THE TACTILE DETECTION RESPONSE TASK: PRELIMINARY VALIDATION FOR MEASURING THE ATTENTIONAL EFFECTS OF COGNITIVE LOAD

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INTRODUCTION

• On April 26, 2013 NHTSA issued final driver distraction guidelines for visual-manual tasks for in-vehicle electronic devices.
• The guidelines do not include any tests to measure cognitive distraction.
• ISO TC22/SC13 WG8 has been developing a standard on the Detection Response Task which uses response time to measure the impact of cognitive load from visual-manual and auditory-vocal tasks on attentional processes.
RESPONSE TIME, ATTENTIONAL PROCESSES, AND DRIVING


Since 1999, the members of the Wayne State University cognitive neuroscience team have been working with the peripheral detection task or PDT (now called the Detection Response Task or DRT).

We are now part of the U.S. delegation to the ISO DRT committee that is working on a draft DRT standard.

The results we present today are from the two U.S. sites that are part of the international effort to collect data to demonstrate the usefulness of the DRT to measure the attentional effects of cognitive load.

Although we recently collected data on 4 versions of the DRT (Tactile, Head-Mounted, Remote, and Extended), we report here today only on the Tactile Detection Response Task (TDRT).
GOAL 1: BE SENSITIVE

1. The test must be sensitive to the attentional effects of cognitive load.

- *Cognitive distraction* is the attentional effect of cognitive load induced by a secondary task performed while driving.
- *Sensitivity* is the probability that a cognitively-distracting task (i.e., one that does not meet criterion) in the population tested will be identified as cognitively-distracting by the test.*

*Does not meet criterion*
2. The test must be *specific* to the attentional effects of cognitive load.

- **Specificity** is the probability that a task with minimal cognitive distraction (i.e., one that meets a criterion) in the population tested will be correctly identified as meeting the criterion by the test.

- In this study, we evaluated whether the TDRT was sensitive and specific to the attentional effects of cognitive load.

*from Porta 2012, p. 227*
**METHOD: ISO TDRT TRIPLE TASK SURROGATE SET-UP**

1. **Driving video**
2A. **Auditory-vocal task speakers**
3. **TDRT finger switch**

1. **Steering**
2B. **Visual-manual task screen**
3. **TDRT tactor**

*from TNO, Netherlands*
METHOD: ISO TDRT TRIPLE TASK ROAD SET-UP

1. Real Driving Scene
   - 2B. V-M screen
   - 2B. V-M buttons
   - 2A. Auditory-vocal task speakers
   - 3. TDRT tactor*

1. Steering
   - 1. Real Driving Scene

1. Braking
   - 3. TDRT finger switch*

3. TDRT tactor*

*from TNO, Netherlands

- Courtesy Dynamic Research, Inc.
Task: Listen to numbers and respond verbally*

- **1-Back** loads verbal memory slightly more than **0-Back**.
- Loading of verbal memory has a known interference effect on executive attention.
- If TDRT is sensitive to effects on attention from cognitive load, then
- The TDRT should show *increased* RT going from **0-Back** to **1-Back** (*sensitivity test*).

*2 min in lab, 1.5 min in road.*
RESULTS: N-BACK

• The TDRT RT correctly indicates that the 1-Back task creates more interference with attention (> RT) than the 0-Back task, for both lab and road.

• This validates the sensitivity of the TDRT to the attentional effects of cognitive load.

<table>
<thead>
<tr>
<th></th>
<th>Lab</th>
<th>Road</th>
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</thead>
<tbody>
<tr>
<td>0-Back</td>
<td>347.1</td>
<td>437.9</td>
</tr>
<tr>
<td>1-Back</td>
<td>436.8</td>
<td>572.9</td>
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</tbody>
</table>

*p=0.001

*p=0.0007

*Road data from Dynamic Research, Inc.

**Miss rate at bottom of each bar.
METHOD FOR VISUAL-MANUAL SPECIFICITY TEST: SURROGATE REFERENCE TASK (SuRT)

Task: Watch display screen and respond with arrow & enter keys for 2 min in lab, 1.5 min on road.

- **HARD** has no difference in cognitive load vs. EASY.
- **HARD** has increased visual difficulty vs. EASY.
- If the TDRT is not sensitive to visual difficulty, then
- The TDRT should show no change in RT going from EASY to **HARD** SuRT (*specificity* test).
**RESULTS: SuRT**

- The TDRT RT correctly indicates that the **HARD** visual-manual task creates no interference with attention vs. **EASY**, for both lab and road.
- This validates the **specificity** of the TDRT RT to the attentional effects of cognitive load, because it is not sensitive to visual load differences.

<table>
<thead>
<tr>
<th></th>
<th>Lab</th>
<th>Road</th>
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<tbody>
<tr>
<td>EASY</td>
<td>409</td>
<td>664</td>
</tr>
<tr>
<td>HARD</td>
<td>406</td>
<td>637</td>
</tr>
</tbody>
</table>

*Road data from Dynamic Research, Inc.*

** Miss rate at bottom of each bar.
The TDRT is validated as sensitive and specific:

- **1-Back > 0-Back** in RT but not TEORT (TDRT sensitivity)
- **Hard > Easy** SuRT in TEORT but not RT (TDRT specificity)
- **TEORT and TDRT RT are independent**
The foregoing results help validate the sensitivity and specificity of the TDRT to the attentional effects of a purely cognitive load increase within the limited set of tasks examined in this study.

**Sensitivity** was shown by the TDRT RT increase from the attentional effects of a purely cognitive load increase from 0-Back to 1-Back.

- Auditory, vocal, visual, and manual loads were held constant.

**Specificity** was shown by a lack of sensitivity to a visual load increase from an EASY to HARD visual-manual task.

- Auditory and vocal loads were held constant (but manual load was higher for the EASY vs. HARD task).

How can these results be explained?

- The paper presents 8 different explanations.
- We believe the best one is the Driver Distraction Dimensional Model (Young and Angell, 2003; Young, 2012a).
Driver Distraction Dimensional Model

- Multivariate analysis of driver performance metrics from nearly 100 on-road visual-manual tasks (Young & Angell, 2003; Young, 2012a) found two major dimensions of driver distraction.
  - The physical load metrics (eyes-off-road time, number of task steps, lane deviations, task time, subjective driver workload, etc.) cluster along Dimension 1.
  - The cognitive load metrics (response time, %misses, long single glances) cluster along an orthogonal Dimension 2.
- We single out two variables to illustrate the model predictions for the ISO TDRT tests we did: EORT for Dimension 1, and RT for Dimension 2.
• Predict TDRT RT is *sensitive* to the attentional effects of cognitive load (Dimension 2).
• If so, 1-Back > 0-Back in RT (Dimension 2).

• Predict TDRT RT is *specific* to the attentional effects of cognitive load (Dimension 2).
• If so, TDRT RT should not be sensitive to the attentional effects of visual load (Dimension 1).
• HARD should have more EORT than EASY SuRT on Dimension 1.

• But no difference in RT on Dimension 2.
As predicted, 1-Back has a longer RT than 0-Back, showing TDRT is sensitive to a pure cognitive load increase.

- There is no effect of N-Back on TEORT.
- As predicted, TEORT is somewhat higher for HARD vs. EASY SuRT.
  - There is no effect of SuRT on TDRT RT.

So Dimension 2 is not sensitive to the attentional effects of the visual load increase going from EASY to HARD SuRT (showing Dimension 2 is specific to the attentional effects of cognitive load).

The Driver Distraction Dimensional Model (developed originally with visual-manual tasks) has therefore now been successfully extended to auditory-vocal tasks.
LIMITATIONS

• A wider variety of visual-manual tasks must be tested with the TDRT to ensure that the TDRT is indeed:
  • Sensitive to the differing amounts of cognitive load in a wide variety of visual-manual tasks as well as in a wide variety of auditory-vocal tasks;
  • Specific to cognitive load, because it is not sensitive to visual load in a wide variety of visual-manual tasks.

• The EASY SuRT task has more manual key presses in its total task time than the HARD SuRT task.
  • This increased manual load in the EASY SuRT task could balance out the increased visual load in the HARD SuRT task, creating only a small difference in total visual-manual load for the EASY vs. HARD SuRT.
  • Hence, the SuRT task by itself isn’t sufficient to prove that the TDRT is insensitive to visual-manual load.
  • However, the remote and head-mounted DRT tests do show sensitivity to an increased visual load, but the TDRT does not.
CONCLUSION

• Under the conditions and the limited set of tasks used in this experiment, the behavioral RT and eyes-off-road time results for TDRT provide a preliminary validation for both road and laboratory that:

1. The TDRT is both sensitive and specific to the attentional effects caused by differences in cognitive load

2. The Driver Distraction Dimensional Model* successfully explains these results after extending it to include auditory-vocal tasks.

*Young and Angell (2003); Young (2012a)
ACKNOWLEDGMENTS

• We thank Toyota CSRC for supporting this work

• And THANK YOU for not being too distracted!
REFERENCES


