Driver Distraction

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Auto-UI Tutorials

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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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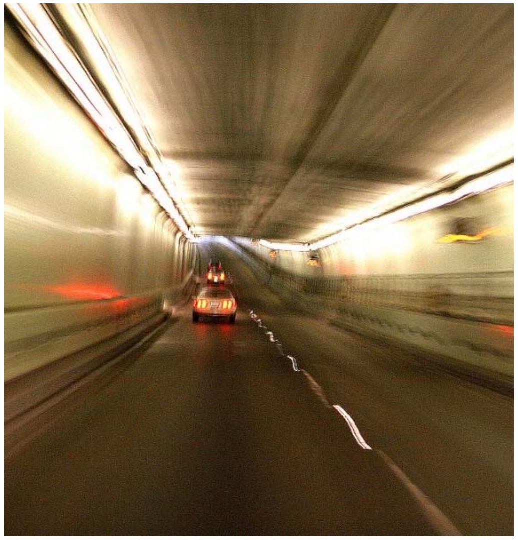
My Favorite Quote

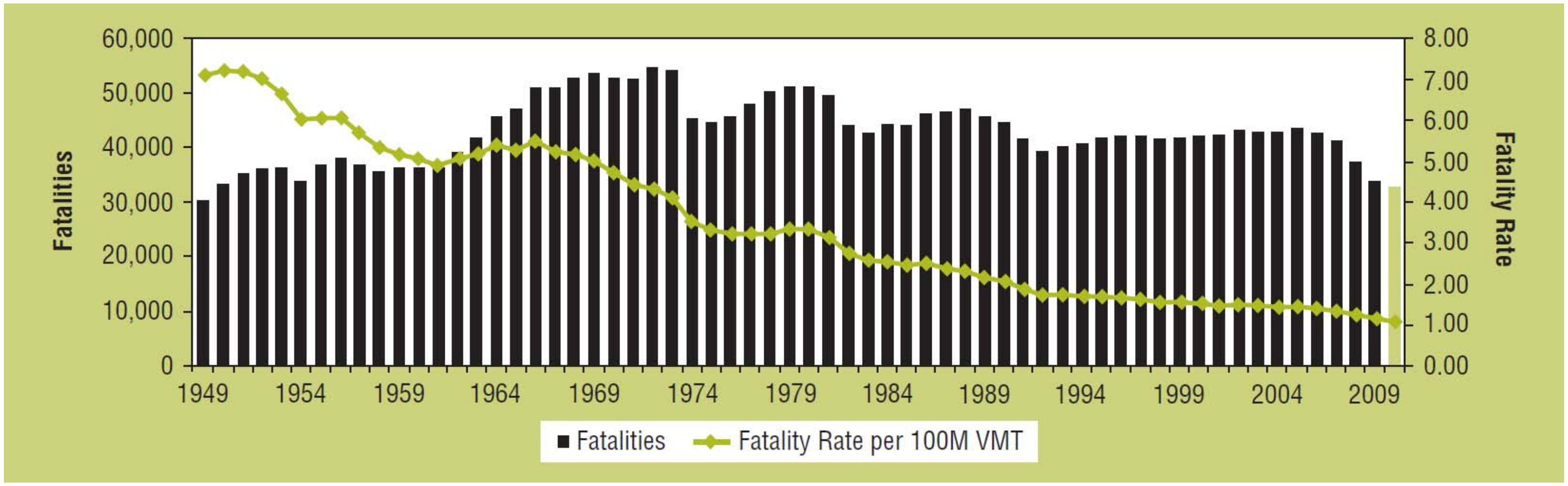
- Drivers are "outdated humans, with stone age characteristics and performance controlling a fast, heavy machine in an environment packed with unnatural, artificial signs and signals." (Dewar, 1988)
- Faber (1993) conceptually expands on this by noting that our ancestors were daytime hunters used to monitoring animals running at speeds of no more than 25 MPH

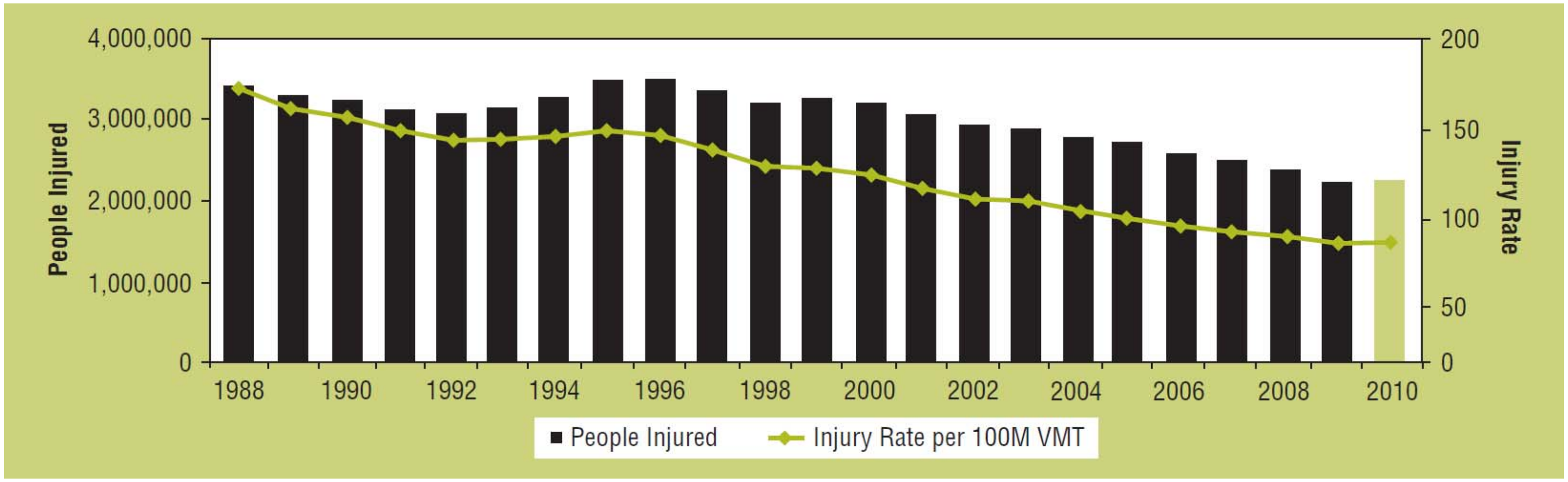


Changing our Perspective of the Car

Over the past 100 or so years we have seen

Trends in Traffic Safety Point to Safer Roads





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

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)

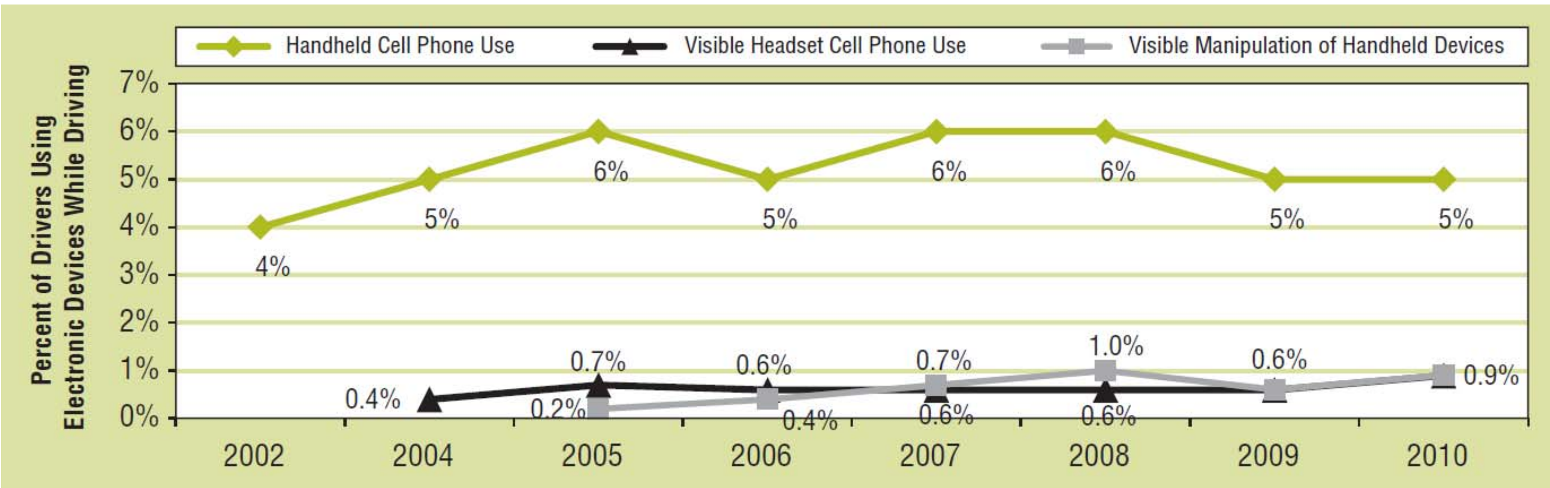
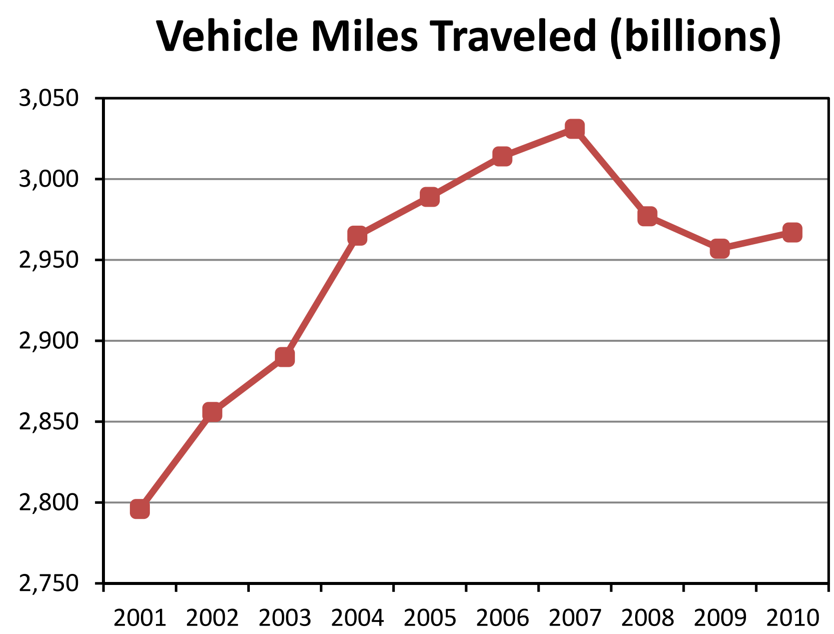


Figure adapted from: NHTSA (2011), Driver Electronic Devices Use in 2010

Increased Experience

The universal law of learning states that the ability to detect and control traffic hazards increases uniformly as the amount of travel increases. This law implies that accident rate per unit of exposure will decline as the amount of exposure increases. (Elvik, 2006)



Source: NHTSA Traffic Safety Facts 2012 DOT HS 811 630

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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The Driving Task Continues to Change without "Updating the Driver"

What's changing fast:

- Secondary tasks and nomadic technology
- Safety systems & telematics
- Traffic, environment and the roadway
- Interfaces

What's NOT:

What is Driver Distraction?

Sources of Distraction

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

Source: Toyota CSRC Driver Distraction Definitions Workshop March, 2012

Cognitive Workload

- 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

The MIT n-back

An Evolving International Procedure for Grading 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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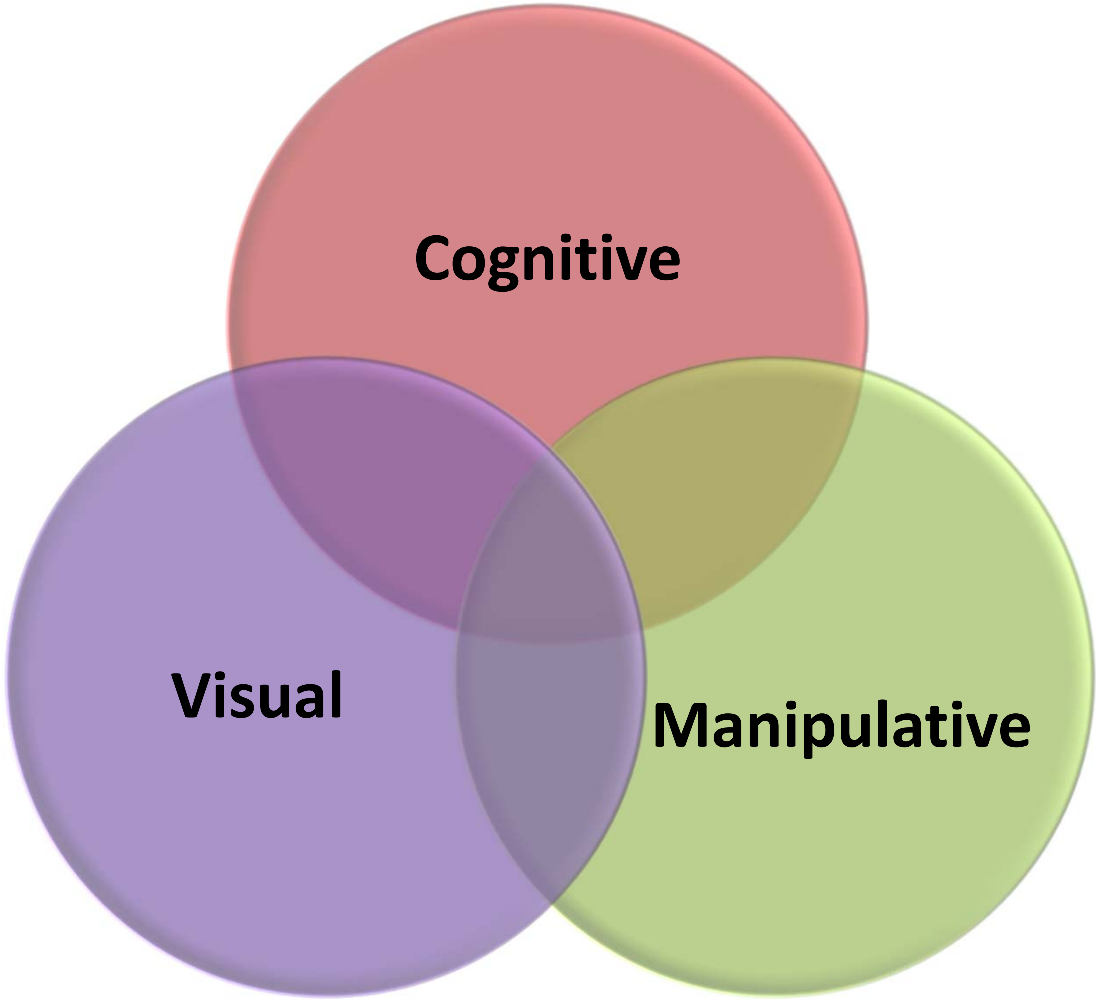
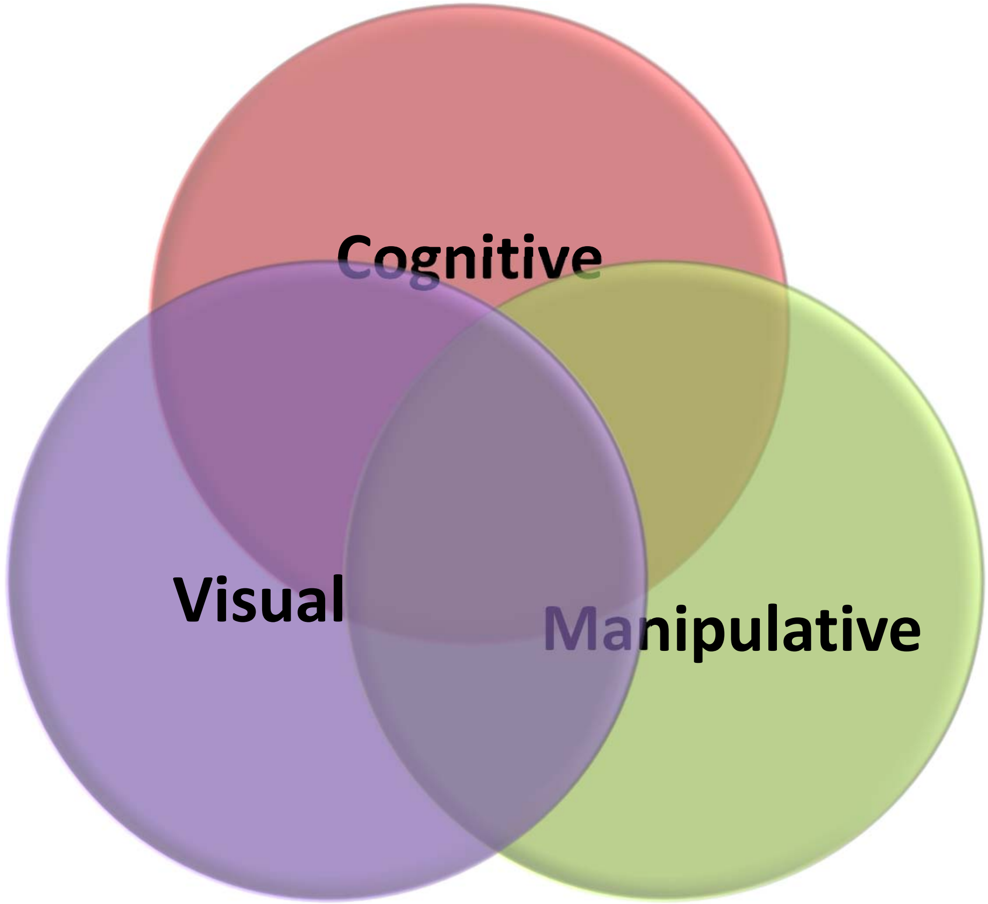
A Common Perception of The Three Major Pillars of Distraction



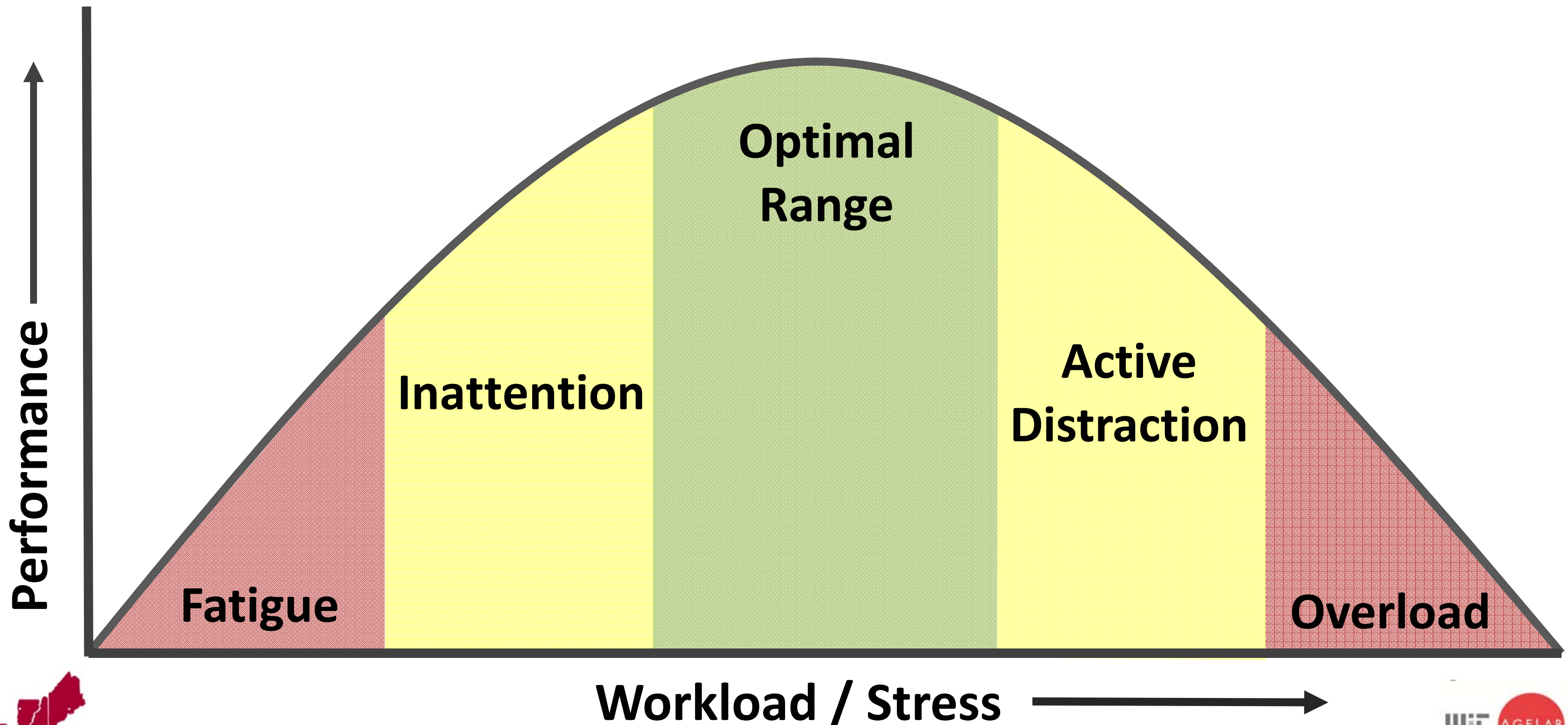
In reality
……. the pillars are highly overlapping



Workload & General Arousal

Yerkes-Dodson Law

The relationship between performance and physiological or mental arousal

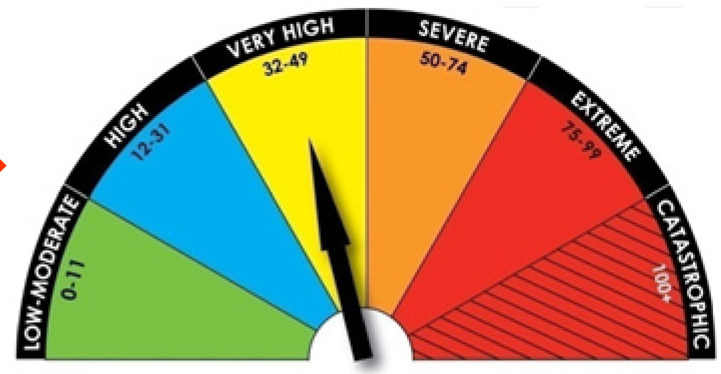


Coughlin, Reimer & Mehler (2011)

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



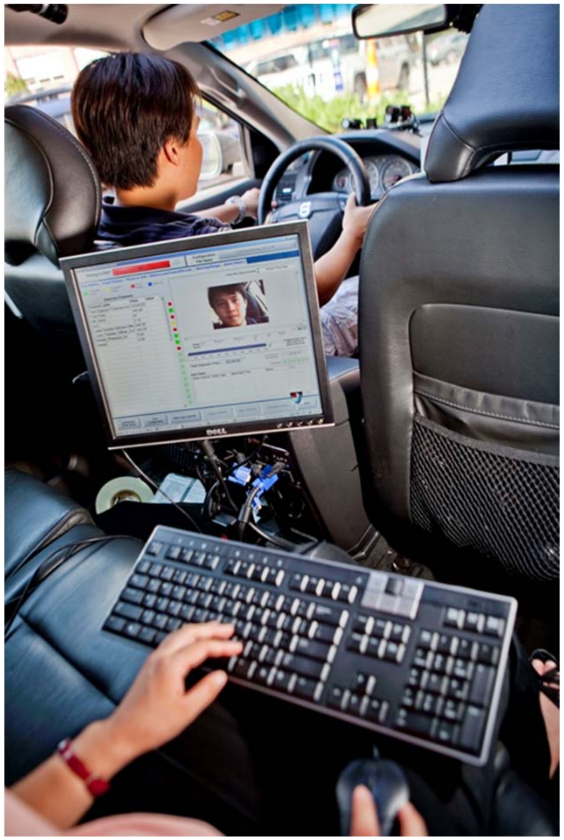
Visual Distraction Is Obvious

Eyes on road ≠ Mind on road

Cognitive demand is harder to "see"

How Do We Measure Driver Demand

- Variety of Methods
  (each with advantages & disadvantages)
  - Self-report
  - Behavioral observation
  - Performance (task & driving)
  - Eye measures
  - Physiological indices
- For longer term monitoring or multi-step tasks, driving performance , eye measures, and physiological measures offer advantage of being objective and relatively continuous



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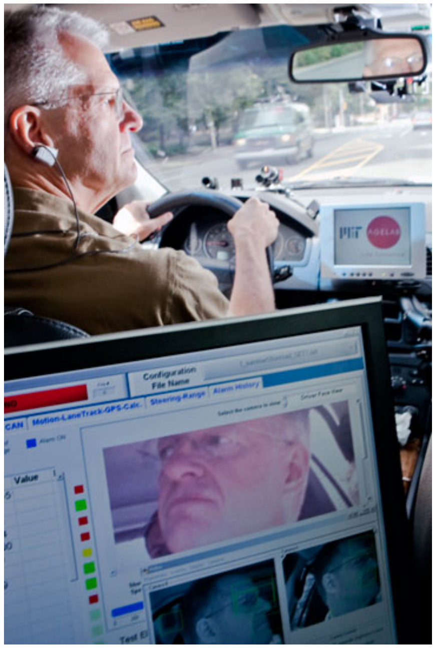
Cognitive Distraction: Developing a Good Ruler

- **Problem** – previous research on the impact of cognitive demand on driver behavior has produced conflicting results
  - Proper scaling of tasks
  - Appropriate training
  - Task difficulty & subject engagement



- **Methodology**
  - Physiology long accepted as a gross measure of arousal, but question of sensitivity in driving research
  - Platform for the collection of physiology, visual attention, vehicle telemetry and environmental sensing (Ford)
  - Delayed digit recall task (n-back)

- **Results** – multiple simulation and field studies demonstrating the impact of systematic changes in cognitive demand on driver behavior and visual attention; new framework for optimizing the assessment of how drivers interface with vehicle systems

Surrogate Cognitive Task Development

- Series of 10 single digit numbers (0-9) presented in random order aurally at 2.25 sec intervals

Stimulus	**6 9 1 7 0 8 4 3 5 2**
0-back Response	6 9 1 7 0 8 4 3 5 2
1-back Response	. 6 9 1 7 0 8 4 3 5
2-back Response	. . 6 9 1 7 0 8 4 3

- Appropriate pre-training to ensure "reasonable" mastery of task prior to assessment
- Each task level presented as 30 sec sets allowing for easy participant re-engagement
- Demand level approaches "capacity"

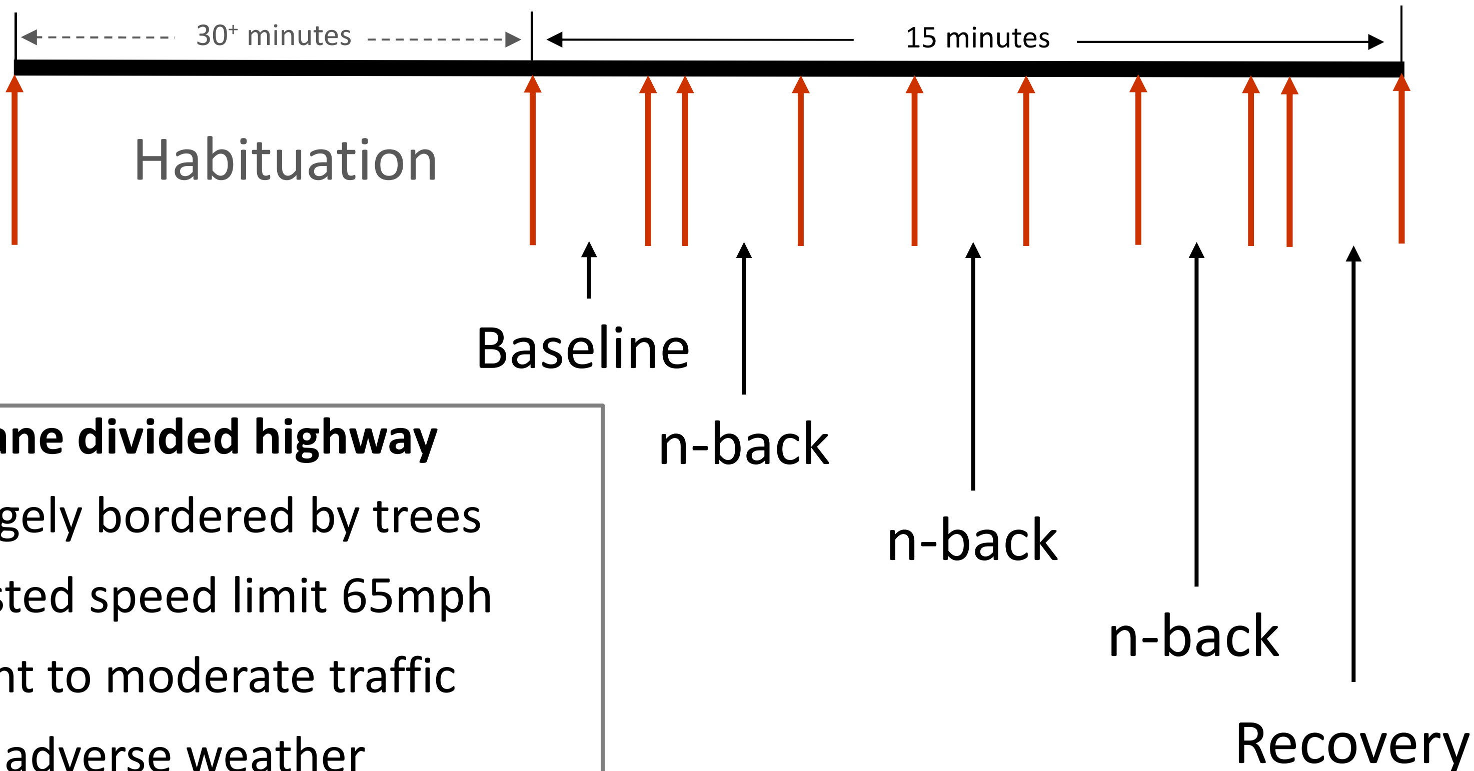
Representative Study: Participants

- Requirements
  - Ages **20-29**, **40-49**, and **60-69**
  - Valid driver's license over 3 years
  - Drive 3 or more times per week
  - No police reported accidents past year
  - Good health
  - Speak & read English

- Community recruitment - online & newspaper advertisements

(Mehler, Reimer & Coughlin, 2012; Reimer, Mehler, Wang & Coughlin, 2012)

Driving Protocol



Multi-lane divided highway

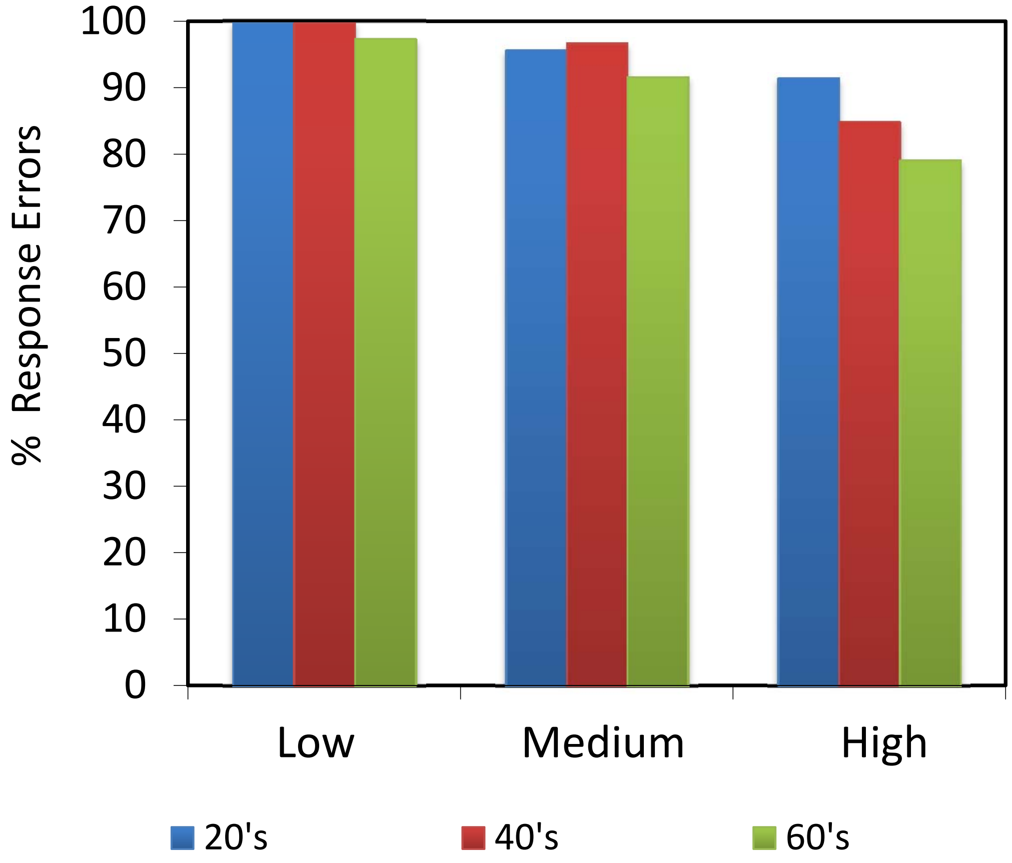
- Largely bordered by trees
- Posted speed limit 65mph
- Light to moderate traffic
- No adverse weather

Data assessed over 2 min periods

Final analysis sample (n=108)

(Mehler, Reimer & Coughlin, 2012; Reimer, Mehler, Wang & Coughlin, 2012)

Secondary Task Performance

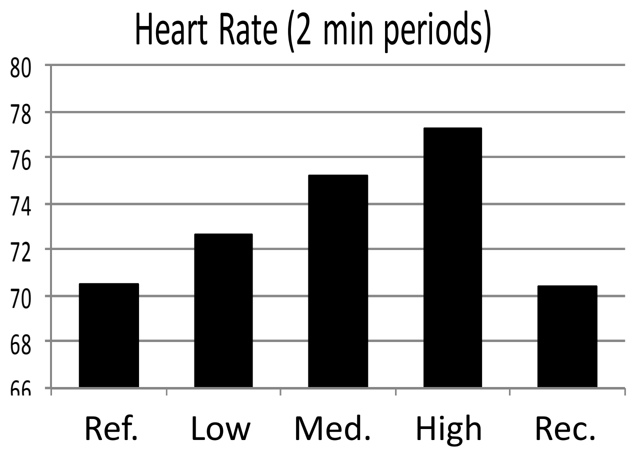


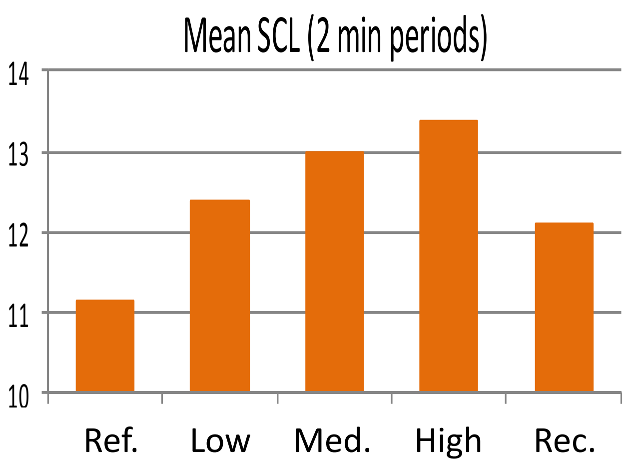
Errors

- Increase with task difficulty
- Increase slightly more in oldest group
- Low overall error rate suggests participants remain fully engaged in the task

(Mehler, Reimer & Coughlin, 2012; Reimer, Mehler, Wang & Coughlin, 2012)

Heart Rate & Skin Conductance Response to 3 Levels of Added Workload

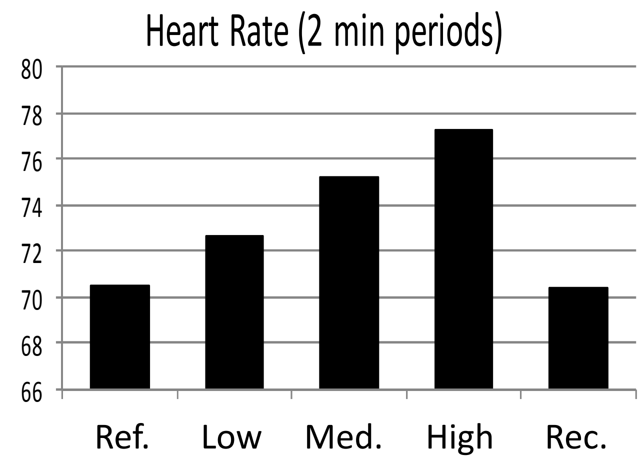


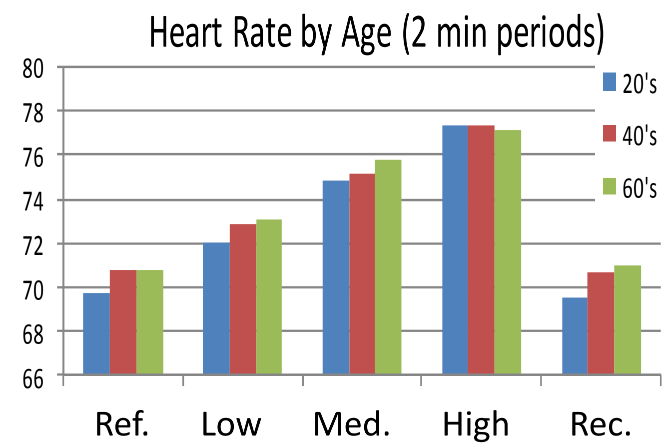


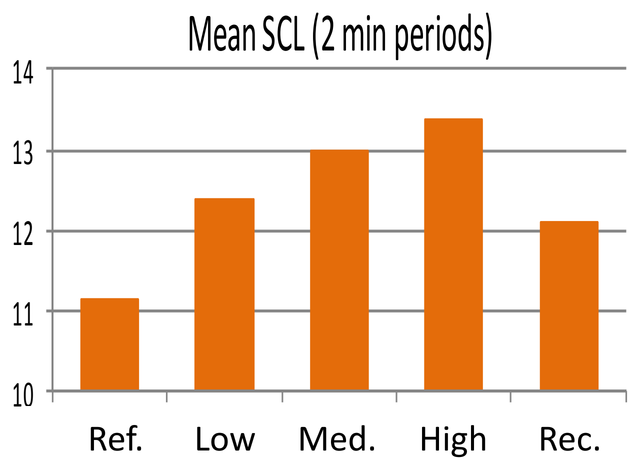
- Both increase with task difficulty ($p < .001$)
- Heart rate (HR) changes essentially linear with demand; rapid recovery
- Skin Conductance (SCL) reactivity at low demand suggests emotional component; slower recovery

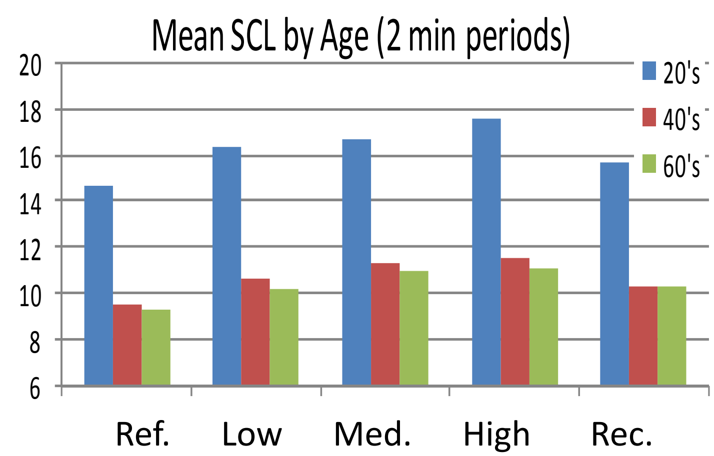
(Mehler, Reimer & Coughlin, 2012)

Physiological Response to Increasing Demand by Age Group



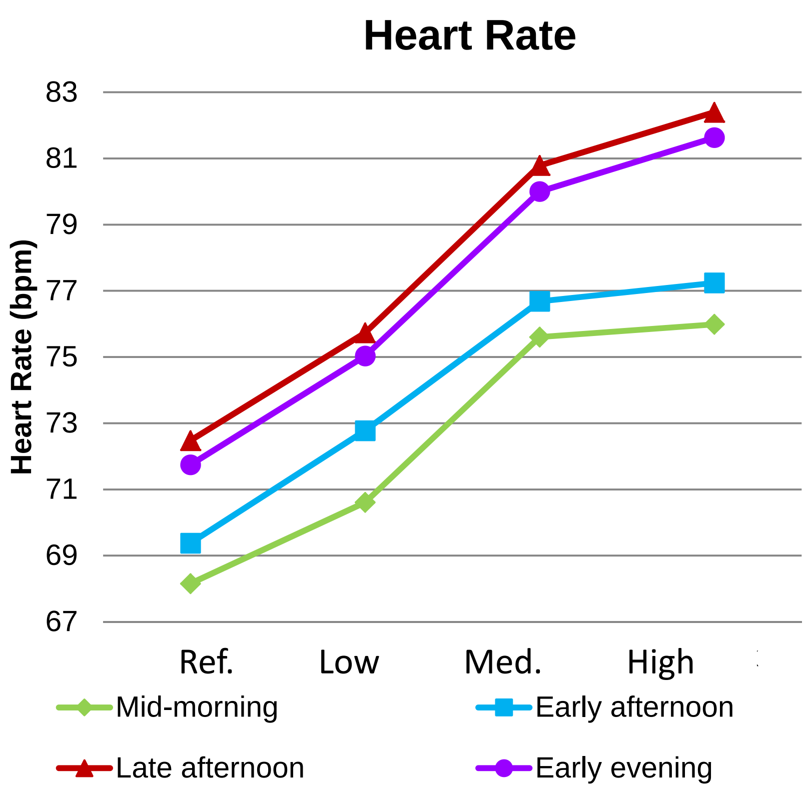


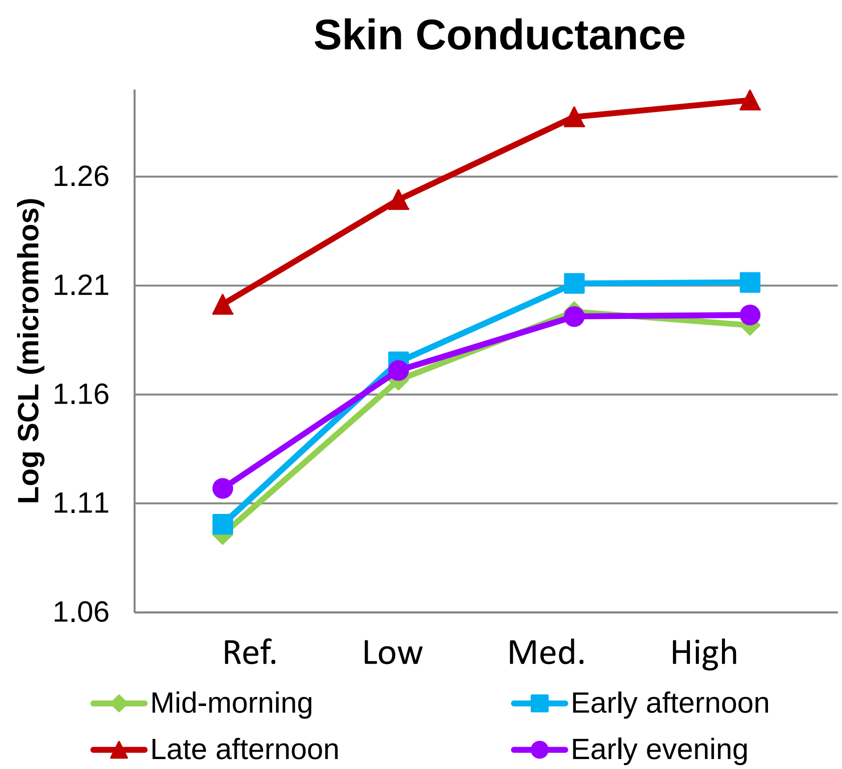




(Mehler, Reimer & Coughlin, 2012)

Physiological Reactivity to Increasing Cognitive Demand by Time of Day

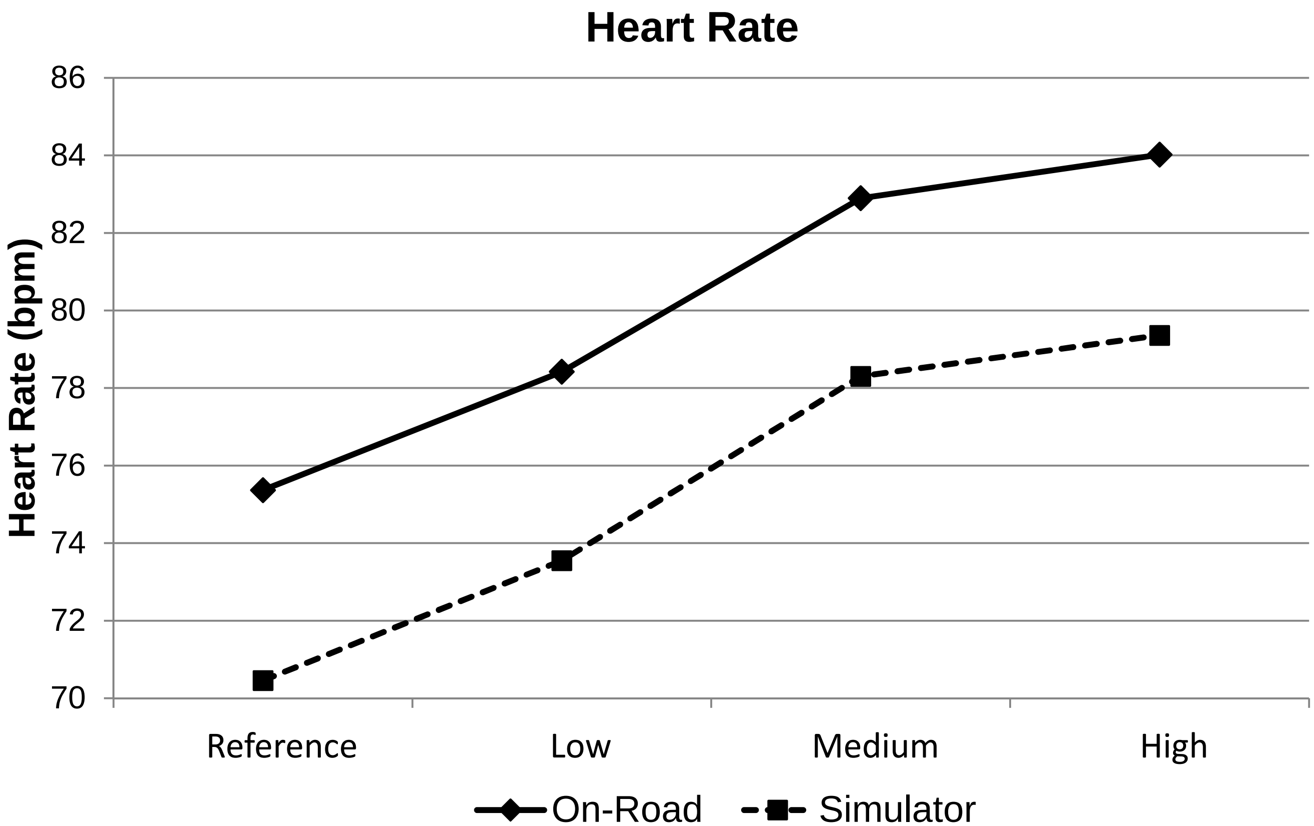




Simulated driving period: 10am, 1pm, 4pm, 7pm.

(Mehler, Reimer, D'Ambrosio, Pina, & Coughlin, 2010)

Validation / Replication of Findings under On-Road Driving Conditions



Same protocol young adults 22-27 years old

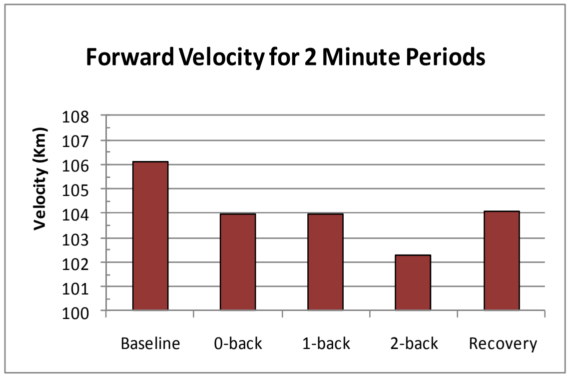
Simulator Sample N= 102

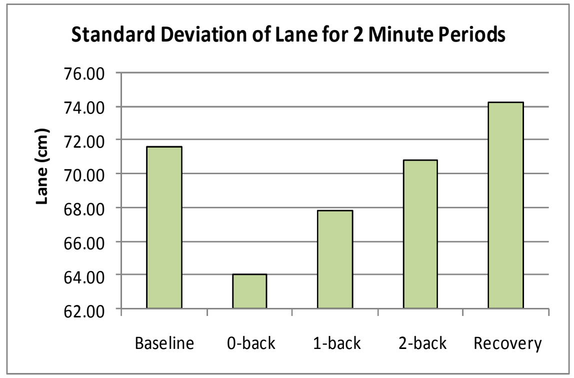
On-road Sample N= 26

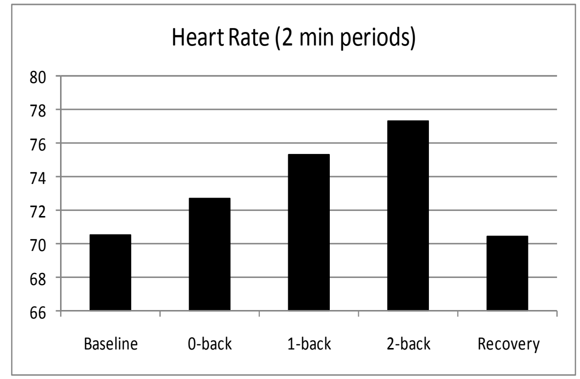
Supports validity of physiological measures obtained in simulation but also ability to use modest sample sizes for some studies

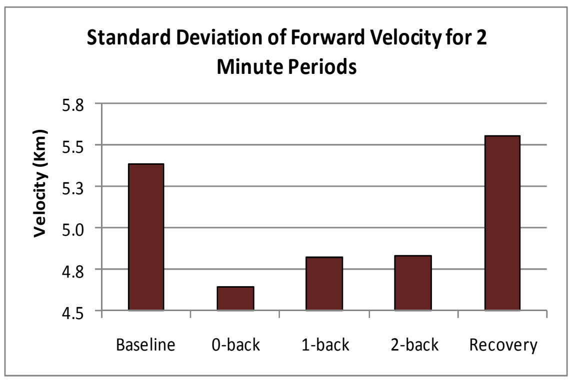
(Reimer and Mehler, 2011)

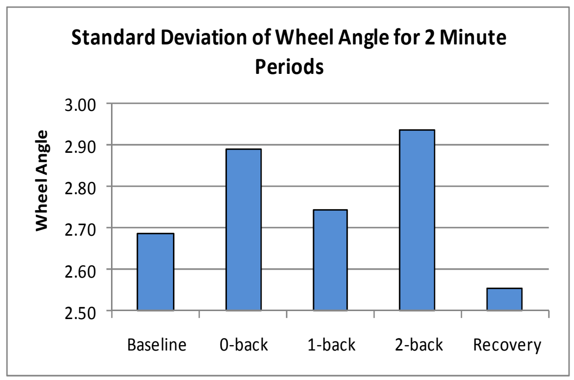
Comparison of Driving Performance vs. Physiological Values with Workload Changes

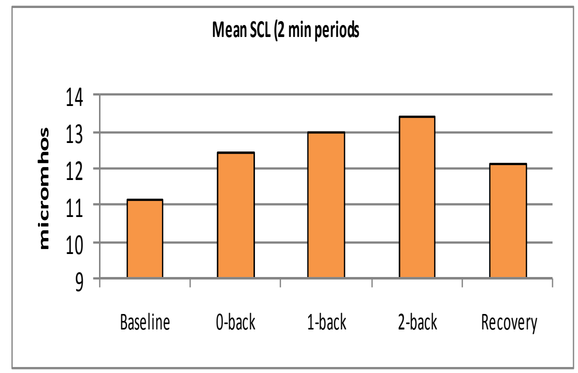






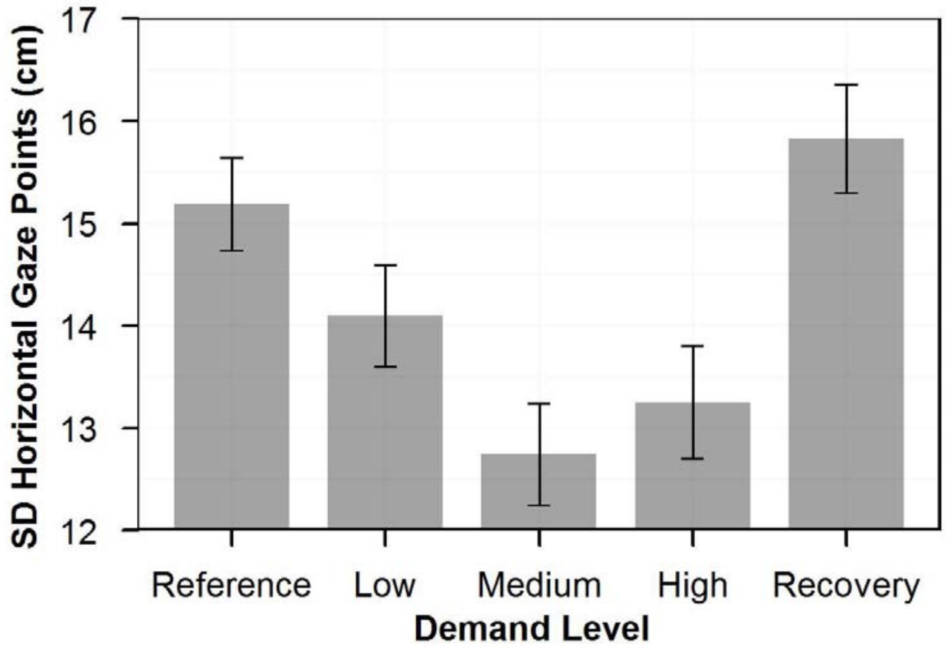






Physiological measures show **stepwise increases** with workload and evidence of recovery that are **not consistently** represented by driving performance variables at these levels of demand.

Horizontal Gaze Changes with Cognitive Workload



With cognitive workload horizontal gaze dispersion:

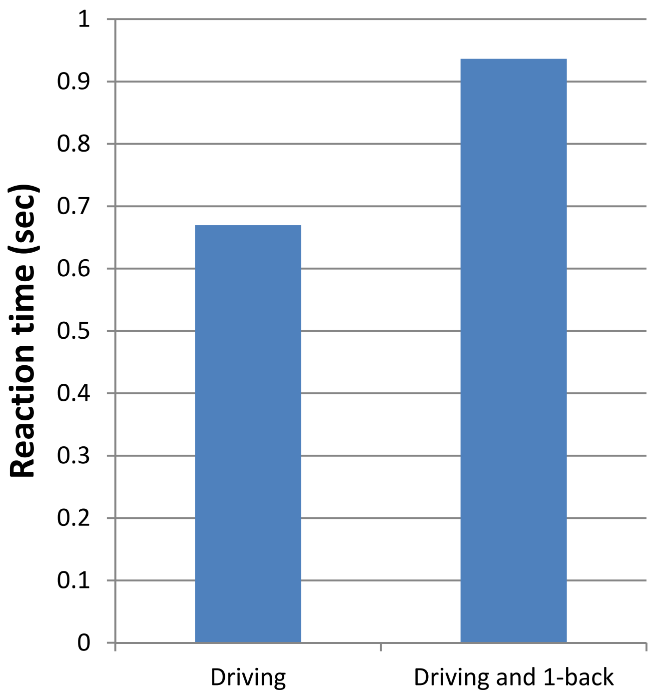
- Becomes more restricted
- Maximum impact on gaze restriction is reached with 1-back (no statistical difference between 1 & 2-back)
- Pattern similar across all age groups

Other changes include less frequent inspection of gauges

(Reimer, Mehler, Wang, & Coughlin, 2012)

Cognitive Demand Impacts Reaction Time

- Strayer, D.L. and Drews, F.A. (2004). Profiles in driver distraction: Effect of cell phone conversation on younger and older drivers. Human Factors, Vol. 46, 4, 640-649
- Engström, J., Aust, M. L., & Viström, M. (2010). Effects of Working Memory Load and Repeated Scenario Exposure on Emergency Braking Performance. Human Factors, 52(5), 551-559.



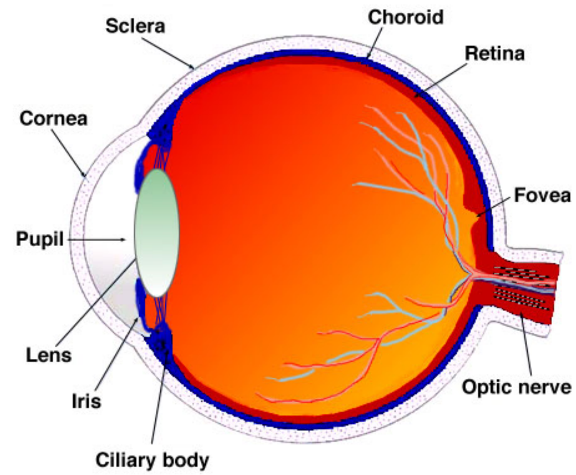
*Data from 53 subjects 60 – 74

Visual Behavior

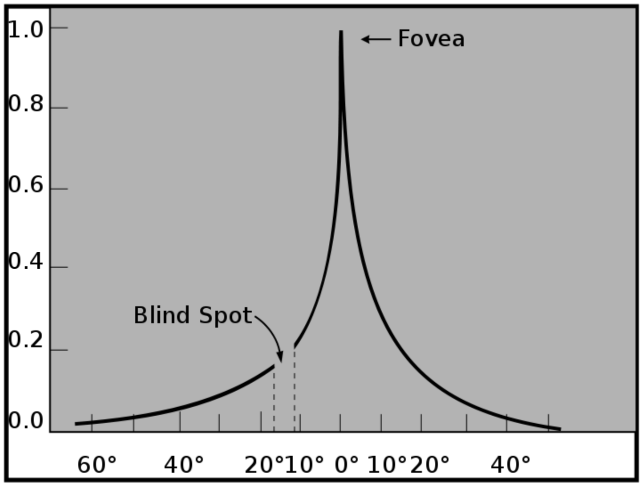
- Perception
- Glance analysis
- Gaze based assessment of cognitive workload
- Pupillometry
- Other visual measures

The Anatomy of the Eye & Perception

Key Points



- The fovea is a section of the retina where color and spatial vision is the highest
  - A region of approximately 2 degrees of visual angle
  - Spatial acuity falls off rapidly toward the periphery visual field
- Eye Movements function to keep the fovea aligned with objects of interest

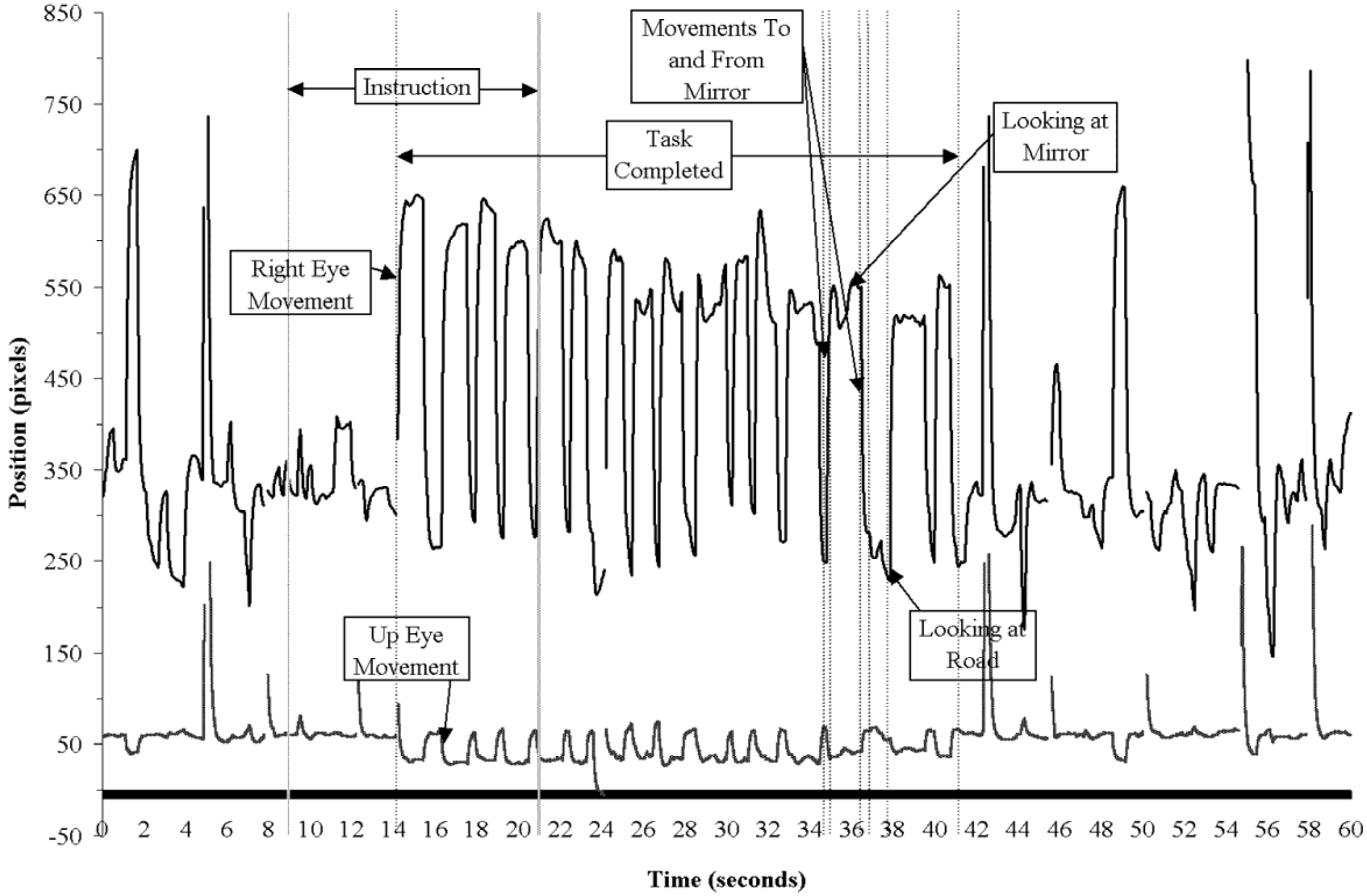


Relative acuity in degrees from the fovea (figure from Hans-Werner Hunziker, 2006)

Eye Tracking

- Crude Gaze or Head Tracking
- Head Mounted Eye Tracking
- Desktop Mounted Eye Tracking
- Video Based Gaze Tracking

An Illustration of a Driver's Scan Path



(figure from Sodhi, Reimer & Llamazares, 2002)

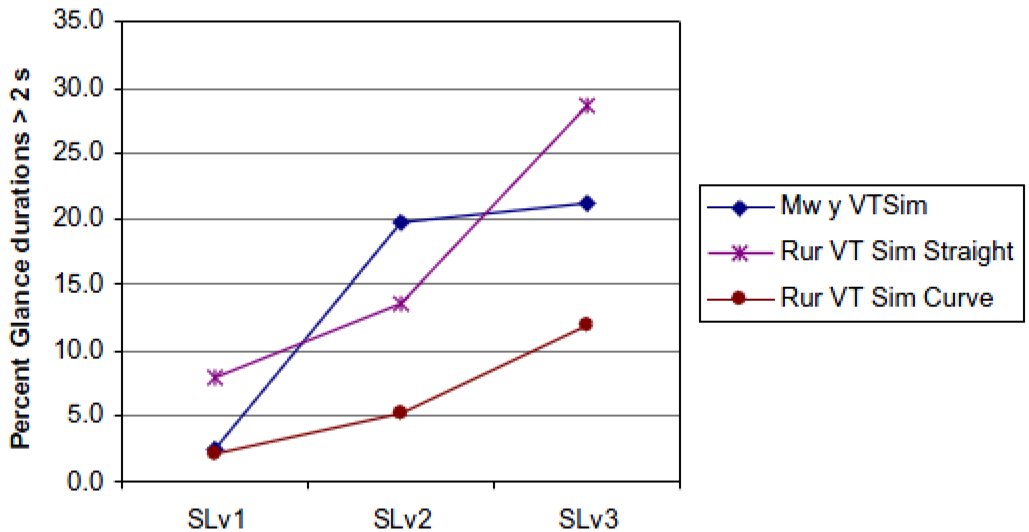
Glances

(typical measures of comparison for overt demands on AOIs)

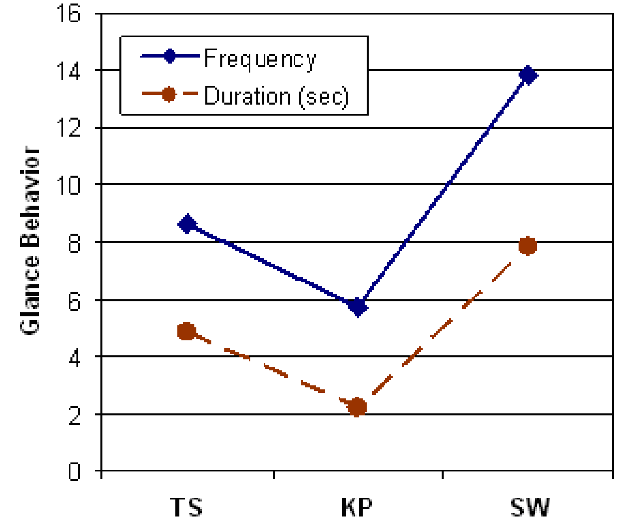
Single glace duration – total of a set of fixations towards an area of interest without an attention shift to another AOI (some researchers include transition time to an object)

- **Number of glances exceeding a threshold** (1.6 or 2 sec) – increase with task demand (considered a major safety bound in distraction assessment)
- **Total glance duration** – sum of singles glances towards an AOI for a given activity (increases with task demand and length)
- **Frequency** – number of visits to an AOI in a given period (provides a measure of chunking and search difficulty that increases with task demand and length)
- **Mean glace time** – Duration / frequency (relative measure of information capture)

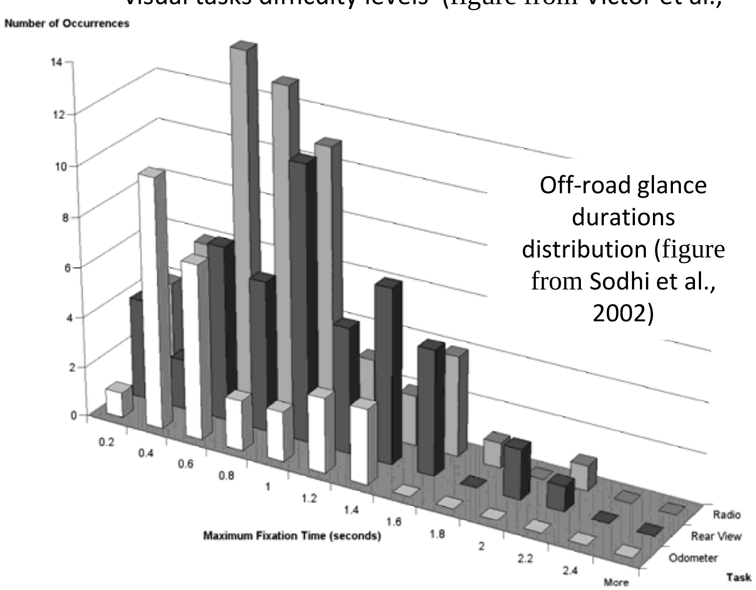
Illustrative Results



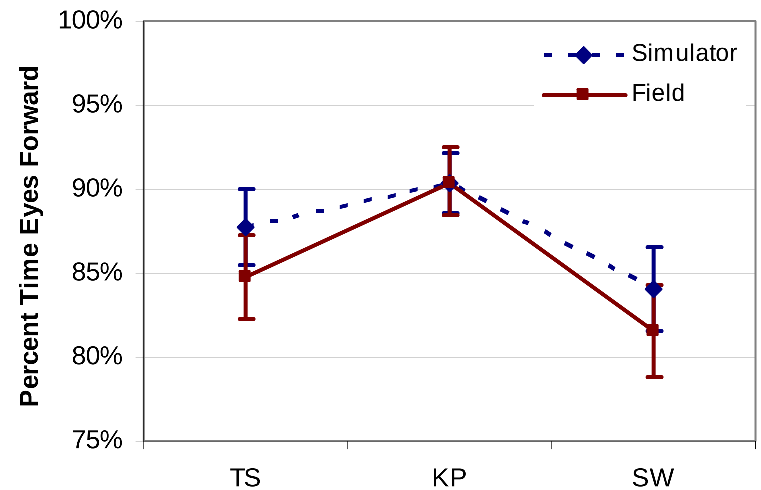
Percent glance duration exceeding 2 s for the three visual tasks difficulty levels (figure from Victor et al.,



Mean number of glances & total glance time for an address entry using three input methods (figure from Reimer et al., 2009)

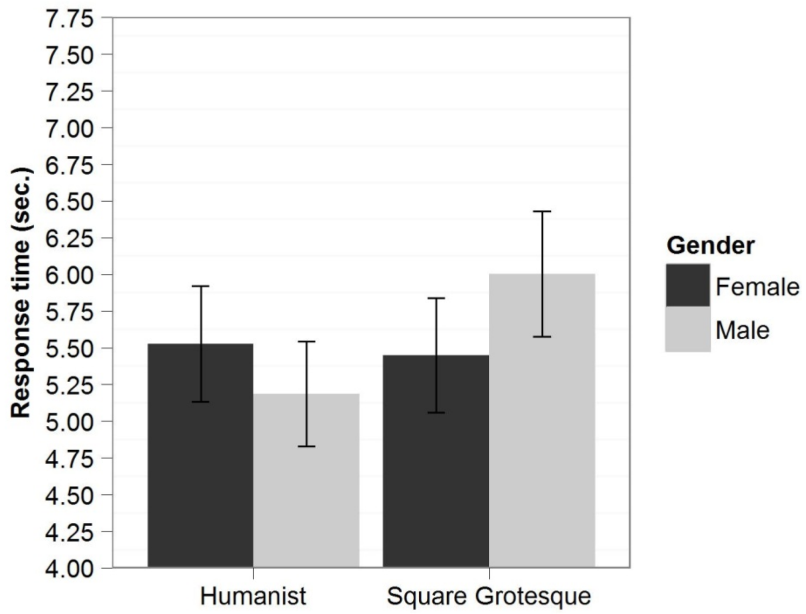


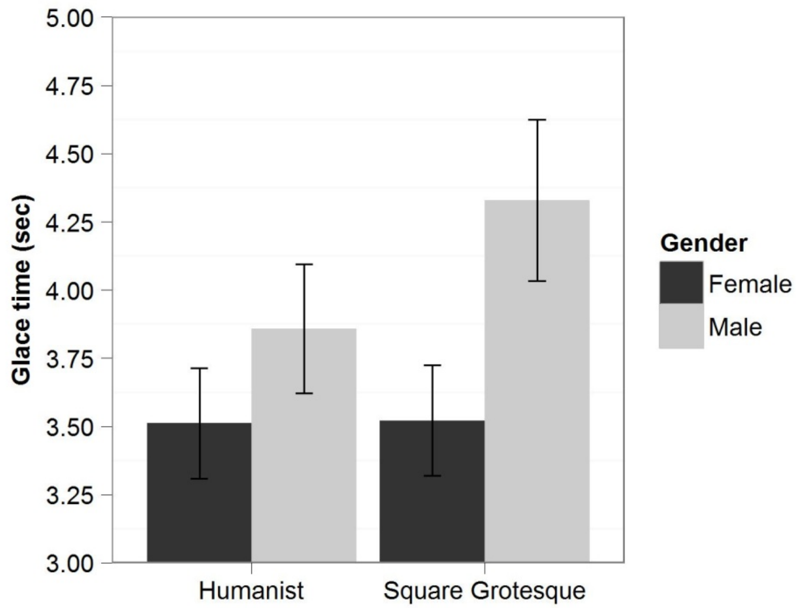
Off-road glance durations distribution (figure from Sodhi et al., 2002)



(figure from Wang et al., 2010)

Task Time vs. Glance time





Burns, P., Harbluk, J., Foley, J., and Angell, L. (2010). The importance of task duration and related measures in assessing the distraction potential of in-vehicle tasks. Proc. Second International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '10)

Guiding Principles

- Numerous ISO and SAE standards, i.e. SAE J2365 The 15-Second Rule
- Alliance Voluntary Driver Focus Guidelines (2001, 2003, 2006)
- Alliance Voluntary Driver Focus Guidelines
  - Phase 1: Integrated visual-manual interfaces (2012)
  - Phase 2: Portable visual-manual interfaces (2013)
  - Phase 3: Voice-based interfaces (2014)
- Future regulation?

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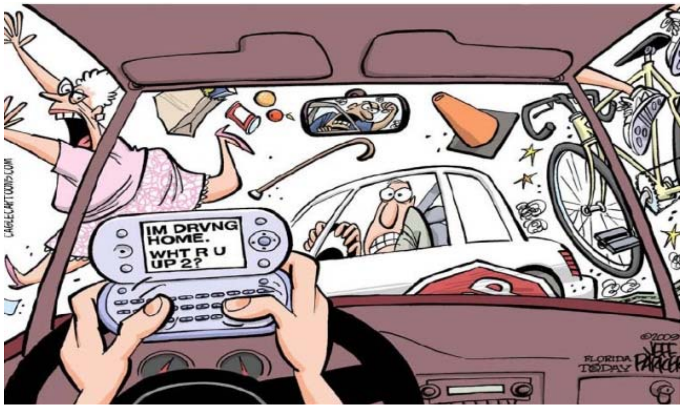
Today's Challenge for Automotive Manufacturers

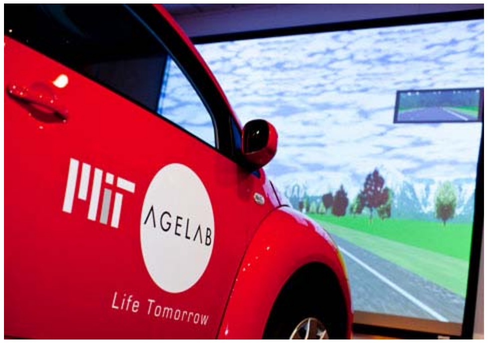
How to develop a vehicle interface that provides drivers with enjoyable and easy access to vehicle systems and applications while minimizing driver distraction?

- Traditional interfaces relied on visual displays and manipulative control
- Voice interfaces now offer the promise of reducing the time that a driver's eyes are drawn away from the roadway



Question remains - how to minimize visual, manipulative and cognitive workload?

Questions?



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