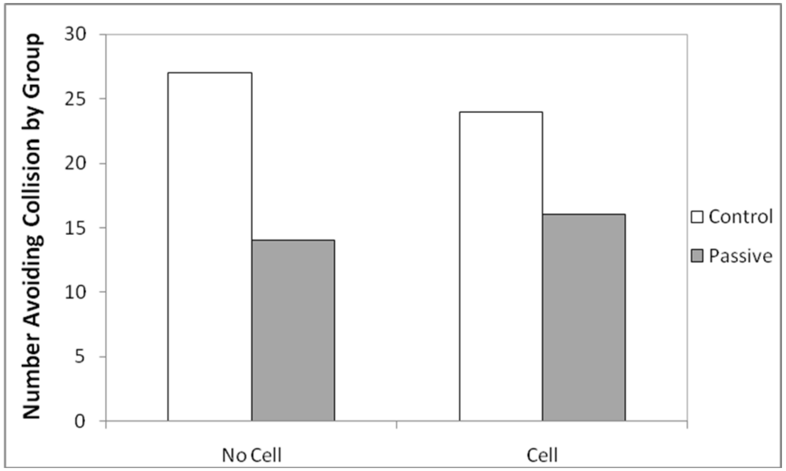


- Automation lowers task engagement
- Cell phone use does not counter disruptions of state
- Increased worry in automation (passive) condition

Performance Effects

- Passive fatigue (automation) slows braking; increases crashes
- No cell phone effect – no benefit to safety





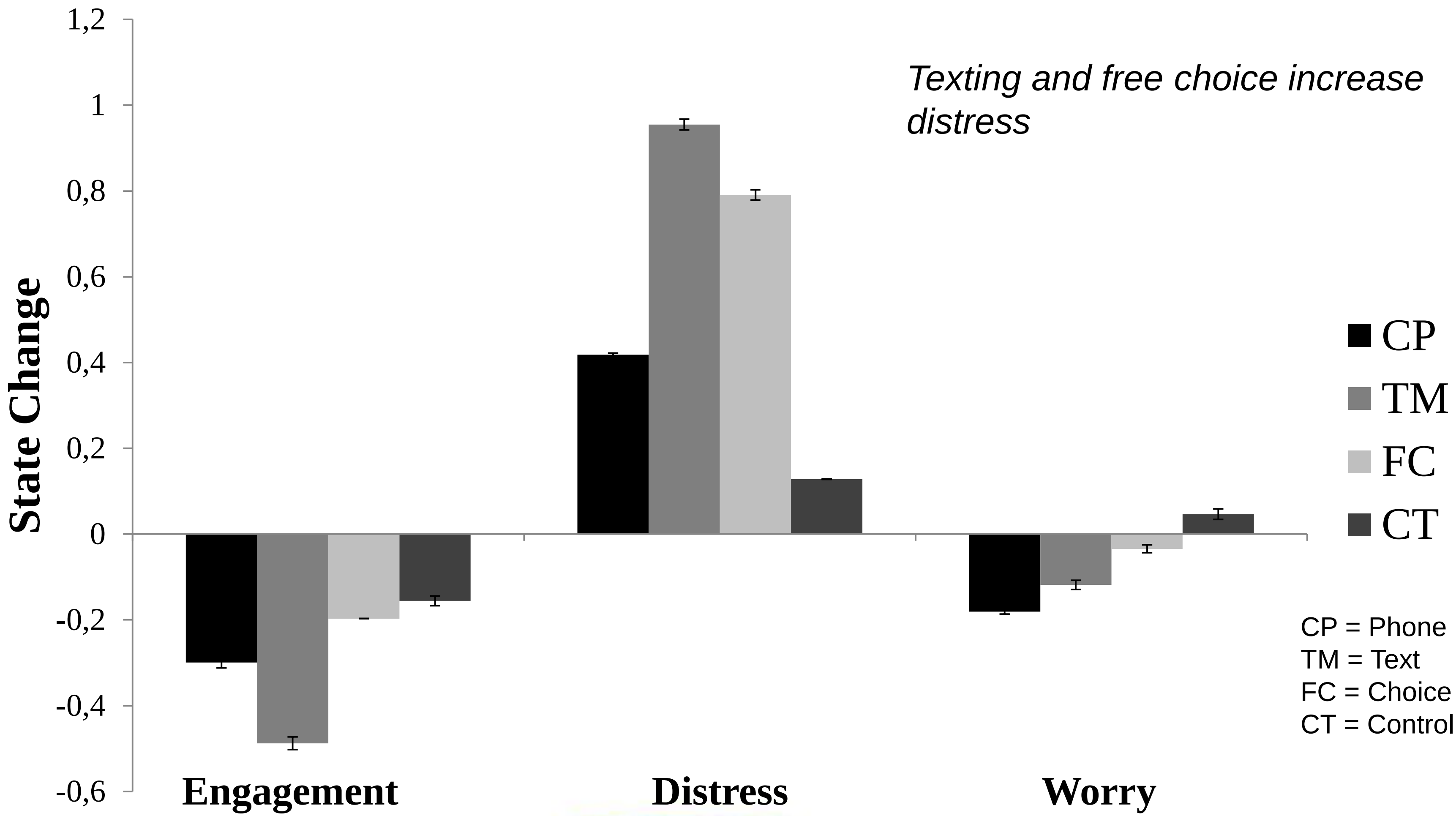
Voice, Text and Choice
(Neubauer et al., 2012b: N=240)

- Aims
  - Test effects of phone use during period of automation
  - Compare speech and text responses to texts
  - Role of voluntary choice
    - In choosing to respond to messages
    - In choosing whether to call or text back to message
- Design (2 x 4)
  - Automation vs. Non-automation (as before)
  - Four media groups - Cell phone (CP) group, Text-Message (TM) group Free-choice (FC) group – choice of calling or texting back, Control group (CT) – no phone use
  - 14 texts sent to participants in first three groups; 7 urgent, 7 optional
  - Texts were general knowledge questions
  - Emergency event as before

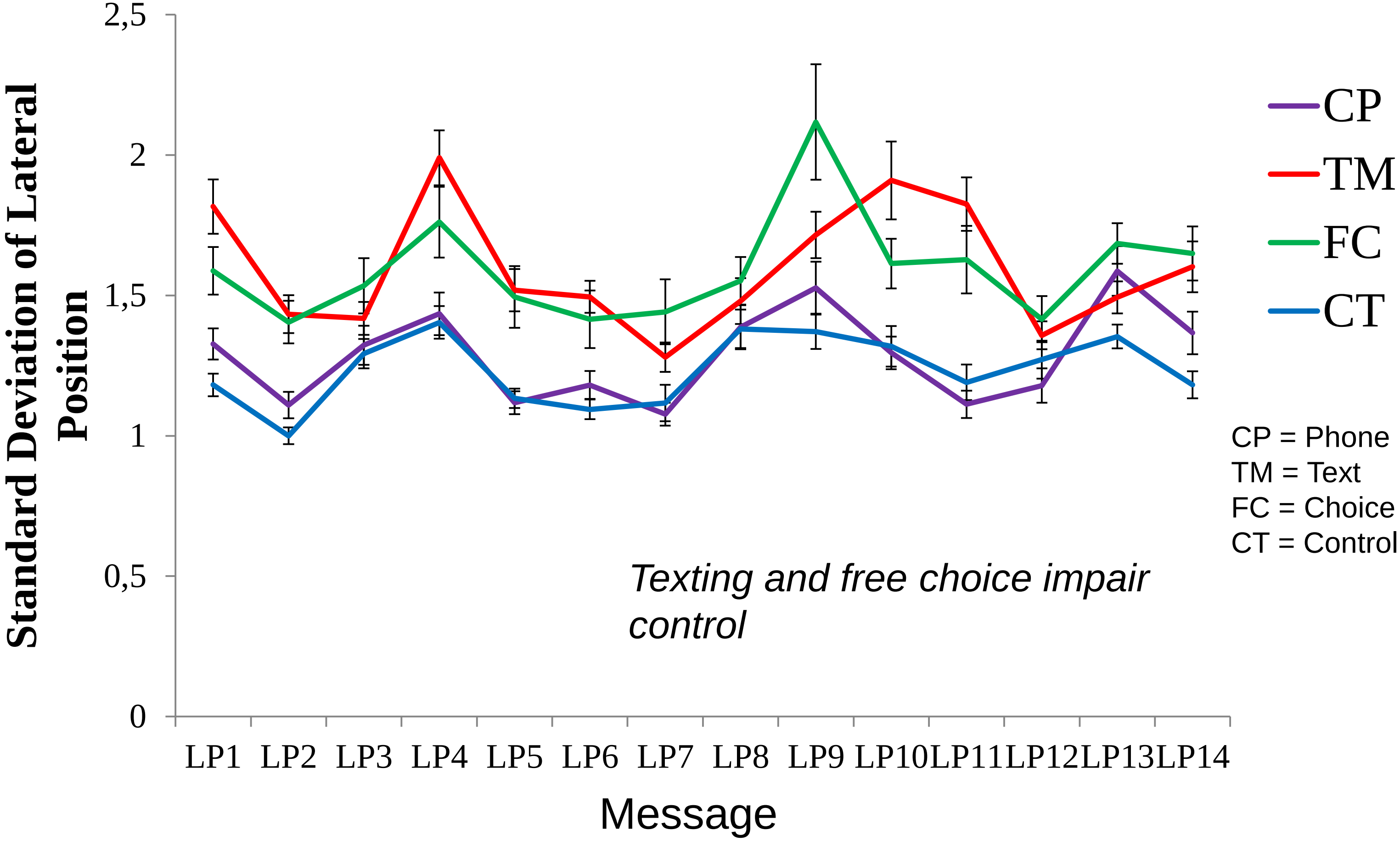
Results

- Automation
  - Reduces task engagement, as before
- Phone use
  - Increased distress, especially in text and free-choice groups
    - Free-choice preferred text over speech
  - Poorer vehicle control in text and free-choice groups (non-automated condition)
  - Effect on response to emergency depends on automation
    - After normal driving, phone groups slower to respond than control
    - After automation, phone groups faster to respond than control
- Choices
  - Automation increases responses to optional messages
  - Participants prefer to respond via text, despite adverse effects on subjective and objective outcomes

Cell Phone Use Effects on Subjective State



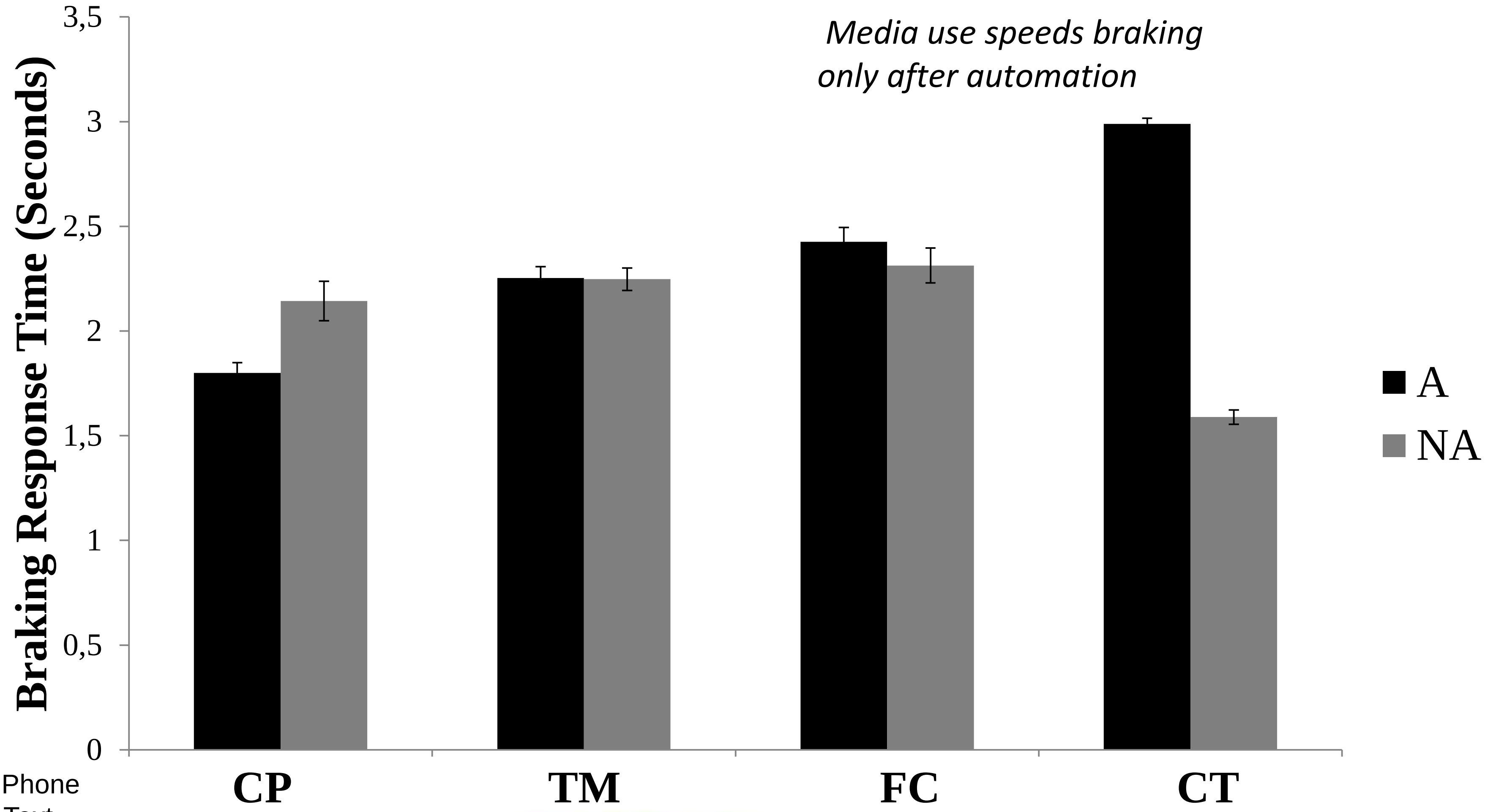
Vehicle Control During Phone Use



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

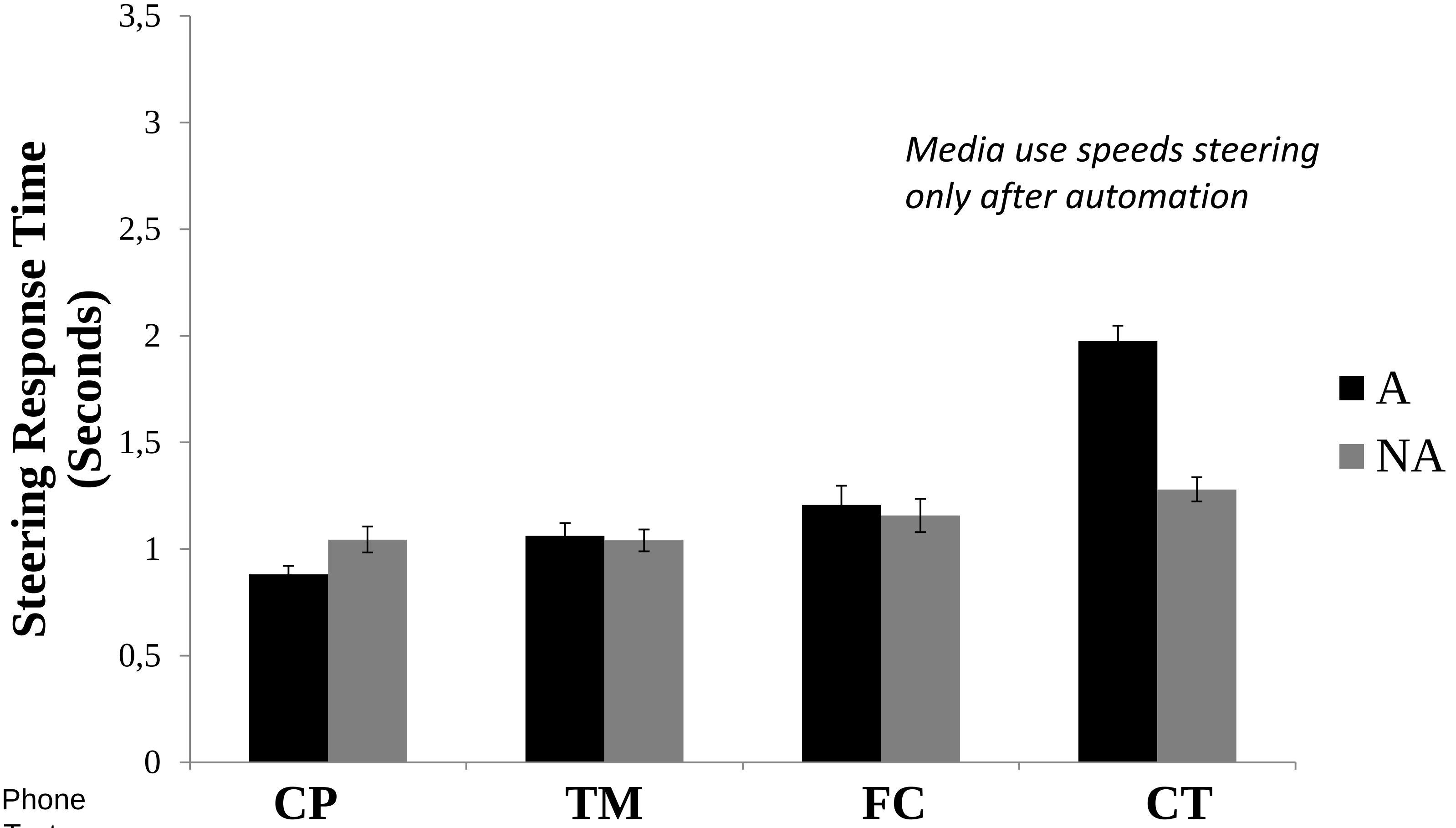
Texting and free choice impair control

Braking Response Time



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

Steering Response Time



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

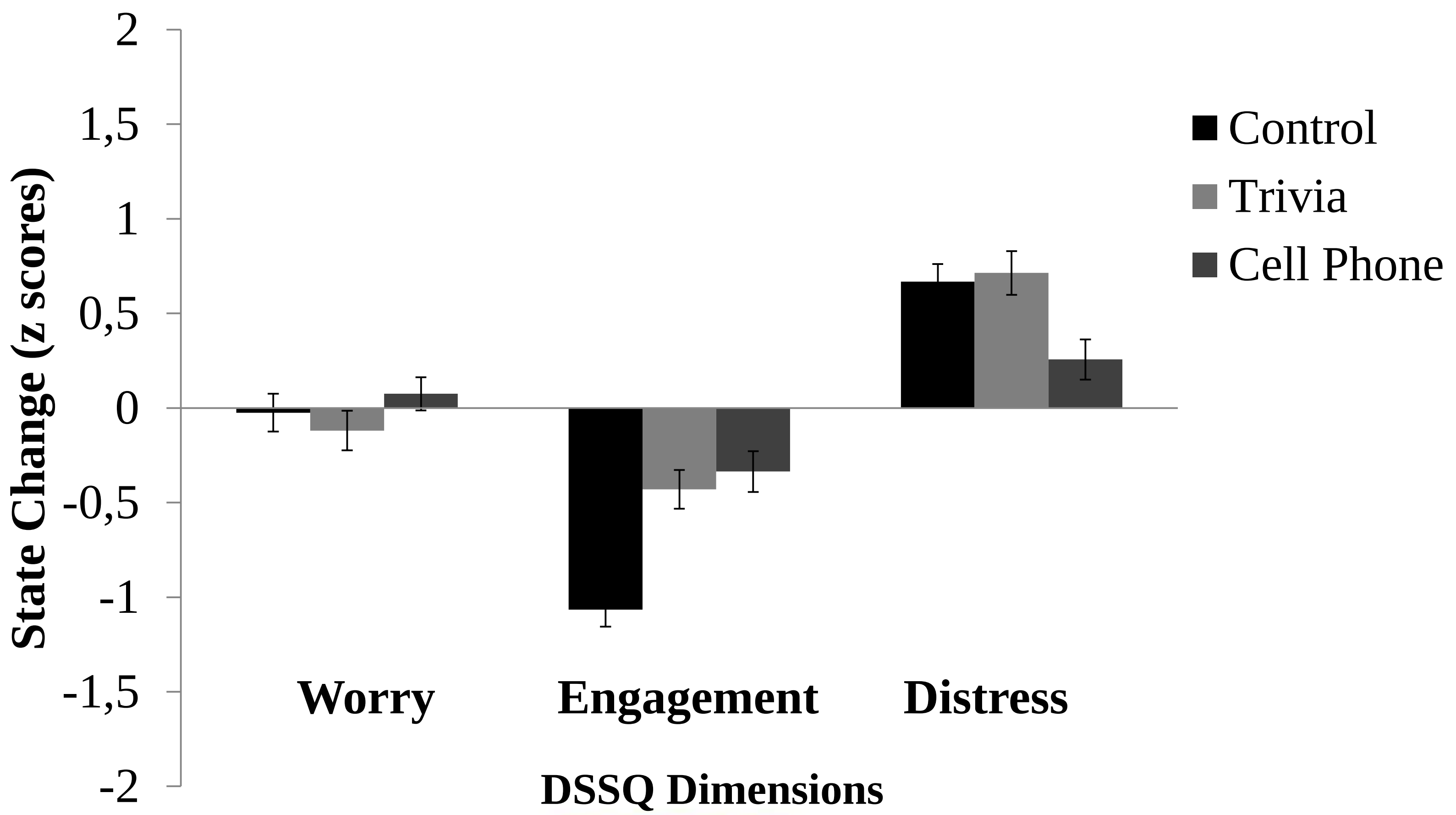
Comparison of Phone and Trivia Game (Neubauer et al., 2014: N=180)

- Aims
  - Compare phone and trivia game impacts on post-automation driving
  - Include partial and total automation conditions
- Design (3 x 3)
  - Automation: Full, partial (cruise control), none
  - Three media groups - Cell phone (CP), Trivia (TR) and Control
  - 40 min drive prior to emergency event
    - Media conditions: two 10-min periods of use early and late in drive
      - 5-15 min and 30-40 min
    - CP: "Close call" cell phone conversation with experimenter
    - TR: Selected question from 1 of 5 categories (e.g., food, sports, movies, current events and general knowledge), similar to Gershon et al. (2009)

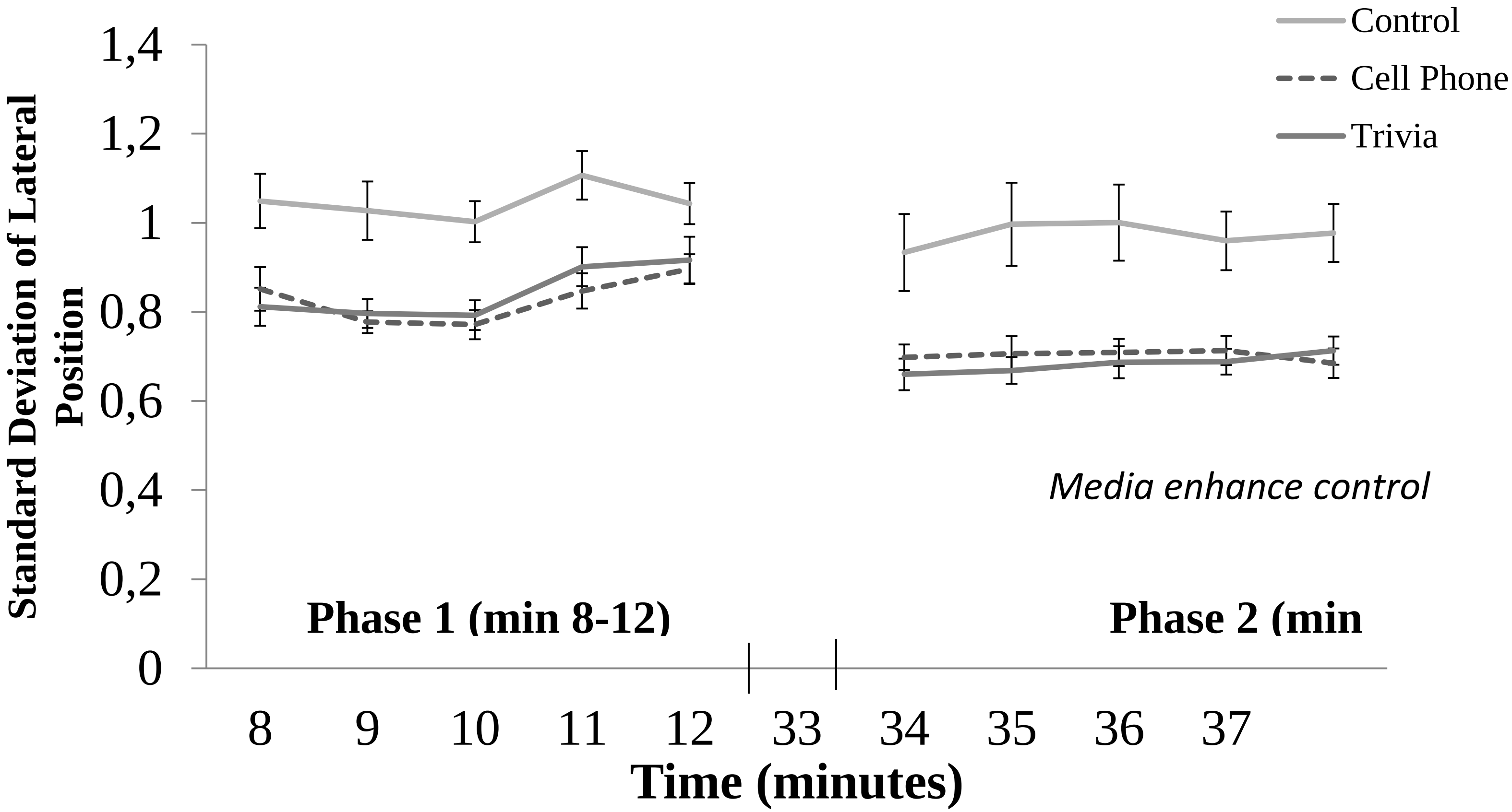
Results

- Subjective state
  - Both trivia and cellphone elevate task engagement
  - Cellphone decreases distress
  - No interaction with automation
- Vehicle control
  - Both trivia and cellphone improve vehicle control
  - Early and late in drive; no clear dependence on fatigue
- Response time
  - Effects of automation only
  - Trend towards media slowing response

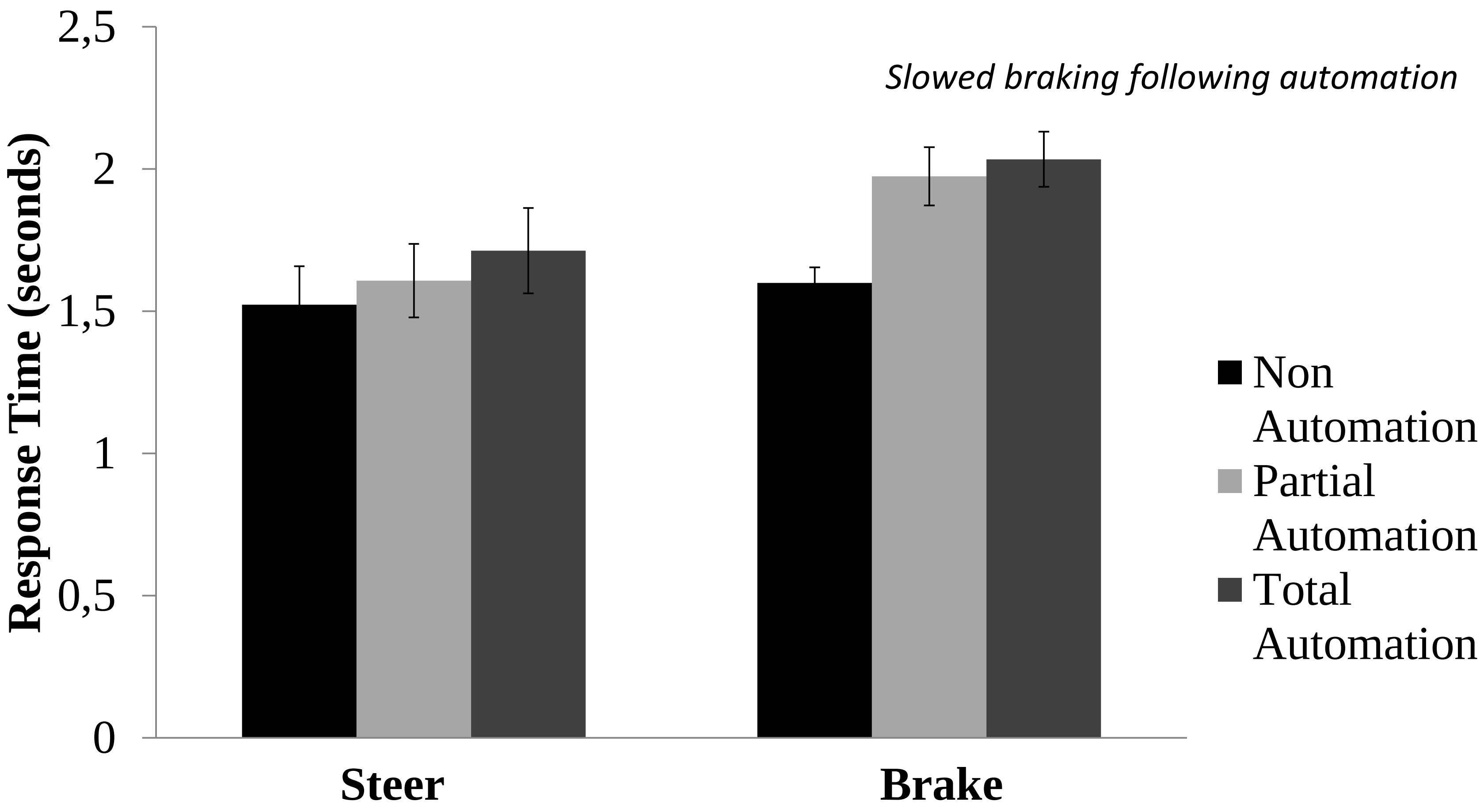
Media Effects on Subjective State



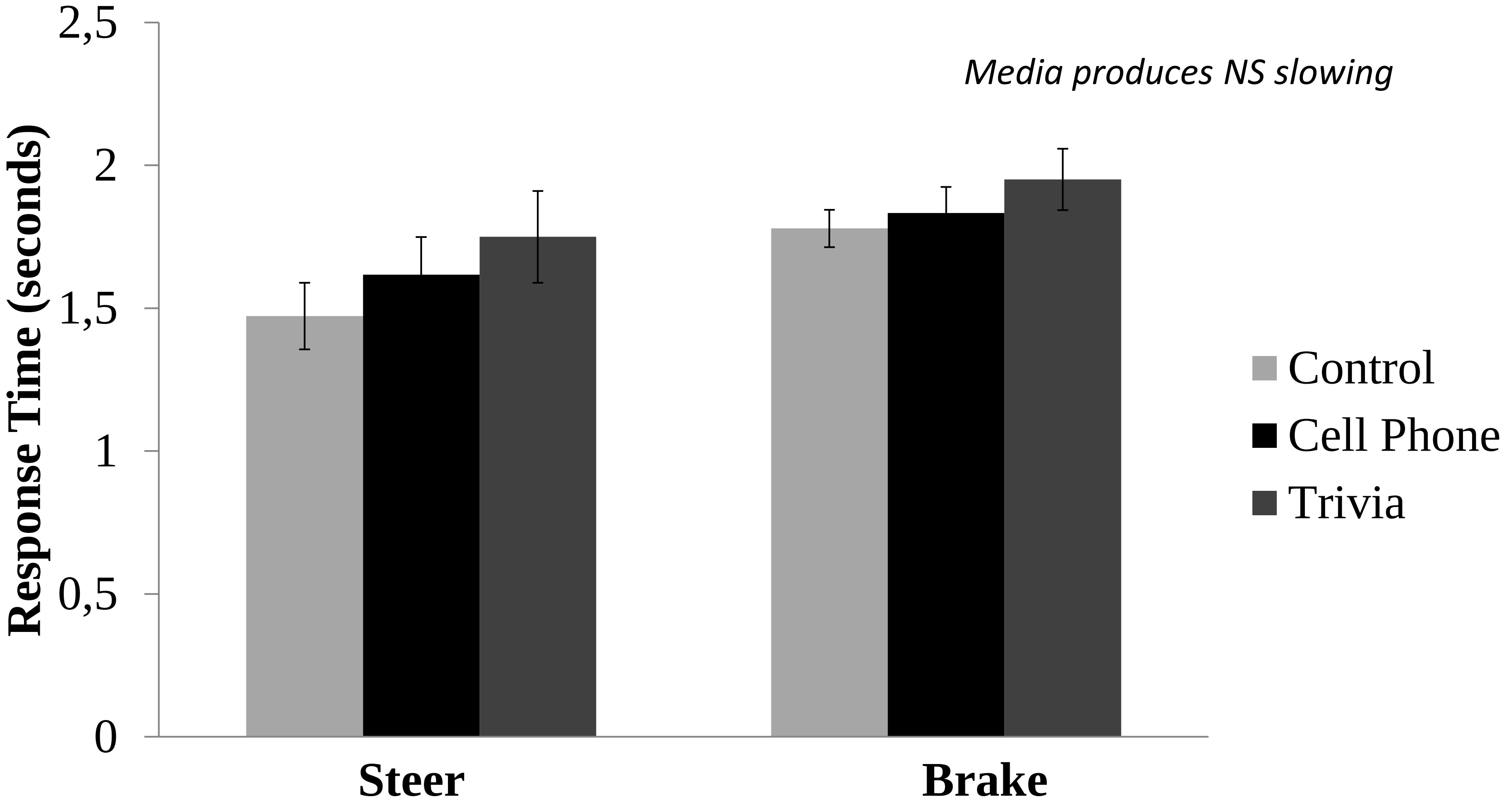
Vehicle Control



Response Time: Automation Effects



Response Time: Media Effects



Impact of Media in the Automated Vehicle

- Automation as a safety hazard
  - Consistent detrimental effects on subjective state and alertness
  - Need for countermeasures during automated periods
- Media effects on subjective state
  - Immediate impact – increased worry
  - Cumulative impact – texting elevates distress – conversation and trivia counter subjective fatigue
  - No interaction with automation-induced fatigue
- Media effects on performance
  - Vehicle control impaired by texting; may be improved by voice
  - Reading texts counters fatigue effect on alertness; speech does not
  - Trivia game has similar effects to speech
  - Unfortunately, participants prefer text to vocal response
- Overall
  - Media have mixed effects on outcomes

Driver Safety Applications I

- Multidimensional assessment is critical
  - Valid assessment for countermeasure evaluation
  - Need for multidimensional assessment of fatigue
    - e.g., to distinguish active and passive fatigue
  - Need for multidimensional assessment of performance
    - Fatigue impacts on alertness and vehicle control may differ
- Perils of automation
  - Even short intervals of automation are hazardous due to fatigue
  - Don’t trust the driver to manage automation
  - Future vehicles: driverless cars with optional driver control (multiple levels of automation)

Driver Safety Applications II

- Secondary tasks: Distraction or countermeasure?
  - Texting is stressful as well as distracting
    - But still a favored action
  - Evidence from one study that verbal response to texts during automation enhances alertness
    - Need further research to determine 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
  - Design for fatigue
    - Different for active and passive
  - Training solutions
  - Situational exercises to promote adaptive coping (Machin, 2003)

Conclusion

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Conclusions: Theory

- Subjective States: A transactional perspective
  - Relational constructs that signal modes of adaptation to environmental and task demands
  - Commitment to effort, overload and personal reflection
- Sources of states
  - The subjective state integrates multiple cues to adaptive status: difficult to reproduce with objective measurements
  - Future challenge: how to assess implicit sources of state
- Consequences of states for performance, safety and wellbeing
  - Integrated response combining changes in neural functioning, 'virtual' resource availability, and coping/effort
  - Future challenge: how to tease out different response components, and their functional significance

Conclusions: Applications

- Diagnosis of operator fitness to perform
  - Specification of task demands is critical
- Diagnosis of tasks and environments
  - e.g., automated systems in vehicle driving
- Evaluating interventions for stress and fatigue
  - e.g., trivia games
- Design for task engagement
  - Optimizing task demands and scope for operator control
- Selection of resilient individuals, in-context
  - Need for multivariate modeling

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HUMANS, TECHNOLOGY AND FATIGUE:
AN UNCERTAIN FUTURE

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