Disconnects in the driver distraction equation: It's more than the technology!

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Technology and Driving: an Age Old Issue?

The New York Times

"**A grave problem** that developed in New Hampshire… now **has all the motor-vehicle commissioners** of the eastern states **in a wax**. **It's whether radios should be allowed on cars.** Some states don't want to permit them at all -say **they distract the driver and disturb the peace**…The [Massachusetts] commissioner thinks the things should be shut off while you are driving…The whole problem is getting very complex, but the upshot is that you'll probably be allowed to take your radio anywhere, with possibly some restriction on the times when you can play it."

Nicholas Trott, 1930

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Changing our Perspective of the Car

Over the past 100 or so years we have seen

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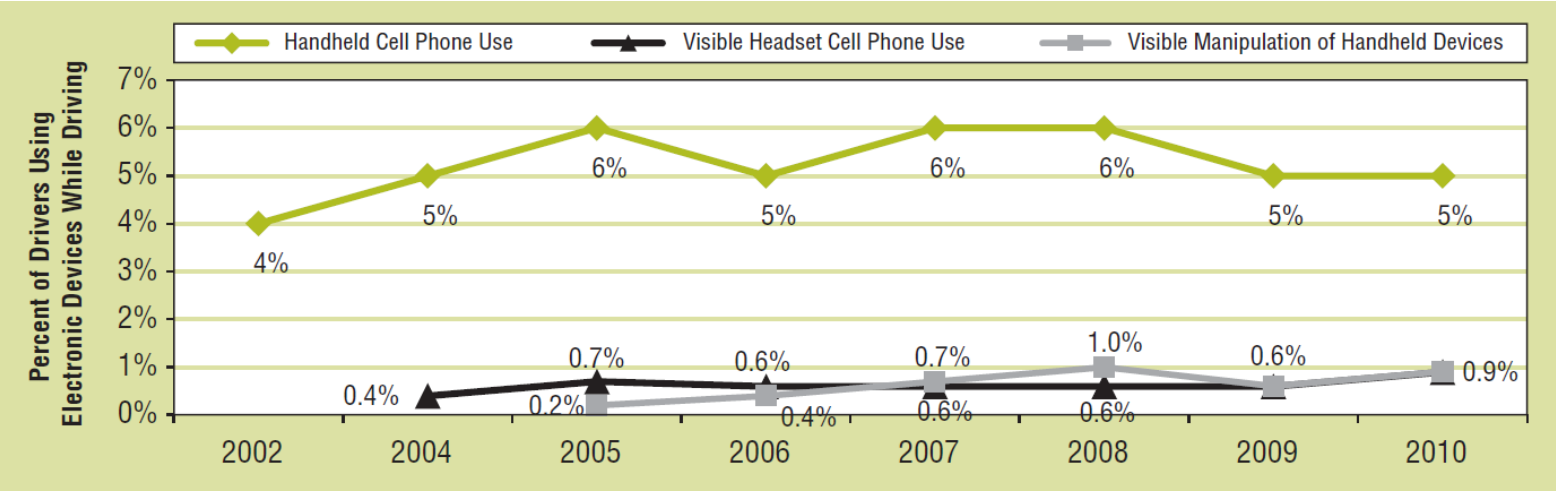
Use of Phone and Other In-Vehicle Technologies Has Increased

- Wireless subscribers increased from 44m in 1996 to 331m in 2011 (CTIA)
- Text messaging barely existed in 1996, in 2011 2.3 trillion were sent (CTIA)
- As of Feb 2012, Smart phones are now more prevalent than traditional feature phones (Nielsen Mobile Insights)



(Figure adapted from: NHTSA (2011), Driver Electronic Devices Use in 2010)

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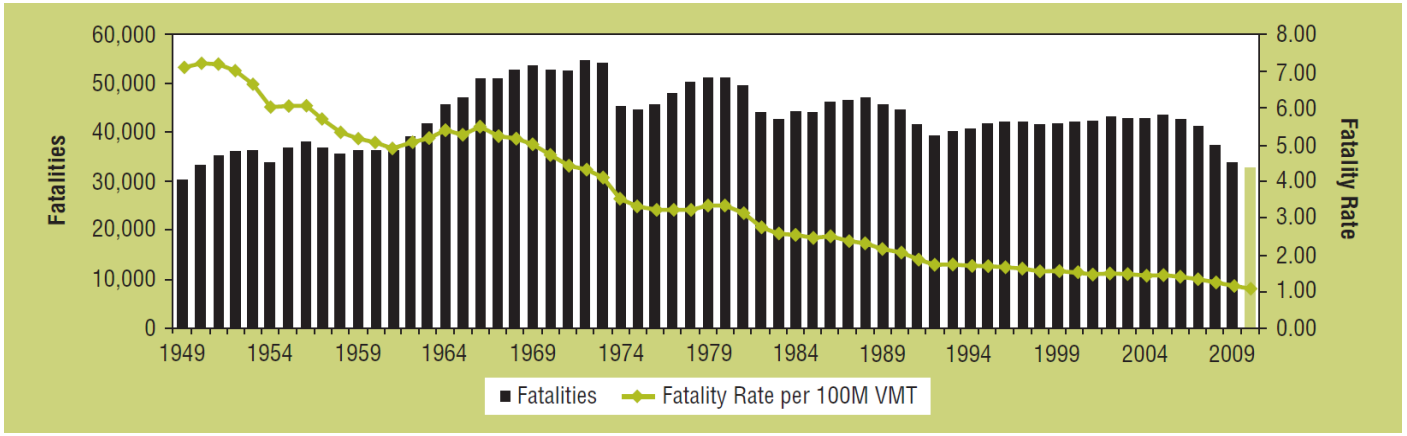
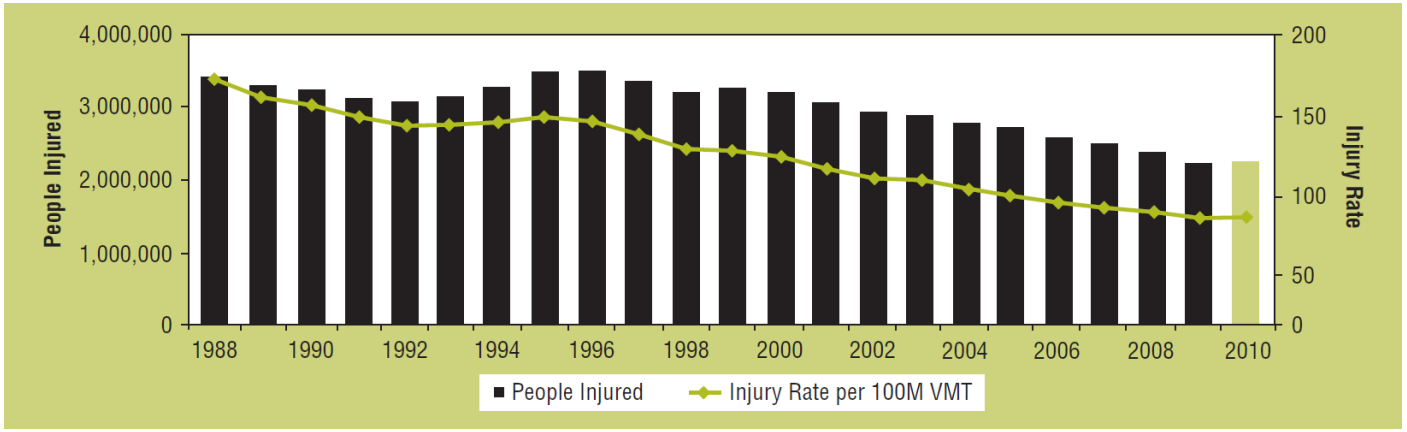
Trends in Traffic Safety Point to Safer Roads





(Figure adapted from: NHTSA (2012), 2012 Motor Vehicle Crashes: Overview)

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Cars are Now Built to Protect the Driver

IIHS 50th anniversary test – 1959 Chevrolet Bel Air and a 2009 Chevrolet Malibu

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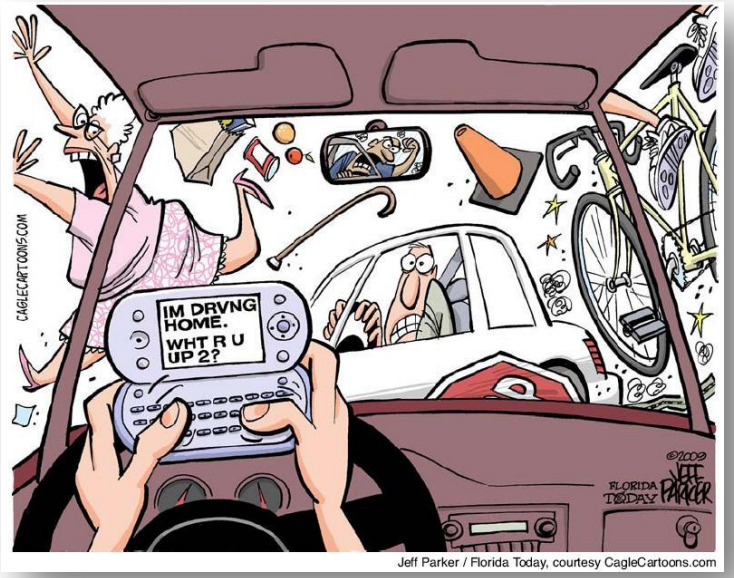
Sources of Distraction

- Cognitive
- Auditory
- Vocal /Verbal
- Visual
- Motoric
- Somatosensory/Vestibular
- Smell
- Taste



Jeff Parker / Florida Today, courtesy CagleCartoons.com

(Source: Toyota CSRC Driver Distraction Definitions Workshop March, 2012)

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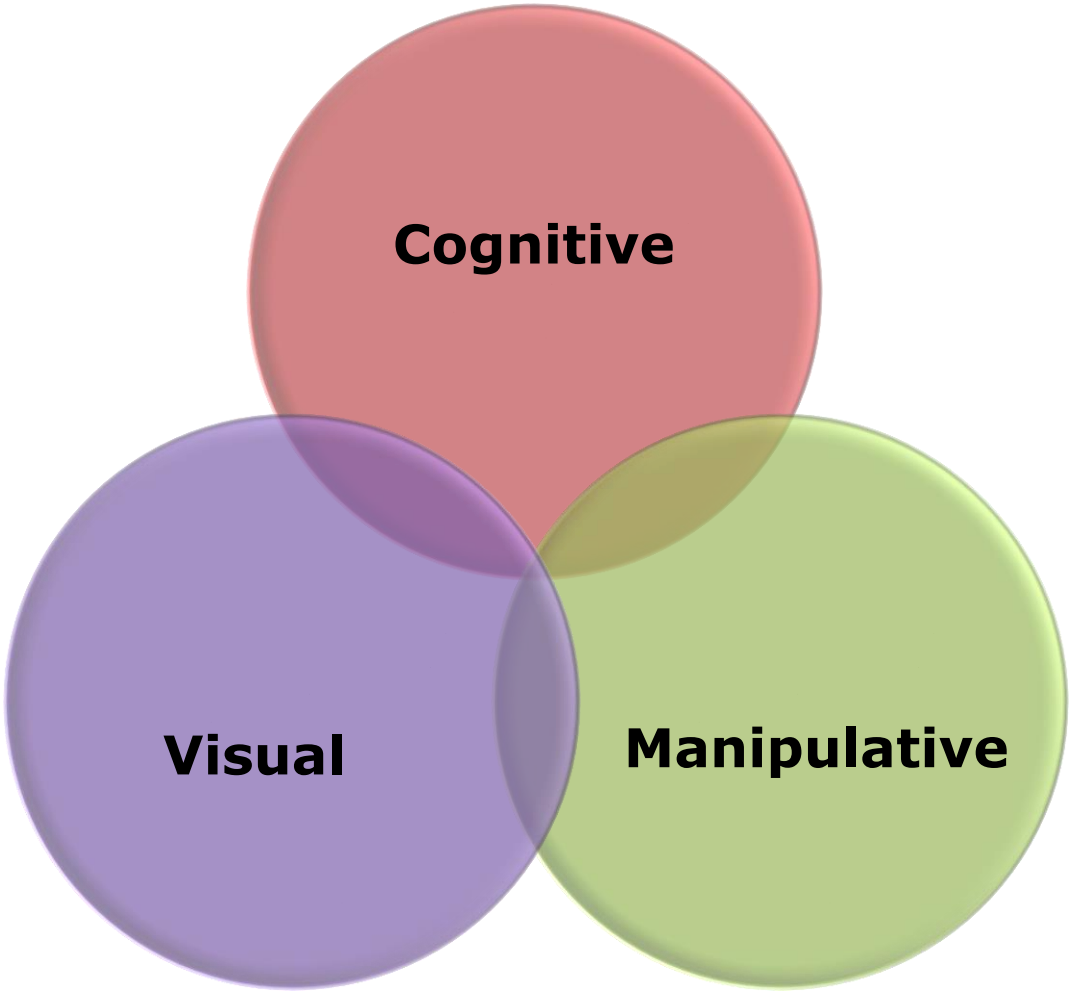
A Common Perception of the Three Major Pillars of Distraction



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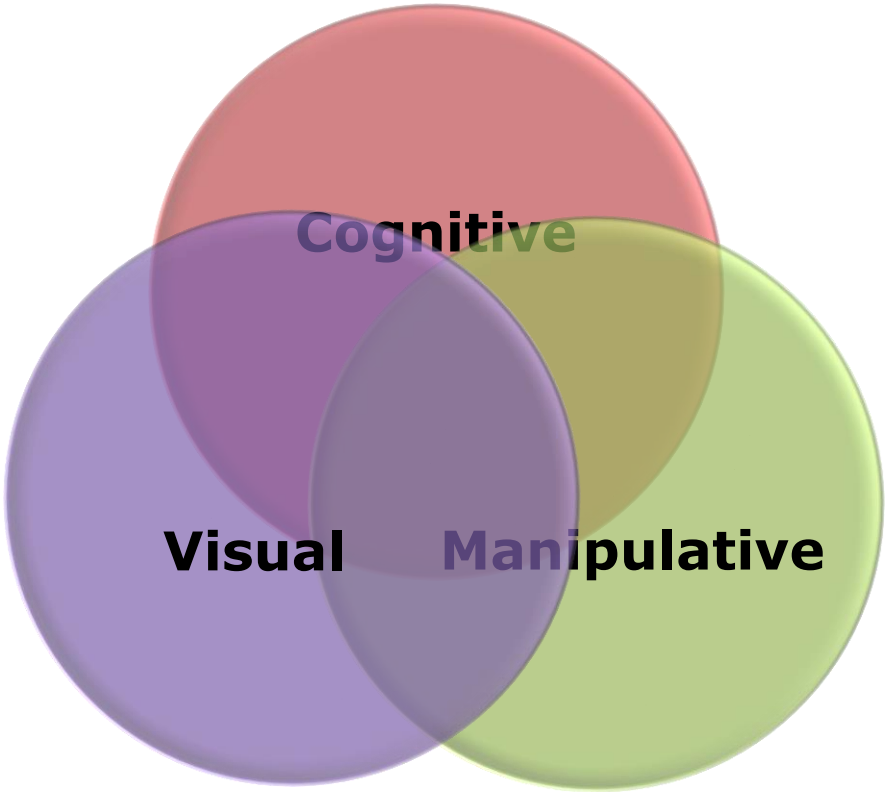
In reality

..... the pillars are highly overlapping



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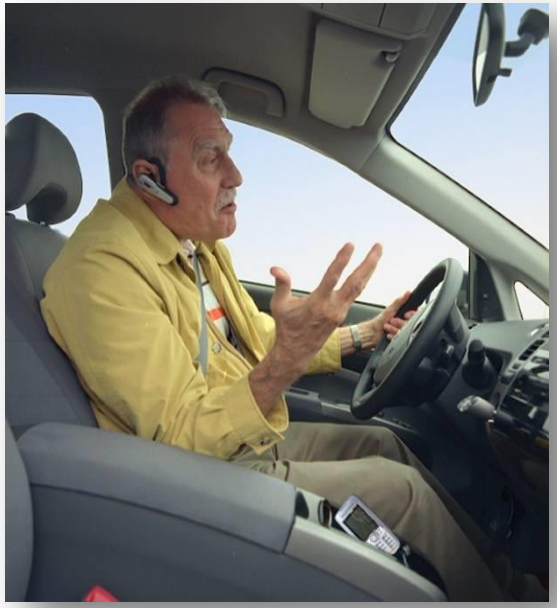
Visual Distraction Is Obvious

Eyes on road



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Mind on road

Cognitive demand is harder to “see”

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Sources of Distraction

- Cognitive
- Auditory
- Vocal/Verbal
- Visual
- Motoric
- Somatosensory/Vestibular
- Smell
- Taste

Three categories often grouped together in simplified discussions of "cognitive workload", but have different neurological underpinnings and potential effects on attention and behavior

(Source: Toyota CSRC Driver Distraction Definitions Workshop March, 2012)

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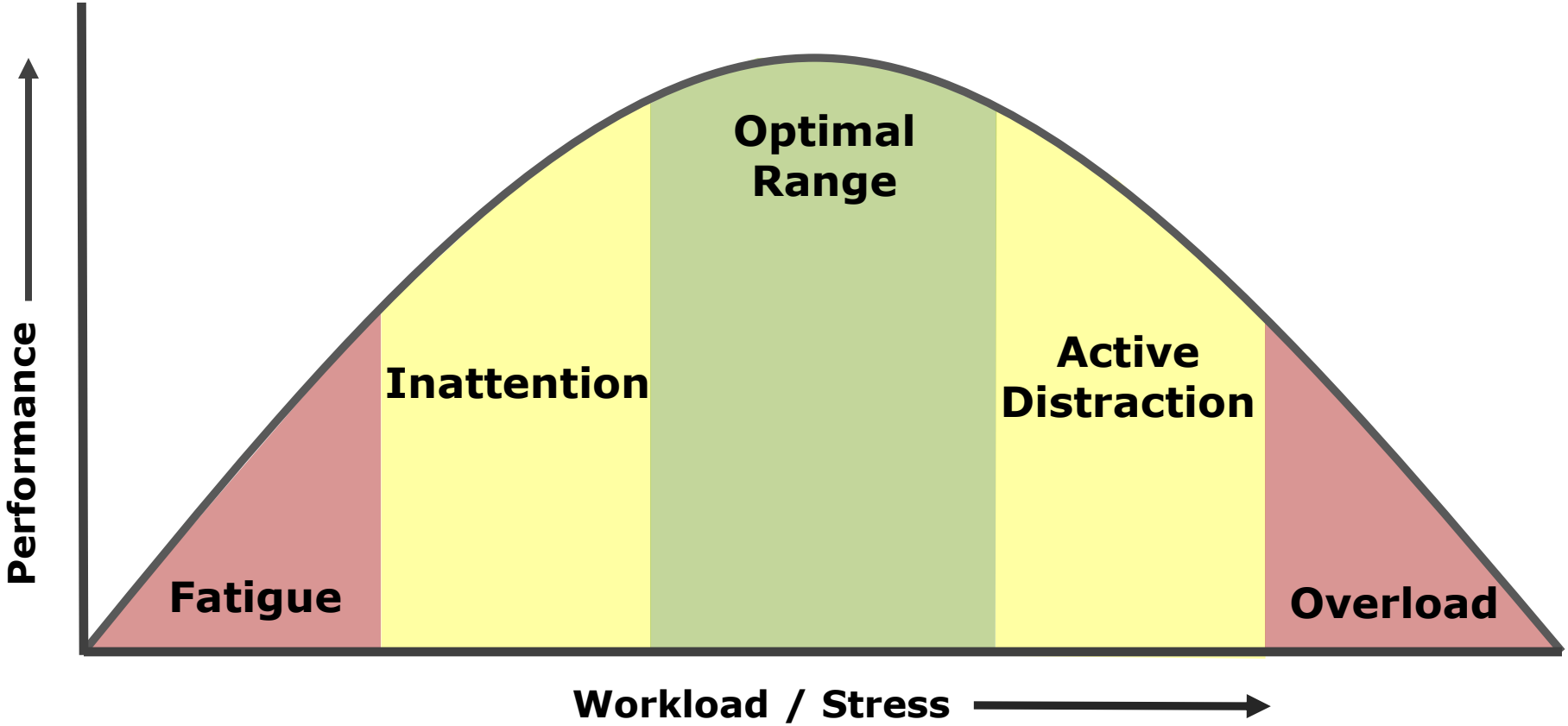
Workload & Performance

Yerkes-Dodson Law

The relationship between performance and physiological or mental arousal



(Source: Coughlin, Reimer & Mehler, 2011)

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Physiological Arousal
What Can We Study in the Car?

Part of a larger project evaluating various methods of detecting driver state

- Measures initially considered:
  - Heart Rate
  - Heart Rate Variability
  - Pulse height (peripheral blood flow)
  - Skin Temperature
  - Skin Conductance Level / Response
  - Respiration Rate
  - Pupil Diameter
  - Muscle Tension (EMG)
  - EEG (brain waves)
  - Stress Hormones
  - fNIRS (brain blood flow)

- Which measures will prove most sensitive at differentiating levels of demand?
- What minimum set of measures is required to quantify changes in driver state that provide a robust understanding of arousal and attentional focus?

(drawn in part from Mehler, Reimer, Coughlin & Dusek, 2009)

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The MIT n-back

An Emerging International Method for Inducing Graded Cognitive Workload

- Series of 10 single digit numbers (0-9) presented in random order aurally at 2.25 sec intervals
- Subject instructed to respond with nth digit back
- Across levels
  - Auditory demands constant
  - Vocal demands "relatively" constant
- Aims to manipulate secondary cognitive demand

Stimulus	**6**	**9**	**1**	**7**	**0**	**8**	**4**
0-back Response	6	9	1	7	0	8	4
1-back Response	-	6	9	1	7	0	8
2-back Response	-	-	6	9	1	7	0

(Mehler, Reimer Dusek & Coughlin, 2011)

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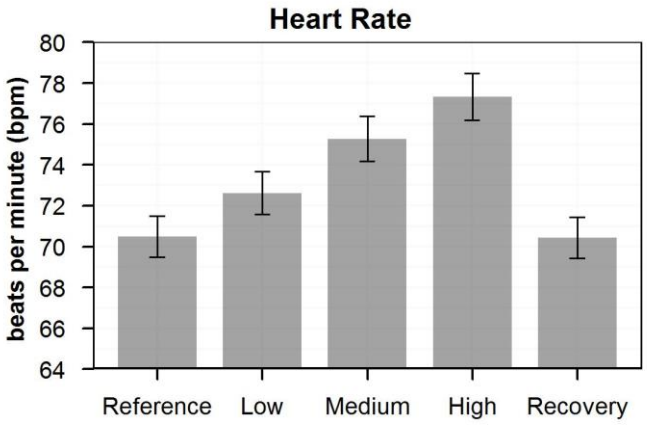
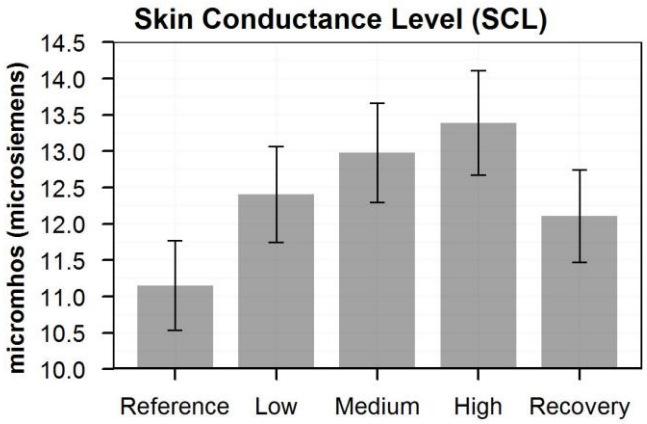
Heart Rate & Skin Conductance





- Both increase with task difficulty ($p < .001$)
- Heart rate (HR) changes essentially linear with demand; rapid recovery
- Skin Conductance Level (SCL) reactivity at low demand suggests emotional component; slower recovery

(Mehler, Reimer & Coughlin, 2012)

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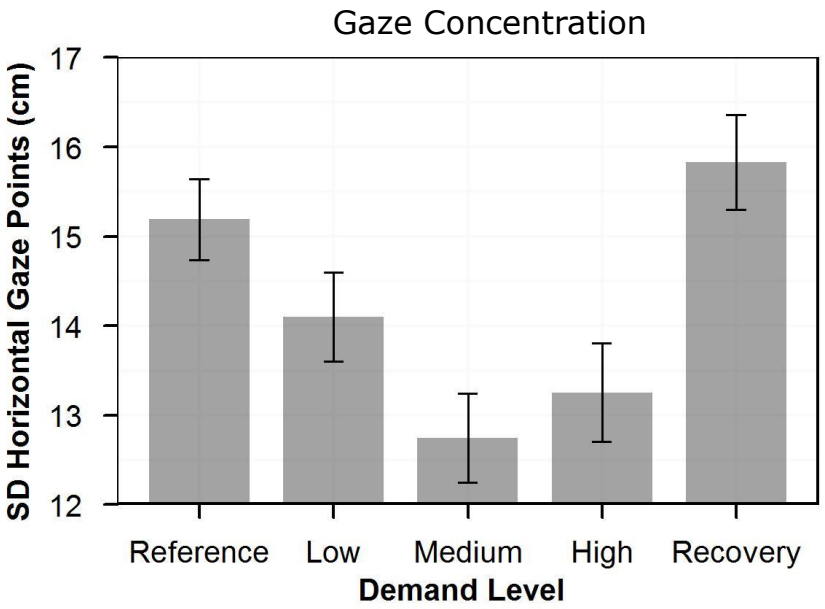
Visual Attention



With cognitive workload horizontal gaze concentration:

- Statistically differs by demand level
- Indicates maximum impact on gaze restriction is reached with 1-back (no statistical difference between 1 & 2-back)

(Reimer, Mehler, Wang & Coughlin, 2012)

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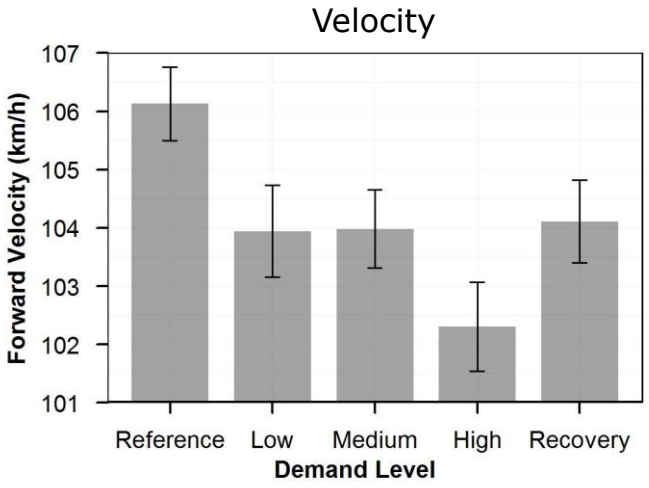
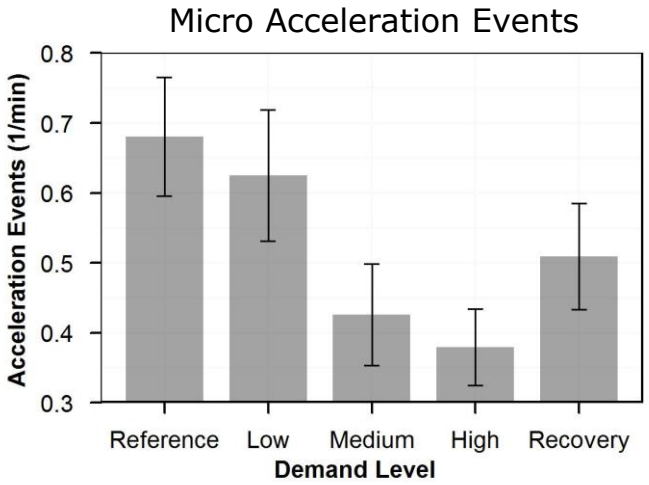
Driving Behavior / Self-regulation?





With secondary cognitive demand, drivers:

- Make fewer lane changes
- Show somewhat reduced likelihood of turn signal use
- Delay onset and turn-off of turn signals
- Travel less often in the leftmost lane

(Reimer et al., 2013; Donmez et al., 2011)

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A Link Between Phone Use and Risky Driving

(Zhao, Mehler, Reimer, D'Ambrosio, Mehler & Coughlin, 2012)

It's clear [from the scientific literature] that cell phones in and of themselves impair the ability to manage the demands of driving, but the fundamental problem may be a broader pattern of behavior of individuals who are willing to pickup the technology.

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Voice Interfaces

While voice interfaces offer the promise of reducing the time a driver's eyes are drawn away from the roadway, a number of questions remain:

- How do we effectively assess the amount of non-visual demand associated with voice interfaces?
- In what conditions does voice control reduce demand over traditional methods of interaction?
- How do different simple vs. more complex voice interactions affect drivers?
- Do age and gender impact drivers' perceptions and use of voice interfaces?

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Cognitive Oriented Interfaces…..

… using voice and hands-free technology offer the promise of reducing the time a driver's eyes are drawn away from the roadway and maximizing the time a driver's hands are on the wheel, however

Distraction Related Accident Risk

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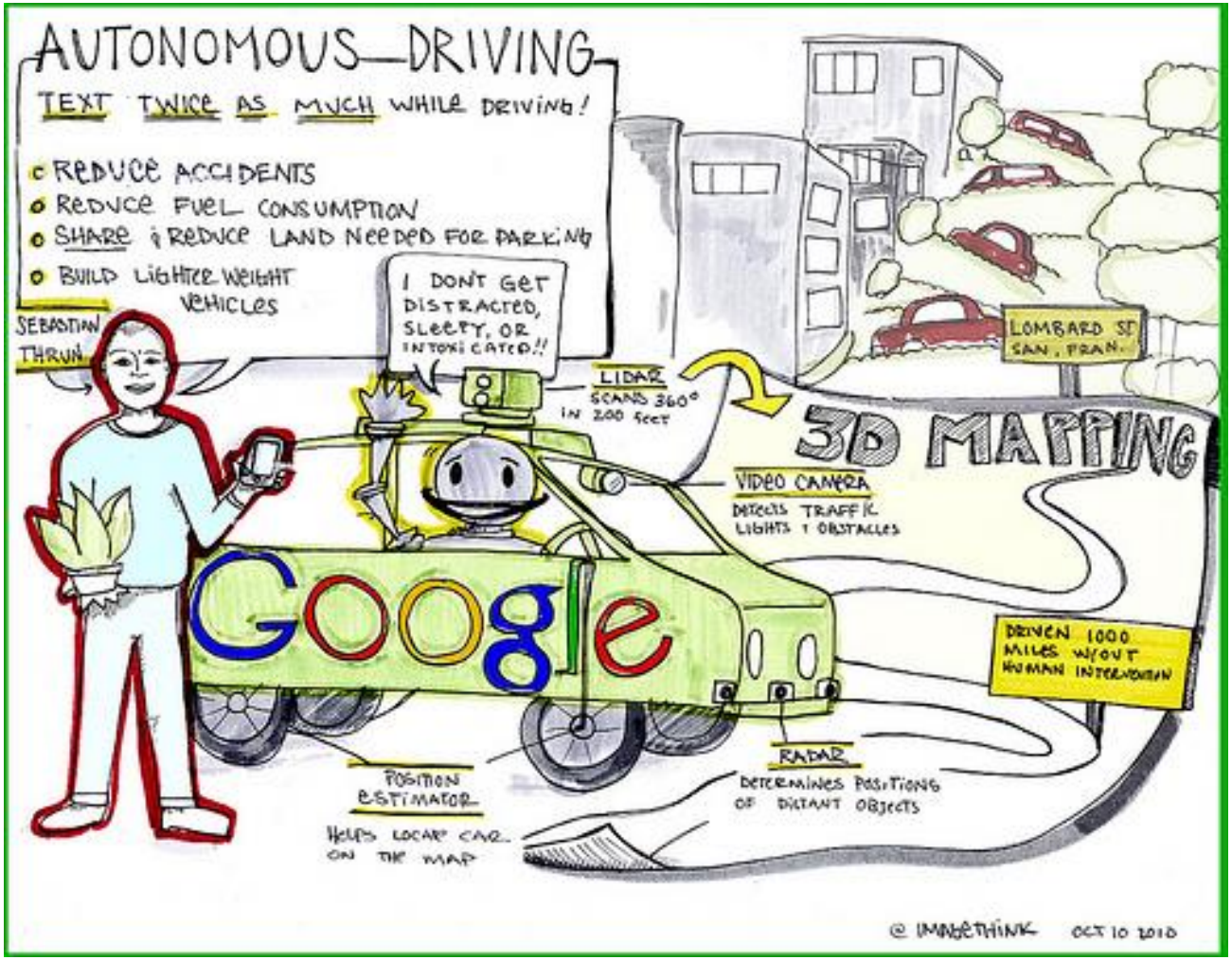
Looking Forward



In Summary, I believe

- Driver distraction is an "age old problem"
- Demands are multi-modal
- Self-regulation is an important consideration in the relationship between distraction and "safety"
- We really are just beginning to understand cognitive distraction
- Driver behavior - not the technology - is the deeper, underlying issue
- We can't continue assuming that safety technologies and autonomy alone will solve our nation's transportation problems

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