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

Richard A. Young, Li Hsieh, Sean Seaman

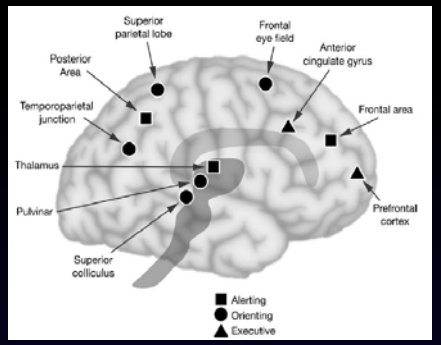
Wayne State University School of Medicine

Detroit, Michigan, USA

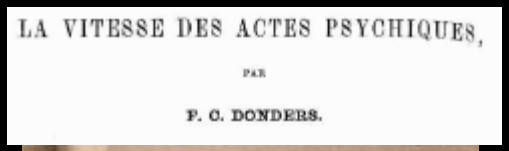
Wayne State University
School of Medicine

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.



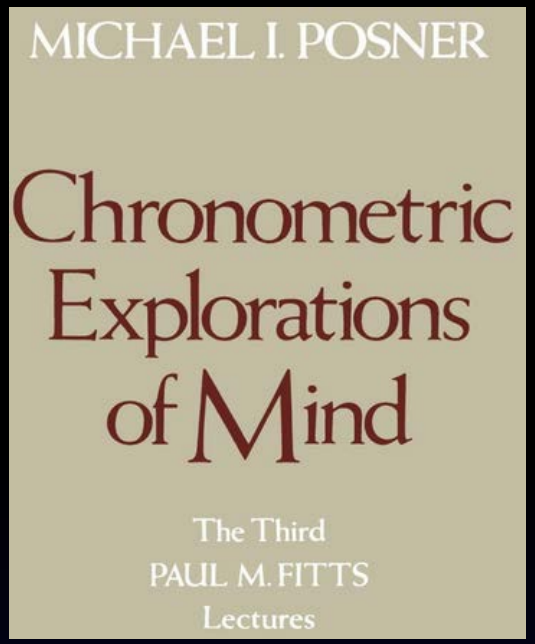
Response Time, Attentional Processes, and Driving


LA VITESSE DES ACTES PSYCHIQUES,

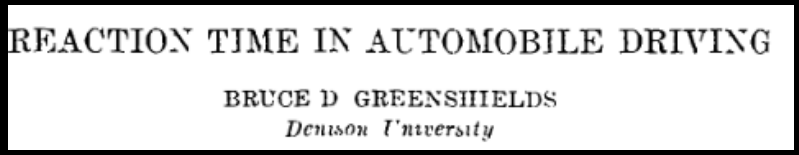
PAR

F. C. DONDERS.

Donders, Franciscus C. 1868. La vitesse des actes psychiques. Archives néerlandaises des sciences exactes et naturelles 3: 296-317



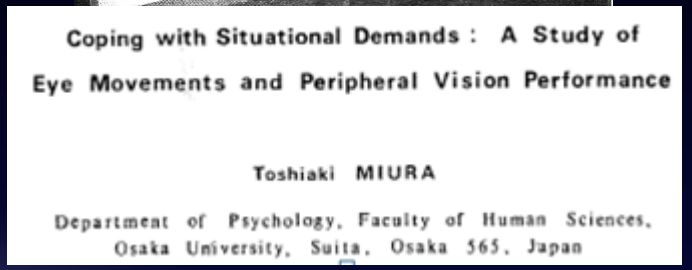
Posner, Michael I. (1976). *Chronometric Explorations of Mind*. Hillsdale, N.J: Lawrence Erlbaum Associates


REACTION TIME IN AUTOMOBILE DRIVING

BRUCE D GREENSHIELDS

Denison University

Greenshields, B. D. (1936). Reaction time in automobile driving. Journal of applied psychology (0021-9010), 20 (3), p. 353


Coping with Situational Demands : A Study of Eye Movements and Peripheral Vision Performance

Toshiaki MIURA

Department of Psychology, Faculty of Human Sciences, Osaka University, Suita, Osaka 565, Japan

Miura, T. (1986). Coping with situational demands: A study of eye movements and peripheral vision. In M. Gale, Freeman, CM Haslegrave, P. Smith & S. Taylor (Eds.), *Vision in Vehicles II*. Amsterdam: Elsevier North Holland.

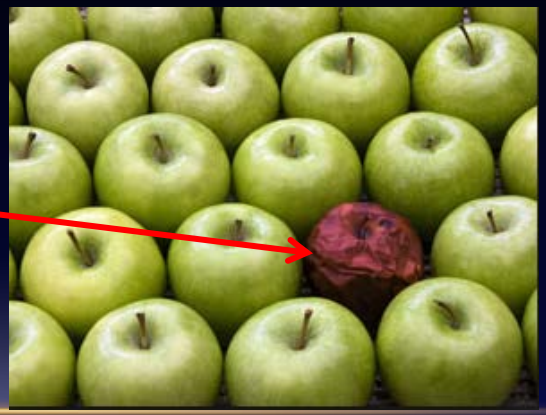
Detection Response Task (DRT)

- 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



*from Porta 2012, p. 227

Goal 2: Be Specific

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.

Meets criterion

- 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

*from TNO, Netherlands

METHOD: ISO TDRT TRIPLE TASK ROAD SET-UP

1. Real Driving Scene

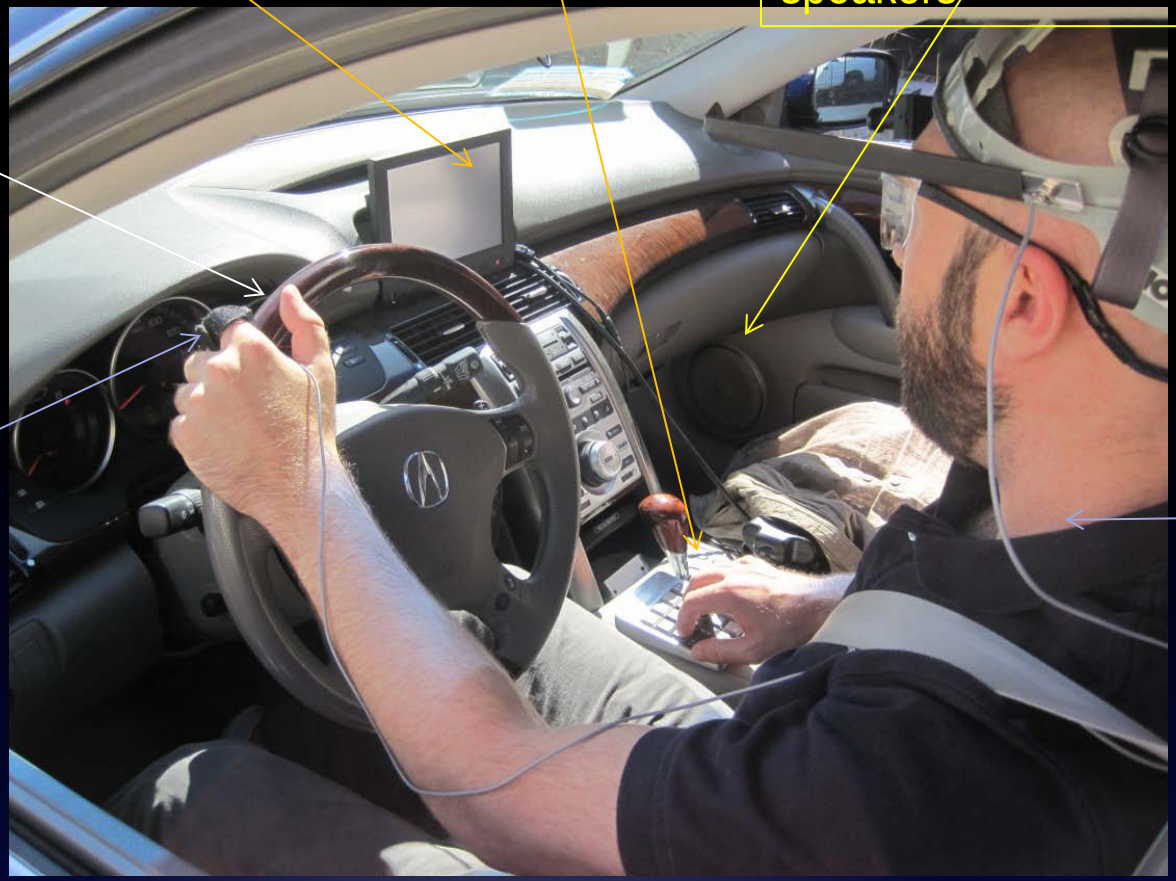
1. Steering

1. Braking

2B. V-M screen

2B. V-M buttons

2A. Auditory-vocal task speakers



3. TDRT finger switch*

3. TDRT tactor*

*from TNO, Netherlands

- Courtesy Dynamic Research, Inc.

Method for Sensitivity Test: Auditory-Vocal N-Back Task

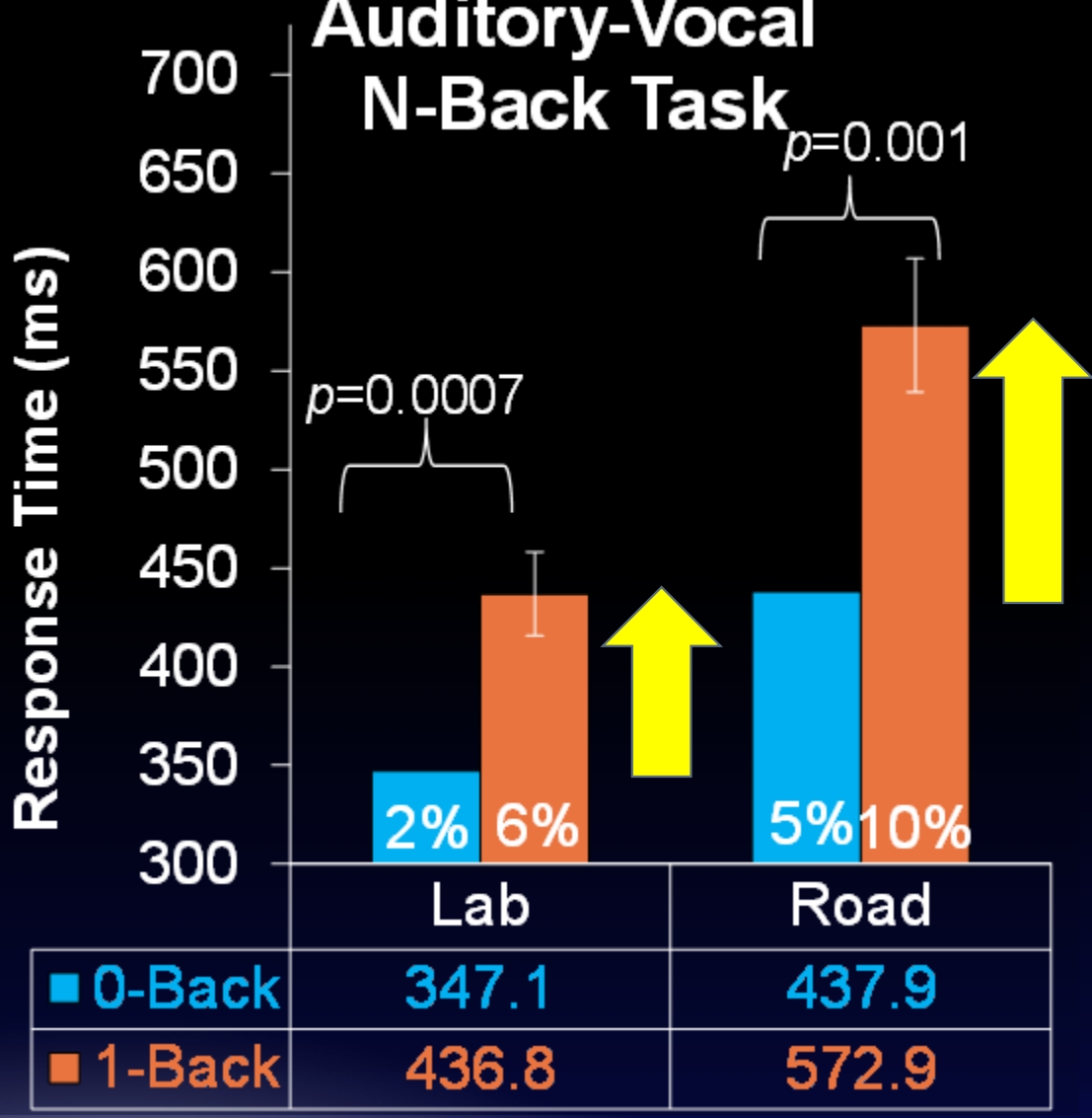
Task: Listen to numbers and respond verbally*

- 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

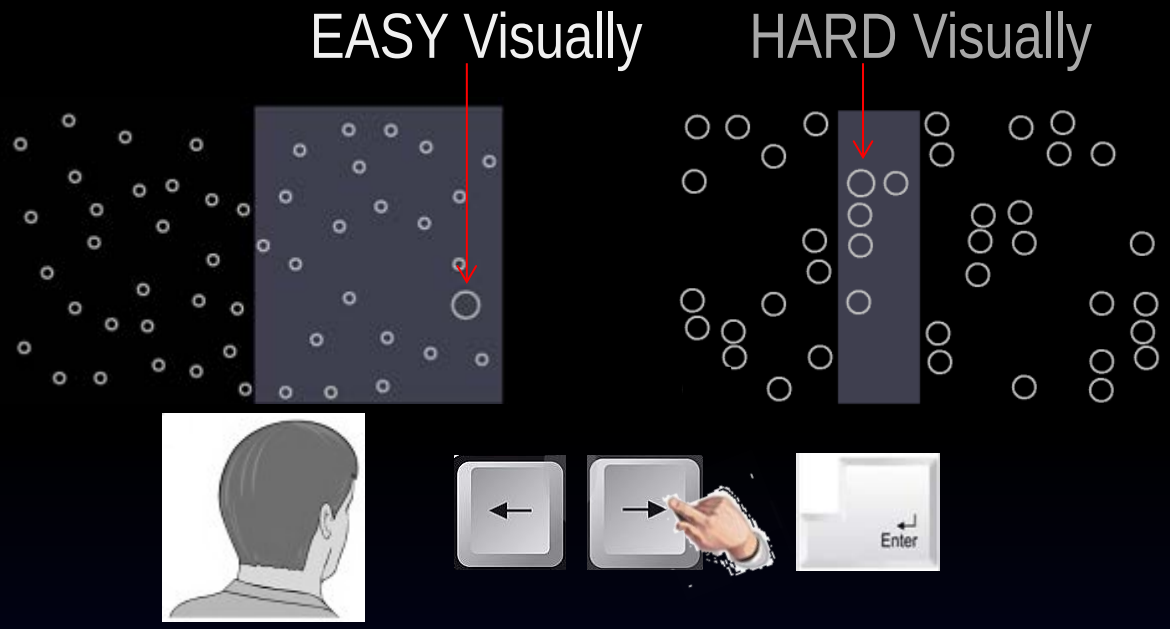
- The TDRT RT correctly indicates that the 1-Back task creates more interference with attention (> RT) than the 0-Back task, for both lab and road.
- This validates the *sensitivity* of the TDRT to the attentional effects of cognitive load.



	Lab	Road
0-Back	347.1	437.9
1-Back	436.8	572.9

*Road data from Dynamic Research, Inc.
** Miss rate at bottom of each bar.

Method for Visual-Manual Specificity Test: Surrogate Reference Task (SuRT)

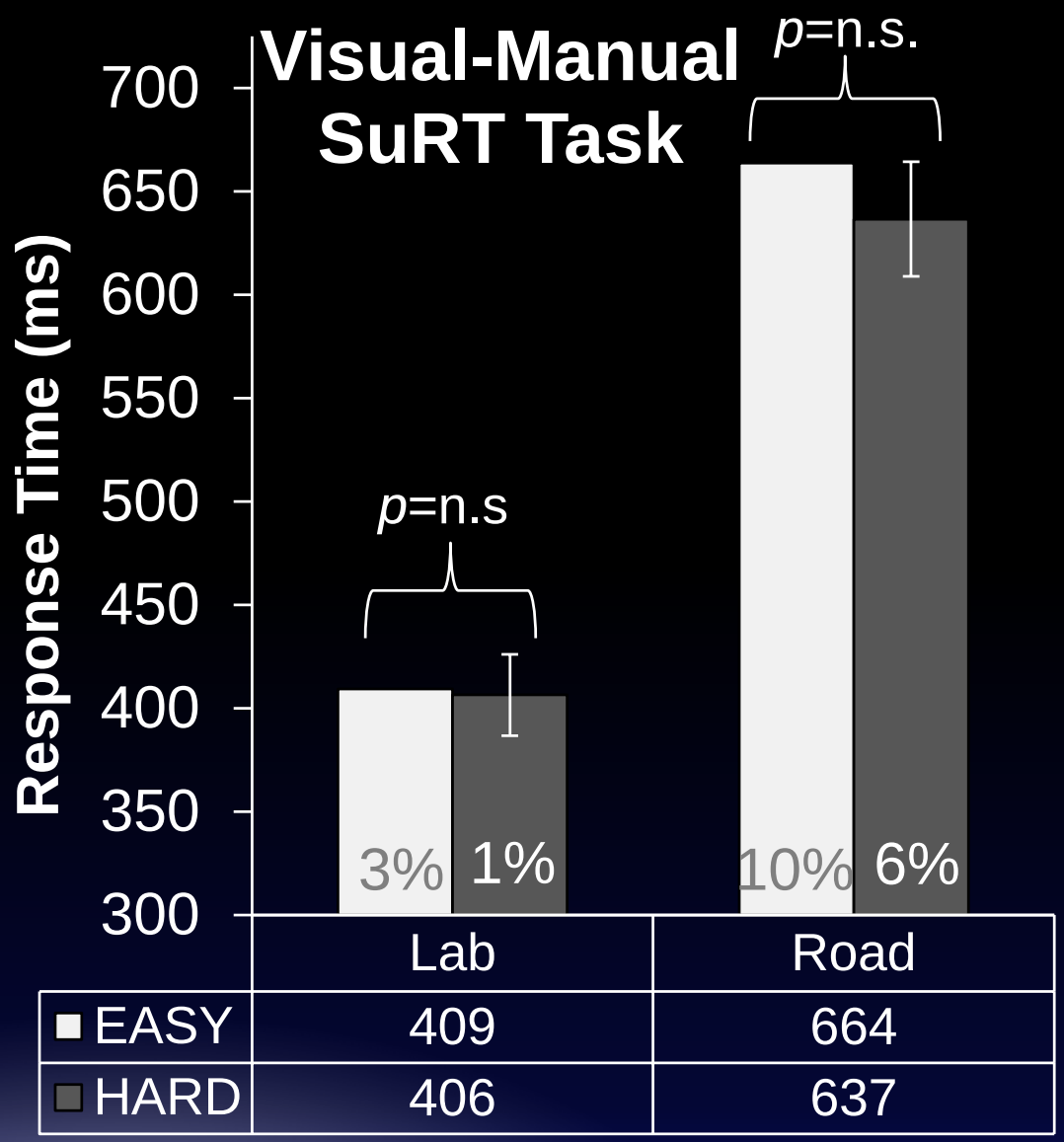


Task: Watch display screen and respond with arrow & enter keys for 2 min in lab, 1.5 min on road.

- 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

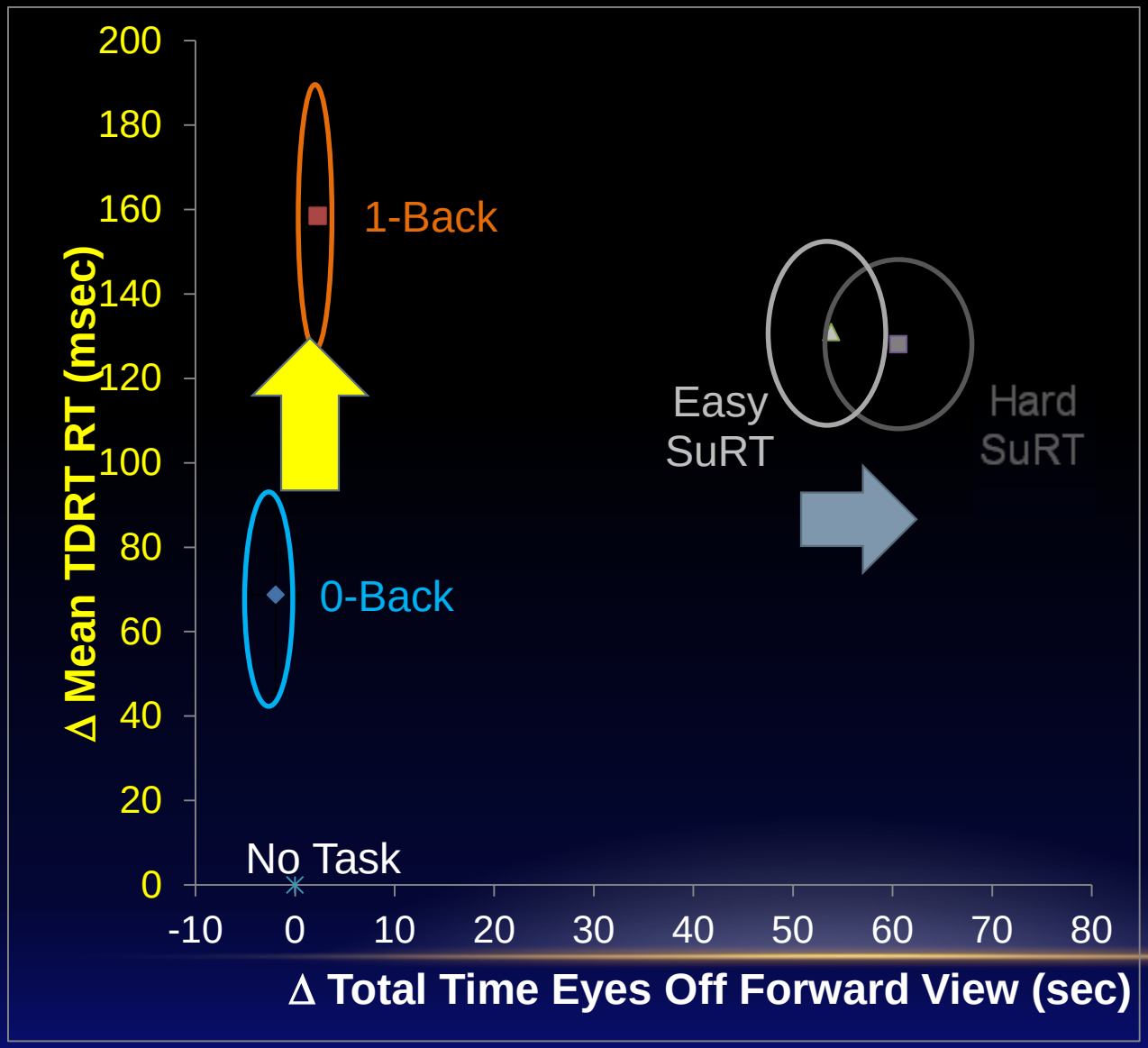
- The TDRT RT correctly indicates that the HARD visual-manual task creates no interference with attention vs. EASY, for both lab and road.
- This validates the *specificity* of the TDRT RT to the attentional effects of cognitive load, because it is not sensitive to visual load differences.



	Lab	Road
EASY	409	664
HARD	406	637

*Road data from Dynamic Research, Inc.
** Miss rate at bottom of each bar.

Results Summary Lab: N-Back and SuRT



The TDRT is validated as sensitive and specific:

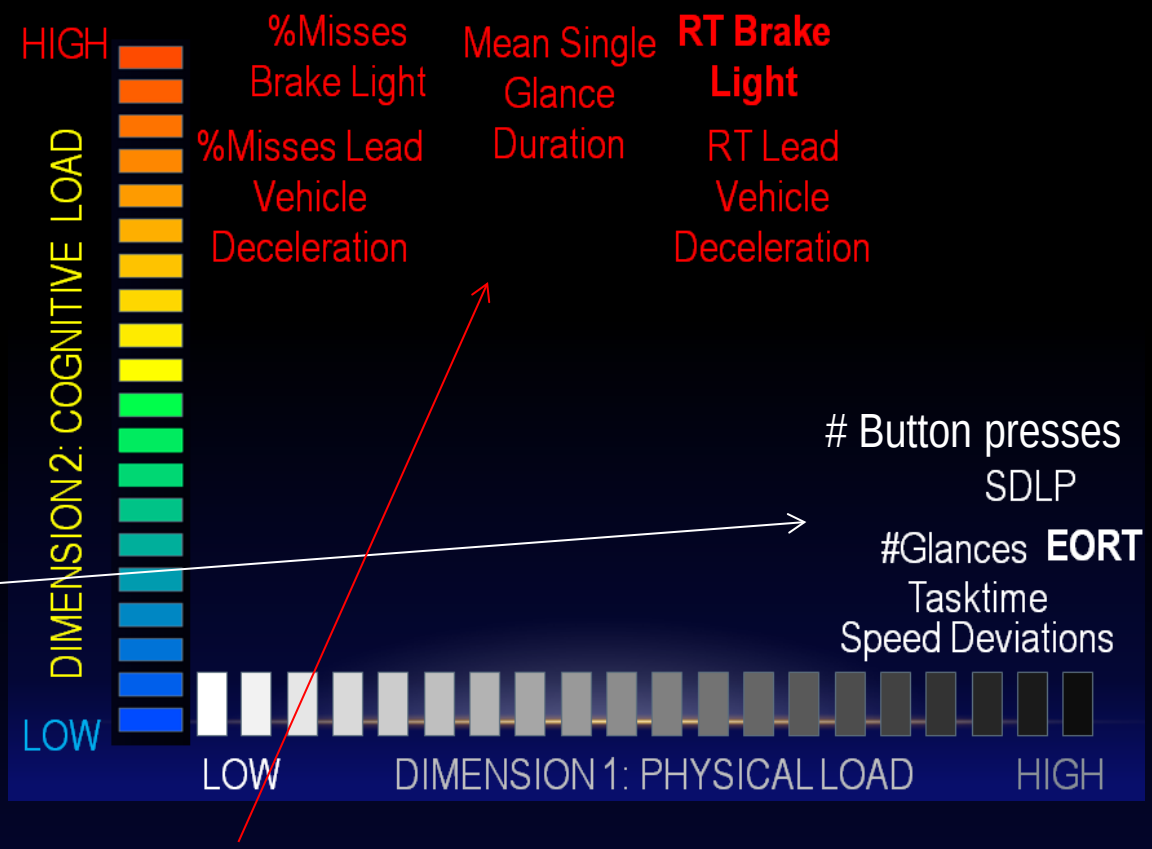
- 1-Back > 0-Back in RT but not TEORT (TDRT sensitivity)
- Hard > Easy SuRT in TEORT but not RT (TDRT specificity)
- TEORT and TDRT RT are independent

Discussion

- 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.

Dimensional Model Predictions for TDRT RT

1-Back

0-Back

- 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.

EASY SuRT → HARD SuRT

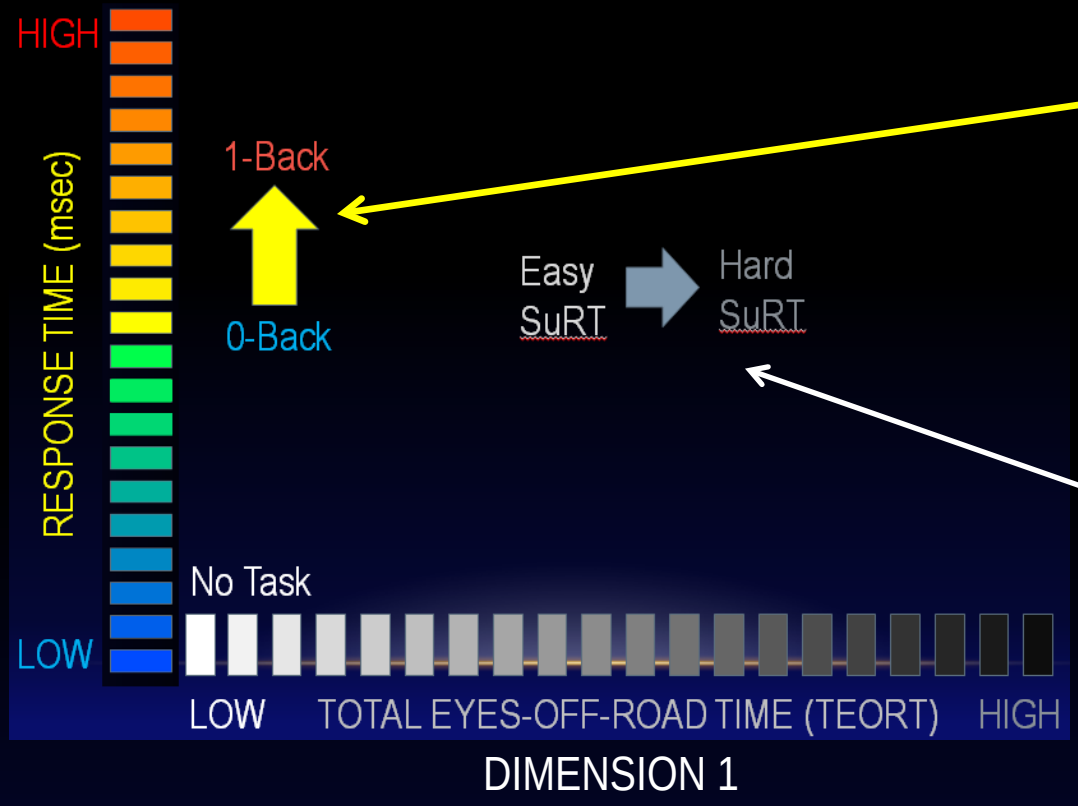
No Task

- But no difference in RT on Dimension 2.

LOW DIMENSION 1 HIGH

TOTAL EYES-OFF-ROAD TIME (TEORT)

Dimensional Model Explains TDRT Results



- 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.

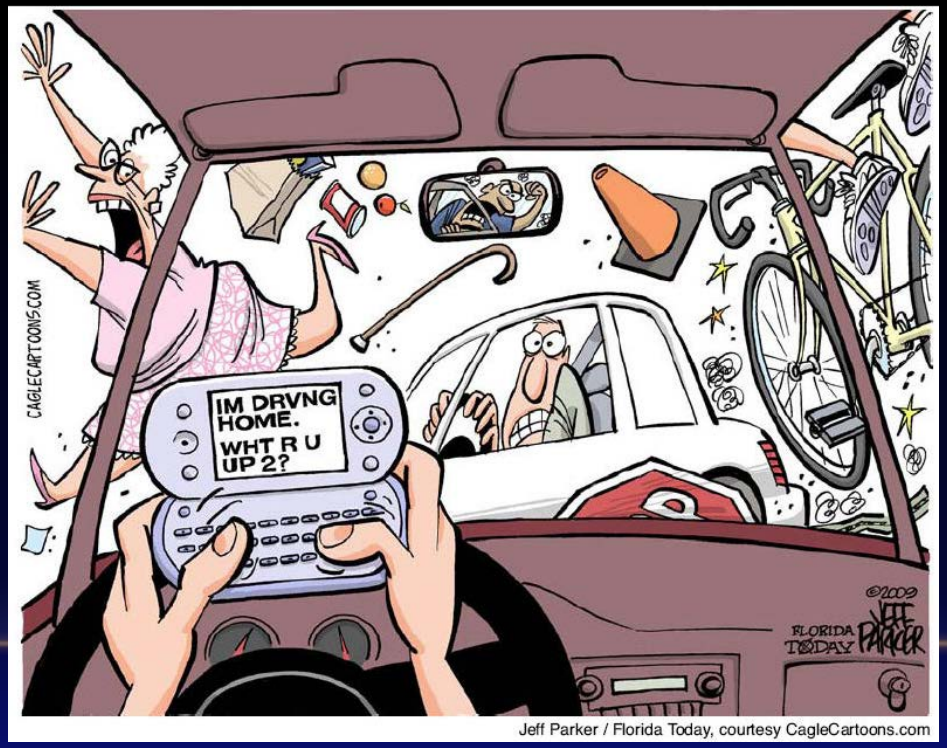
*Young and Angell (2003); Young (2012a)

Acknowledgments

- We thank Toyota CSRC for supporting this work

CSRC Collaborative Safety Research Center TOYOTA

- And THANK YOU for not being too distracted!



Jeff Parker / Florida Today, courtesy CagleCartoons.com

WAYNE STATE School of Medicine

References

ISO WD17488. (2012). Detection-Response Task for assessing selective attention in driving. ISO/TC 22/SC 13/WG 08 (preliminary work item, version 8, February).

Porta, Miquel. (2008). *A Dictionary of Epidemiology* (M. Porta Editor Fifth Edition). Oxford England: Oxford University Press.

NHTSA. (April, 2010). *Overview of the National Highway Traffic Safety Administration's Driver Distraction Plan*. Washington, D.C.: U.S. Department of Transportation Retrieved from http://www.nhtsa.gov/staticfiles/nti/distracted_driving/pdf/811299.pdf.

NHTSA. (April 24, 2013). *Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices*. (Docket No. NHTSA–2010–0053). Washington, DC: National Highway Traffic Safety Administration Retrieved from http://www.regulations.gov/contentStreamer?objectId=09000064812a9508&disposition=attachment&contentType=pdf.

Young, Richard A., & Angell, Linda S. (2003, July). *The dimensions of driver performance during secondary manual tasks.* Paper presented at the Driving Assessment 2003: Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, Park City, Utah.

Young, R.A. (2012a). Event detection: The Second Dimension of Driver Performance for Visual-Manual Tasks. *SAE Int. J. Passeng. Cars - Electron. Electr. Syst. , 5*(1). doi: 10.4271/2012-01-0964

Young, R. A. (2012b). *Seven Myths about Cognitive Distraction and Driving*. Paper presented at the 5th International Conference on Traffic and Transport Psychology, Groningen, The Netherlands. http://www.icttp2012.com/images/stories/presentations/30th/1330_Driver_attention_and_distraction_Eyes_on_the_road/Young_ICTTP2012_Seven_Myths_about_Cognitive_Distraction_and_Driving.pdf

Young, R. A. (2013, accepted). *Drowsiness and Crash Risk: Underestimates of Odds Ratios from Confounding in the 100-Car Naturalistic Driving Studies.* Paper presented at the 3rd International Conference on Driver Distraction and Inattention, September 4-6, Gothenburg, Sweden.