TRB 91st Annual Meeting

Measuring Cognitive Distraction on the Road and in the Lab with the Wayne State Detection Response Task

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Goals

1. Evaluate the Wayne State Enhanced Detection Response Task ("EDRT") as a measure of "cognitive distraction."

2. Compare lab to road results for other versions of the DRT.

Lab Methods:
EDRT Dual Task (Baseline) Condition

• Primary Task
  – Attend to a high-definition video of a real driving scene; steer to keep marker in center of lane.

• EDRT Task
  – Only one Light Event (green or red) appears at a time; Inter-Stimulus Interval of 3 to 5 seconds.*
  – Light Event stays on for 1 second.*

• Instructions to Subjects:
  – First priority: Watch driving video and steer to stay in lane.
  – Second priority: Respond to all red lights with finger presses; do not respond to green lights.

* Per draft ISO DRT standard.
Lab Methods: EDRT Visual Stimuli

Steer to stay in lane.

- Red Left: Small red lights to left or center; respond
- Green Left: Small green lights; do not respond
- Red Center: Small red lights to center
- Green Center: Small green lights; do not respond
Lab Methods: EDRT Manual Response

- Finger press for red light*; do not respond (inhibit) to green light.
- RT recorded from stimulus onset until response with finger press.*
- “Miss” defined as RT outside range of 100 < RT < 2500 msec.*

*Per draft ISO DRT standard.

Finger response paddle

Not Pressed

Pressed
Triple Task Condition

• Dual Task plus N-Back or SuRT third task
  – N-Back and SuRT same priority as responding to lights.*
  – But secondary priority to driving or simulated driving.*

• Triple Task Instructions (lab and road):
  “Your main priority is to drive safely. Please remember to maintain your position in the center of the lane. The light and the [n-Back/SuRT] tasks will both be active during the run. Please do your best to pay attention to both tasks.”*

*Per draft ISO DRT standard.
Triple Task Condition: N-Back

- Dual Task plus N-Back Task.
- While responding to lights while driving, subjects were also presented a series of spoken numbers for two minutes.
- For 0-Back, subjects spoke the last number heard.
  
  **SPEAKER:** 6 3 7 8 …
  **CORRECT RESPONSE:** 6 3 7 8 …

- For 1-Back, subjects spoke number heard before last.
  
  **SPEAKER:** 6 3 7 8 …
  **CORRECT RESPONSE:** 6 3 7 8 …
Triple Task Condition: SuRT

- Dual Task plus SuRT (“Surrogate Reference Task”).
- While responding to lights while driving, subjects scan a visual display of circles, one of which was larger than the others, and then use three keys on a keypad to indicate which region of the screen held the larger circle.
- Subjects instructed to complete the task as quickly and accurately as possible, and worked at their own pace, repeatedly doing the SuRT for a two-minute period.

Easy SuRT task:
- The target circle is much bigger than the distracting circles.
- There are only two regions to choose from.

Hard SuRT task
- The target circle is only slightly bigger than the distracting circles.
- There are six regions to choose from.
Lab Triple Task: Primary Driving + Lights + SuRT
Lab: Statistical Methods

• 12 healthy subjects 25-45 years old; minimal annual driving 6,200 miles.
• 2 min for every condition; each condition run twice.
• Means and SEs plotted for: five task conditions (Baseline, 0-Back, 1-Back, Easy SuRT and Hard SuRT) x four light conditions (Red Left, Red Center, Green Left, Green Center).
• All subjects run in all conditions so paired t-tests are used, reducing variability and improving power:
  – Difference of 1-Back from 0-Back DRT responses.
  – The significance levels of difference scores were based on 1-tailed probabilities, because the direction of the effect was predicted in advance.
• (Not shown today: subjective workload, error rates, and task times for secondary n-Back and SuRT tasks; eye glance data)
Lab: EDRT (n=12)

EDRT Response Time

- Longer RTs during 1-Back vs. 0-Back
- RTs about = during Easy vs. Hard SuRT

EDRT Miss Rate

- More red light events missed during 1-Back vs. 0-Back
- More red light events missed in Hard vs. Easy SuRT

Key:

- *p < .05
- **p < .01

1/24/12
Lab: EDRT Inhibition Failure Rate (n=12)

More responses to Green Light Event ("failures to inhibit") during Hard SuRT vs. Easy

Key:
*p < .05
Lab – Other DRTs (n=12)

DRT Response Time

- R,H,T: Longer RTs during 1-Back vs. 0-Back
- R,H: RTs = during Easy vs. Hard SuRT
- Tactile: Shorter RTs during Hard vs. Easy SuRT

DRT Miss Rate

- More events missed during 1-Back than 0-Back
- Remote: More red light events missed during Hard vs. Easy SuRT

Key:
* $p < .05$
** $p < .01$
Road RT (n=5)*

DRT Reaction Time

*Data from Dynamic Research, Inc.
Road Miss Rate (n=5)*

Remote & Head-Mount:
More red light events missed during Hard vs. Easy SuRT

Tactile:
Tendency for fewer misses during Hard vs. Easy SuRT

*Data from Dynamic Research, Inc.
Predicting Road\textsuperscript{1} from Lab Results

The correlation from lab to road across RTs for all corresponding tasks was high at $r = 0.89$, $p = 6.51 \times 10^{-16}$, $n=15$ tasks (3 DRT conditions x 5 Delta RT conditions for each).

\textsuperscript{1}Road data from Dynamic Research, Inc.

The correlation from lab to road across miss rates for all corresponding tasks was high at $r = 0.89$, $p = 9.54 \times 10^{-16}$, $n = 15$ tasks.

- Validation results consistent with Young et al. (2009) on-road validation study of Extended Static Load Test, similar to ISO-compliant EDRT.
Results Summary: N-Back

1-Back vs. 0-Back

<table>
<thead>
<tr>
<th>DRT</th>
<th>Visual Location</th>
<th>Venue</th>
<th>RT Rate</th>
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<tbody>
<tr>
<td>Extended</td>
<td>Left</td>
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<td>Center</td>
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<td>Tactile/Auditory</td>
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<td>None</td>
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*Wayne State Lab DRT performance data validated by Dynamic Research Inc. On-Road test.
### Results Summary: SuRT

- Different DRT types and RT and Miss Rate gave contradictory predictions for cognitive load during Hard vs. Easy SuRT.

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*Wayne State Lab DRT performance data validated by Dynamic Research Inc. On-Road test.
Discussion: Main Findings

• All DRT types correctly predicted increased cognitive load during 1-Back vs. 0-Back for Lab and Road.
  – In the lab, the Wayne State Extended DRT also showed an increased “failure to inhibit” to the green light event during 1-Back vs. 0-Back.

• There were contradictory predictions about cognitive load during Hard vs. Easy SuRT.
  – Different DRT types gave opposite predictions; RT and Miss Rate metrics gave different predictions.
  – There appear to be complex interaction effects between sensory modalities for DRT types and tasks.

• The Wayne State lab results for Remote, Head-Mount, and Tactile DRT were validated by on-road tests by Dynamic Research, Inc.
  – Consistent with previous Remote PDT validation results (Angell et al., 2002, 2006; Young et al., 2009)
Conclusions and Recommendations

• These preliminary DRT results for the N-Back task are promising, continuing an active line of research into the PDT and its variants that is now over 15 years old.

• However, the different DRT types and RT vs. Miss Rate metrics give contradictory estimates of the relative amount of “cognitive distraction” during Hard vs. Easy SuRT, for both lab and road.

• Therefore, the DRT is not recommended as an ISO standard for measuring “cognitive distraction” or “workload” while driving.

• Instead, the DRT is recommended at a minimum as an ISO standard for measuring “selective attention” while driving.

• The DRT is recommended for consideration as a general measurement of “event detection and response” while driving, a more general category than either “cognitive distraction” or “selective attention” (Young, accepted, 2012).
Acknowledgements

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References


