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Road vehicles — Transport information and control systems — Detection-Response Task (DRT) for assessing attentional effects of cognitive load in driving

Véhicules routiers — Systèmes de commande et d'information du transport

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Contents

Page

Foreword

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This second/third/... edition cancels and replaces the first/second/... edition (), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

Introduction

Driving is a complex task consisting of a range of sub-tasks such as keeping the vehicle in the lane, avoiding other traffic and obstacles, observing road signs and signals, planning and initiating specific manoeuvres, scanning mirrors, and navigating. In addition, drivers often engage in secondary tasks, not directly related to driving, such as operating the media player, conversing on the phone and reading road-side commercial signs.

These different activities place varying, and sometimes conflicting, demands on the driver. In order to manage the various driving and secondary tasks, the driver thus needs to allocate different *resources* such as the eyes, hands, feet, perceptual systems, motor control systems and higher level cognitive functions, to the different sub-tasks in a dynamic and flexible way. This allocation of resources to driving and non-driving activities may be generally conceptualized as *driver attention*. In most driving situations, attention is largely proactive (top-down, endogenous) based on anticipation of how the upcoming situation will develop. However, when the situation does not develop as expected, reactive (bottom-up, exogenous) attention is needed to trigger corrective action.

There is a need for methods that can be used to assess how engagement in secondary tasks affects driver attention. In general, the effect of a task on attention depends on the amount and type of resources demanded by the task. As outlined in further detail in Annex A, resources can be conceptualised at three general levels: (1) *sensory-actuator resources*, (2) *perceptual-motor resources* and (3) *cognitive resources*. *Sensory/actuator resources* refer to the basic interfaces between the driver and the environment used to sense the environment and perform overt actions. Examples include the eyes, the ears, the skin, the feet, the hands, the mouth, the vocal cords, etc. *Perceptual/motor resources* can be regarded as brain functions for controlling specific perceptual-motor activities, for example visual perception, manual tracking and hand-to-eye coordination. Finally, *cognitive resources* refer to brain systems implementing higher-level cognitive operations such as planning, decision making, error detection, sustaining information in working memory, dealing with novel or difficult situations and overcoming habitual actions. These types of high-level cognitive functions may be conceptualized in terms of *cognitive control*. While sensory-actuator and perceptual-motor resources are, at least to some extent, modality-specific, cognitive control can be regarded as a single resource with strongly limited capacity, not associated with any particular sensory modality. *Cognitive load* thus refers specifically to the demand for cognitive control that a task imposes on the driver.

Several existing and draft ISO standards address the assessment of secondary task demand in the context of driving. ISO 15007-1 and ISO/TS 15007-2 (Measurement of Driver Visual Behaviour) provide guidance on how to measure glance behaviour, and ISO 16673 (Occlusion Method to Assess Visual Distraction) focuses exclusively on the viewing time required to perform a task using an in-vehicle information system. Hence, these methods focus mainly on the assessment of (visual) sensory demand (i.e., the demand for the eyes). ISO 26022 *(Simulated Lane Change Test)* provides a technique for evaluating the combined effect of sensory-actuator, perceptual-motor and cognitive demands on a driver's performance in a combined event-detection-and-vehicle-control-task.

However, a standardised measurement method that specifically addresses cognitive load is lacking. While, for example, ISO 26022 *(Simulated Lane Change Test)* is sensitive to cognitive load, it lacks specificity since its main performance metric (MDEV) is also sensitive to visual sensory motor interference (i.e., visual time sharing; see Annex A). A standardised method specifically addressing cognitive load is particularly needed in order to evaluate the attentional demands of new driver-vehicle interfaces designed to minimise visual interaction such as voice-based interfaces, haptic input devices and head-up displays.

The Detection Response Task (DRT) method defined by the present standard intends to fill this gap. More specifically, the DRT is mainly intended to measure effects of the cognitive load of a secondary task on attention. However, some versions of the DRT specified by this standard may also be used to capture other forms of secondary task demand (e.g., visual sensory demand). The general rationale behind the DRT methodology is further outlined in Annex A.

Annex B provides guidance for how to select between the different DRT versions defined in the standard. Annex C reviews factors that could potentially affect DRT performance and thus needs to be accounted for when designing DRT experiments. Annex D offers a review of existing alternative DRT methodologies not covered by this standard. Annex E provides an overview of the results from a set of coordinated studies with the purpose to support the development of the standard. Finally, Annex F provides a general bibliography for existing DRT-related research.

Road vehicles — Transport information and control systems — Detection-Response Task (DRT) for assessing attentional effects of cognitive load in driving

1 Scope

This standard provides a Detection Response Task mainly intended for assessing the attentional effects of cognitive load on attention for secondary tasks involving interaction with visual-manual, voice-based, or haptic interfaces. Although the standard focuses on the assessment of attentional effects of cognitive load (see Annex A), other effects of secondary task load may be captured by specific versions of the DRT, as further outlined in Annex B. Secondary tasks are those that may be performed while driving but are not concerned with the momentary real-time control of the vehicle (such as operating the media player, conversing on the phone, reading road-side commercial signs and entering a destination on the navigation system).

Note 1 to entry: According to this definition, secondary tasks may still be driving-related (such as in the case of destination entry).

The standard does *not* apply to the measurement of primary (driving) task demands related to the momentary real-time control of the vehicle, such as maintaining lane position and headway, or responding to forward collision warnings. However, this does not preclude that the DRT method, as specified in this standard, may be adapted to measure such effects.

This standard applies to both Original Equipment Manufacturer (OEM) and After-Market in-vehicle systems, and to permanently installed as well as portable systems.

It should be emphasized that, while the DRT methodology defined in this international standard is intended to measure the attentional effects of cognitive load, it does not imply a direct relationship between such effects and crash risk. For example, taking the eyes off the road for several seconds in order to watch a pedestrian may not be very cognitively loading but could still be expected to strongly increase crash risk.

Furthermore, caution is needed when interpreting DRT results in terms of demands on a specific resource, such as cognitive load. Specifically, if the goal is to isolate the effect related to the cognitive load imposed by a secondary task on attention, care must be taken to avoid overlap with other resources required by the DRT (e.g., perceptual, motor, sensory or actuator resources). A particular concern derives from the fact that the DRT utilises manual responses (button presses). Thus, for secondary tasks with very frequent manual inputs (on the order of one or more inputs per second), increased response times on the DRT may reflect this specific response conflict (which is due to the nature of the DRT) rather than the actual cognitive load demanded by the task when performed without the DRT (i.e., alone or during normal driving; see Appendix E). Thus, for such response-intensive tasks, DRT results should be interpreted with caution. The present standard defines three versions of the DRT and the choice of version depends critically on the purpose of the study and the conditions under which it is conducted (see Annex A and Annex B for further guidance on this topic).

This standard specifically aims to specify the Detection Response Task and the associated measurement procedures. Thus, in order to be applicable to a wide range of experimental situations, the standard does not define specific experimental protocols or methods for statistical analysis. However, some guidance, as well as examples of established practice in applying the DRT, can be found both in the main body of the standard and in the Annexes (in particular Annex C and Annex E).

2 Normative references

There are no normative references for this standard.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
Actuator demand
demand for actuator resources imposed by a task

3.2
Actuator resources
Human body systems used to execute overt motor actions

Note 1 to entry: Examples of actuator resources include the hands, the feet, the vocal cord etc.

3.3
attention
see *driver attention*

3.4
cognitive control
mental operations such as planning, decision making, error detection, inhibiting habitual actions, utilizing information in working memory, and resolving novel and complex situations

3.5
cognitive resources
brain systems implementing cognitive control

3.6
cognitive load/demand
demand for cognitive control imposed by a task

3.7 data segment
continuous portion of data

3.8
driver attention
allocation of resources to driving or non-driving-related activities

3.9
hit rate
number of valid responses divided by the total number of stimuli presented in a data segment, excluding stimuli responded to prematurely (see *premature response*)

3.10
missing response
no response is given within 100 - 2 500 ms after stimulus onset

3.11
motor demand
demand for motor resources imposed by a task

3.12
motor resources
brain systems implementing the control of motor actions

3.13
perceptual demand
demand on perceptual resources imposed by a task

3.14
perceptual resources
brain systems implementing perception

Note 1 to entry: Perceptual functions include lower-level, modality-specific perception (e.g., visual and auditory perception) as well as higher-level cross-modal perceptual integration.

3.15
premature response
response initiated within 100 ms from the stimulus onset

3.16
primary task
driving or driving-like task used in the surrogate driving, driving simulator or on-road DRT experimental set-ups

3.17
repeated response
response given within 100 – 2 500 ms after the stimulus onset that is preceded by another response in the same interval

3.18
resources
systems in the brain or body that can be utilised to perform tasks

3.19
response
signal generated by the participant pressing the response button

3.20
response time
time from the stimulus onset until the response onset

Note 1 to entry: Response time is only defined for valid responses.

3.21
secondary task
task that may be performed while driving but that is not concerned with the momentary real-time control of the vehicle

Note 1 to entry: Examples include operating the media player, conversing on the phone, reading road-side commercial signs and entering a destination on the navigation system. Thus, secondary tasks may be driving-related.

3.22
sensory demand
demand on sensory resources imposed by a task

3.23
sensory resources
human body systems used to sense the exterior environment or internal bodily states

Note 1 to entry: Examples of sensory resources include the eyes, the ears, the skin etc.

3.24
stimulus duration
time during which the stimulus is turned on

Note 1 to entry: Stimulus duration depends on responses. The maximum stimulus duration represents the pre-set duration of the stimulus in the absence a response. If the response is initiated prior to maximum stimulus duration, the stimulus is turned off.

3.25
stimulus cycle period
time from the onset of a stimulus until the onset of the next stimulus

3.26
stimulus offset
point in time when the DRT stimulus is turned off

3.27
stimulus onset
point in time when the DRT stimulus is turned on

3.28
task
process of achieving a specific and measurable goal using a prescribed method

3.29
trial
test of one participant undertaking one secondary task one time

3.30
unrequested response
a response given later than 2 500 ms after the stimulus onset

3.31
valid response
response initiated within 100 – 2 500 ms from the stimulus onset and not preceded by an earlier response in the same interval

3.32
visual angle
angle subtended at the eye by a viewed object or separation between viewed objects

3.33
visual eccentricity
visual angle, relative to the centre of the fovea, at which a certain visual stimulus impinges on the retina

3.34
working memory
executive and attentional aspect of short-term memory involved in the interim integration, processing, disposal, and retrieval of information

4 Abbreviations

B	Baseline
DRT	Detection Response Task
DRV	Dual Remote Visual
HDRT	Head mounted DRT
HR	Hit Rate
MR	Miss Rate
N0	0-Back
N1	1-Back
OEM	Original Equipment Manufacturer
R	Response
RT	Response Time
RDRT	Remote DRT
SE	Easy SuRT
SH	Hard SuRT
TDRT	Tactile DRT

5 The DRT methodology: Principles and overview

The DRT method is based on a simple detection-response task where participants respond to relatively frequent artificial stimuli presented with a specified degree of temporal uncertainty. Detection performance, measured in terms of response time and hit rate, is assumed to represent the degree to which attention is affected by the demand, and in particular the cognitive load component imposed by the secondary task under evaluation. Longer reaction times and reduced hit rate are indicative of higher cognitive load.

The method may be implemented in several different ways, depending on the purpose of the study. The DRT versions specified by this standard differ in terms of (1) stimulus presentation modality and (2) experimental set-up, as further described below.

6 Measurement methods and procedures

6.1 Participants

Participants should be licensed drivers with a similar level of prior experience with the secondary task under evaluation. Other relevant characteristics of the participants shall be recorded, including at least driving experience (e.g., miles or km driven in the last year), similar device use experience, gender, age and previous experience with the DRT.

6.2 Experimental setup

The DRT may be used in different experimental set-ups as described below.