Measuring Cognitive Distraction: From Research to Reality

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Foreword

- Researchers and research users may have slightly different realities
  - Research results become important when they touch the users' reality
- Research involves trading realism for control
  - How much realism will we need to give up to understand cognitive distraction?

Background

- Cognitive distraction occurs when a driver's mind (attention) is diverted from driving
  - Task related
    - Task procedure
    - Task content (contemporary tasks emphasize content)
  - Non-task related (no obvious external stimulus)
    - Mind wandering/ Lost in thought
  - Level of Engagement driven by participant's response to task content
    - "Driveway Moment"

Background: Challenges for Measurement

- Cognitive distraction is personal
  - Personal interests, knowledge, and values contribute to level of engagement
- Cognitive distraction is situational
  - Ongoing or recently-experienced events, emotions, and momentary priorities contribute to level of engagement
- Cognitive distraction is difficult to replicate reliably in a controlled setting
  - Consider books on tape (Experimental vs. Real-world)

What are the Cognitive Aspects of Driving?

- Situation Awareness/Anticipation
  - Projecting what other drivers will do
  - Adjusting and maintaining safety margins (e.g., following distance)
- Maneuver Planning (tactical)
  - Gap acceptance
  - Stop/go decisions
- Route selection (strategic)
  - Assessment of immediate traffic dynamics

Cognitive Distraction Effects on Driving: Implications for Measurement

- Immediate effects
  - Missed events (inattention blindness, “looked but did not see”)
  - Slowed responses
- Gradual effects: As drivers become loaded, their perspective shrinks:
  - Reduced situation awareness
  - They no longer anticipate, adapt, or plan effectively
  - They reallocate a reduced set of resources to a more rudimentary level of vehicle control
  - Passive maintenance replaces active involvement
- Drivers may be led unwittingly into situations with no obvious escape options
  - These situations may have higher likelihood of adverse outcome

Implications for Measurement: Where Do We Look?

- Focus on time immediately preceding a precipitating event may not reveal evidence of cognitive distraction
  - Visual problems are predominant in this time frame
- Looking upstream will likely require more complex metrics
  - Changes may be gradual
  - Evidence may be ambiguous/stimuli may be difficult to identify
- Look at the driving environment – What cues do drivers use to adapt?
- Look to the driver
  - Physiological measures may provide best indicators of driver engagement

VRTC Research on Distraction

- Majority of research made no attempt to differentiate among the components of distraction
- Metrics used in VRTC research studies
  - Vehicle Control
    - Steering entropy
    - Standard deviation of lane position
    - Car-following coherence (phase shift/delay)
    - Headway (mean, std)
  - Target detection performance
    - PDT (DRT) response time and accuracy
  - Subjective workload ratings
    - RSME
  - Glance metrics
    - Proportion of time viewing road center

VRTC Guidelines Support: Test Development

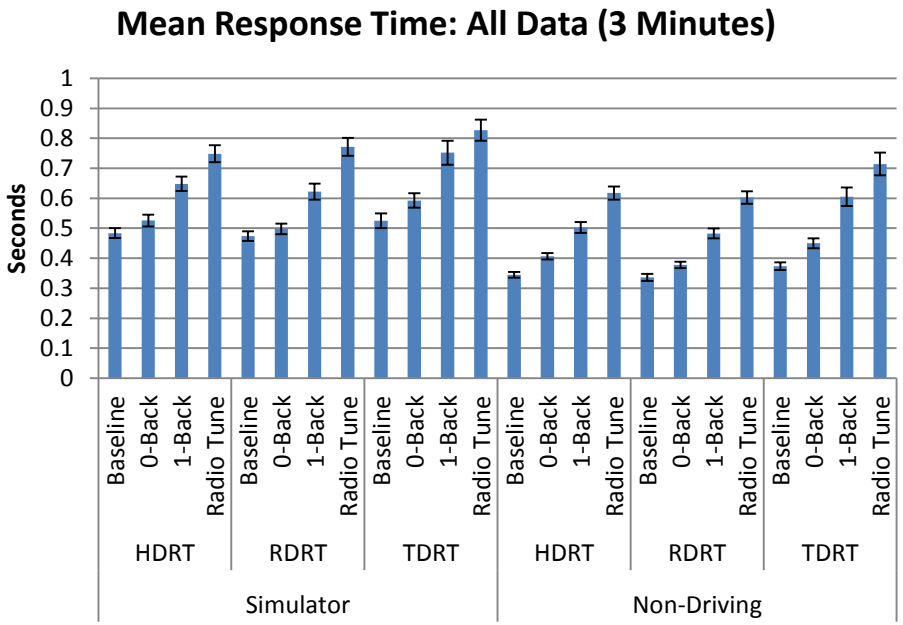
- Test Development in Phases following NHTSA Guidelines
- Distraction Effects separated by task type
  - Visual manual
  - Auditory-Vocal/Hybrid
- Test Specifications
  - Simple to implement (restricted set of metrics)
  - Appropriate for small-sample testing
  - Performance criterion (related to safety)
- Research Objectives (Tasks performed with voice commands)
  - Identify most promising DRTs for simulator and non-driving test venues
  - Provide an empirical basis for setting a benchmark criterion of acceptable attentional/cognitive demand
  - Determine whether a non-driving test is a valid substitute for a driving-based test

Experiment 1: Design

- Repeated Measures Design: All participants/all conditions
  - 48 participants (Two 24-person samples per Phase I Guidelines)
- Six test conditions
  - 2 test venues (driving simulator, non-driving)
  - 3 DRT variants (Head-mounted, Tactile, Remote)
- Four secondary task conditions (tasks performed continuously for 3 minutes)
  - 0-back
  - 1-back
  - Visual-manual radio tuning
  - Baseline
- DRT metrics
  - Response Time (RT)
  - Hit Rate (Detection Accuracy)

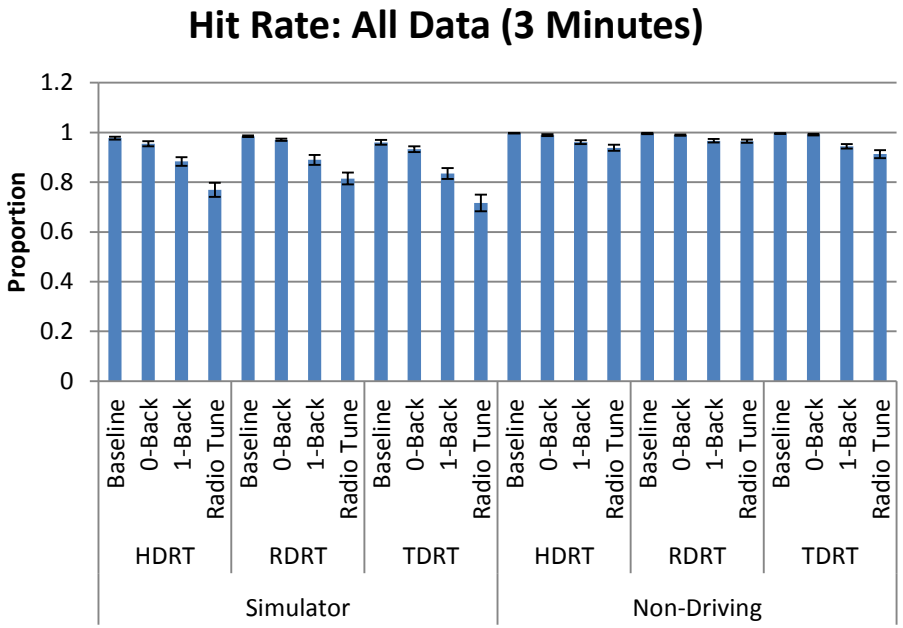
Experiment 1: Results

- All 6 test conditions were successful in detecting all differences
- Non-driving RTs faster than driving simulator RTs
- Order of secondary task conditions consistent
- Differences slightly greater in TDRT condition
- Patterns were identical for shorter data collection intervals
- 6 Test Conditions:
  - Simulator (HDRT, RDRT, TDRT)
  - Non-Driving (HDRT, RDRT, TDRT)



Experiment 1: Results

- Ordering of Secondary task conditions generally consistent across 6 test conditions
- Differences between conditions much smaller in non-driving test conditions
- Non-driving hit rates reveal ceiling effects, reduced sensitivity, indicate lack of validity
- Patterns were identical for shorter data collection intervals
- 6 Test Conditions:
  - Simulator (HDRT, RDRT, TDRT)
  - Non-Driving (HDRT, RDRT, TDRT)



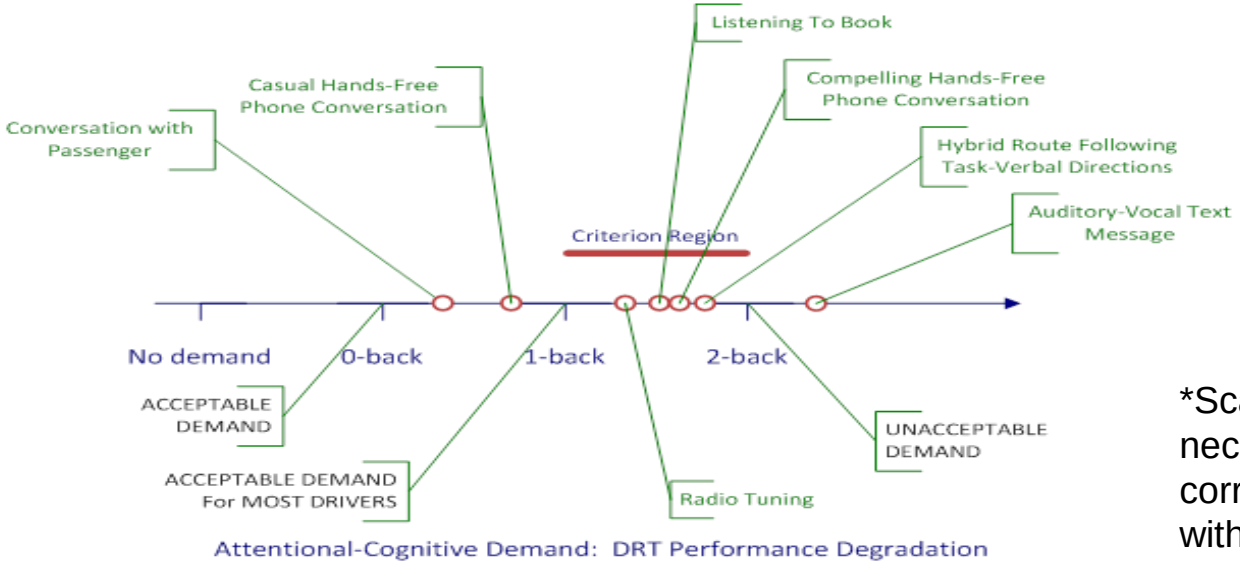
Experiment 1: Conclusions

- In simulator, differences among DRT variants were small
  - TDRT was more sensitive than other DRT variants for RT metric
- In non-driving venue, differences among DRT variants were smaller;
  - All DRT variants provided comparable sensitivity for RT metric
- Comparable differences in both venues indicate that non-driving venue offers relative validity for detecting differences using RT metric
- Hit rates are not valid in non-driving venue
  - Consistently high hit rates mean that hit rate may not be needed in non-driving venue to establish minimum accuracy; Can RT stand alone as primary metric?

Experiment 2: Objectives (selected)

- Identify benchmark criterion level of acceptable cognitive load
- Tie benchmark to external reference (e.g., 1-back) to ensure consistent implementation
- Demonstrate benchmark is effective in classifying tasks performed with audio-vocal or hybrid interfaces

Research Goal: Develop a common scale to support selection of benchmark*



*Scale does not necessarily correlate directly with crash risk

Methodological Challenges

- Standardizing Driving Task Demands (Simulator Testing)
  - Drivers adopt shorter glance durations and tasks require shorter TEORT under driving conditions with high demand
  - How is cognitive distraction influenced by driving task demands?
- Standardize Secondary Task Pacing
  - When drivers perform secondary tasks at their own pace, they can influence the load associated with the task
  - N-back: external pacing provides a consistent level of task demand

Bigger Challenges

- Laboratory control may be more efficient for isolating factors that contribute to cognitive distraction, but
  - Can laboratory methods be developed to accurately recreate the range of engagement experienced in real-world situations?
  - Can observational studies identify episodes and characterize different levels of engagement?
- Can we reconcile disparate results from lab and naturalistic studies?
  - Reconsider the bias toward considering crash data as the only valid reality
  - Create an atmosphere of inquiry that eliminates the sense of competition among different methodologies
  - Develop research program model that maximizes the strengths of different methodologies and emphasizes the opportunities for synergy

- Thanks for your attention!

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