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Road vehicles — Measurement and analysis of driver visual behaviour with respect to transport information and control systems

Véhicules routiers — Mesurage et analyse du comportement visuel du conducteur en relation avec les systèmes de commande et d'information du transport

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Foreword

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 39, *Ergonomics*.

This edition cancels and replaces ISO 15007-1:2014 and ISO/TS 15007-2:2014, which have been technically revised.

The main changes compared to the previous editions are as follows:

— integration of ISO 15007-1 (*Part 1: Definitions and parameters*) and ISO/TS 15007-2 (*Part 2: Equipment and procedures*) into one document;

— detailed description of different data reduction procedures;

— detailed description of procedures and criteria for quality assurance.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document supports the quantification and description of visual behaviour while using TICS (transport information and control systems) and driving vehicles in different driving levels of automation. It supports the quantification of information acquisition related to internal and vehicle external environment/objects (e.g. vehicles, billboards, information displays, variable message signs).

It provides assistance in the assessment of driver state considering visual attention. This document does not address fatigue and drowsiness.

This document describes the phases of visual behaviour assessment including the following steps:

— calibration setup and calibration verification (piloting phase);

— data collection;

— data reduction;

— quality assessment;

— data presentation.

Each of these steps should be handled with care, documented and checked for quality before moving to the next step.

Road vehicles — Measurement and analysis of driver visual behaviour with respect to transport information and control systems

1 Scope

This document defines key terms and parameters applied in the analysis of driver visual behaviour focused on glance and glance-related measures. It provides guidelines and minimum requirements on equipment and procedures for analysing driver visual behaviour including assessment of TICS to:

— plan evaluation trials,

— specify (and install) data capture equipment, and

— validate, analyse, interpret and report visual-behaviour metrics (standards of measurement).

The parameters and definitions described below provide a common source of reference for driver visual behaviour data.

It is applicable to on-road trials (e.g. field operational tests or naturalistic studies), and laboratory-based driving studies. The procedures described in this document can also apply to more general assessments of driver visual behaviour. Data collected and analysed according to this document will allow comparisons to be performed across different TICS applications and experimental scenarios.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Basic terms

3.1.1
area of interest
AOI
pre-determined area within the visual scene

Note 1 to entry: Region of interest (ROI) is used as a synonym.

Note 2 to entry: An AOI will be no smaller than the normal resolution of the eye-measurement system being used (e.g. no smaller than 0,5 ° for typical eye tracking systems). See F.1.

EXAMPLE A rear-view mirror.

3.1.2
blink
short period of time in which the eye is closed by the eyelid

Note 1 to entry: The blink starts when the eyelid starts moving downwards and ends when the eye is fully opened again.

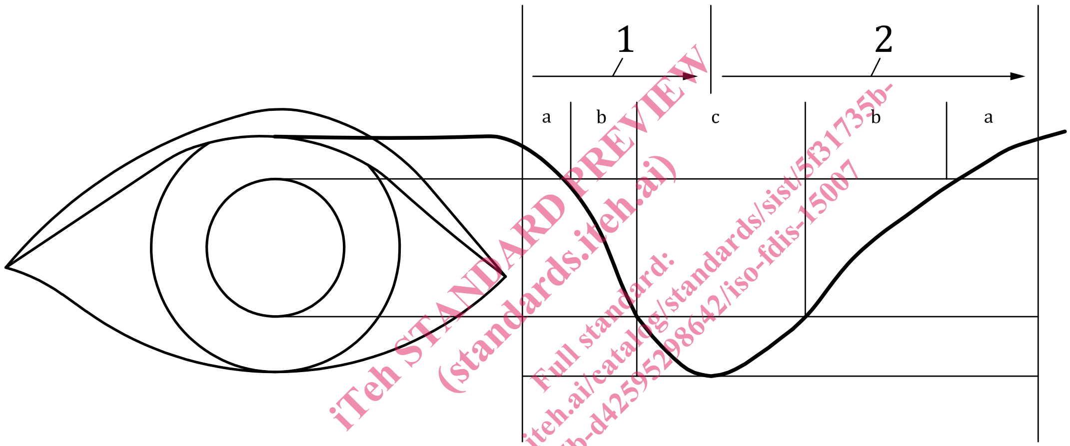
Note 2 to entry: According to the duration for which the eye is closed the following classification applies (see Reference [13]):

— Normal blinks: ≤300 ms (mean duration 257 ms; standard deviation 11 ms)

— Long closed durations: 300 ms to 500 ms

— Eye-lid closures: ≥500 ms (indicating microsleeps)

Note 3 to entry: Depending on participant state and/or *glance* (3.1.6) direction of a participant the eyelid may not fully open, although the blink might end. Especially in these cases the visibility of the pupil or major part of the pupil is important for correct gaze recognition.



Key

1 closing phase
2 opening phase
x vertical positioning of upper eyelid
a Open.
b Partially closed.
c Closed.

Figure 1 — Phases of a blink (see Reference [17])

Note 4 to entry: A blink is performed by the down movements the upper eye lid while lower eyelid remains static. Upper eyelid movement is considered in defining a blink.

3.1.3
direction of gaze
orientation of the eye to the *area of interest* (3.1.1) to which the eyes are directed to

3.1.4
fixation

short temporal holds of movements that keep alignment of the eyes to a particular point within an *AOI* (3.1.1) which falls on the fovea (the middle of the retina responsible for our central, sharpest vision) for a given time period

Note 1 to entry: Typically, individual fixations last from 100 ms to 2 000 ms (see Reference [5]). Fixations are the briefest of pauses during which visual information extraction is done by the eyes-and-brain from spatial areas that fall on the fovea of the eye (and hence are quite small). During fixation, there are believed to be at least three processes taking place (see Reference [16]) 1) analysis of the image falling on the fovea, 2) selection of a new *saccade* (3.1.7) target and 3) programming of the saccade to-be-made-next. It is not yet known how these processes are synchronized by the brain, nor how precisely they are synchronized – since fixation durations are not always long enough to comprehend completion of all the processes. (Sometimes the eyes move before information extraction from the site of fixation has been completed, as evidenced by frequent corrective return fixations to a site under some conditions that was fixated too briefly). There is evidence that the brain both pre-programs fixation duration, and also does "process-monitoring" during a fixation to determine if analysis of the foveal image is complete within the fixation's duration before moving on. Thus, fixation time is dependent on both the immediate stimulus and the history of prior fixations. The contribution of both components suggests that fixation time may depend on the task and the amount of useful information in the fixated display (or viewed information) (see Reference [7]).

Note 2 to entry: See F.1 to F.4.

3.1.5
fly through

small 'snapshot' of a *saccade* (3.1.7) (<120 ms) that may be an artefact captured when the eye is moving from one *area of interest* (3.1.1) to another area of interest, and passing through one or more intermediate Areas of Interest in between

EXAMPLE The eye moves from the road scene ahead to the instrument cluster and passes the head-up display.

Note 1 to entry: Sometimes a small 'snapshot' of such a saccade may appear to be a *short fixation* (3.1.4), when it is really still part of the saccade. Such fly throughs (<120 ms) are not treated as fixations. Fly throughs may be grouped with the saccade they are part of, if saccades are being measured.

Note 2 to entry: Research shows that fixations cannot be shorter than 100 ms (see Reference [10]).

3.1.6
glance

temporal maintaining of visual gaze within an *AOI* (3.1.1), bounded by the perimeter of the AOI which can be comprised of more than one *fixation* (3.1.4) and *saccades* (3.1.7) within the AOI and its duration is measured as *glance duration* (3.2.1.3)

Note 1 to entry: A glance is a scientific *construct* that sums over one or more fixations that are made contiguously within a given area of interest (but one that is larger than the area corresponding to the eye's foveal region – an area that usually requires more than one fixation to view). The construct of a glance, therefore, typically comprehends more than a single fixation and is a coarser unit of analysis than a single fixation (since it is summing over fixations that are contiguous in time and spatially proximal within an area of interest. The construct of a "glance" is needed because often the salient questions in a study relate to the amount of contiguous time spent gazing at a particular area of interest (before the eyes move away from it). Of course, in some instances, the "glance" construct is also necessary because some measurement approaches are not capable of the fine discriminations needed to identify individual fixations (spatially and temporally) – and can only discriminate at the spatial/temporal granularity of glances. Thus, "glances" are a coarser measure of visual information extraction by the eyes/brain from a continuously viewed but somewhat larger spatial region. Typical glance lengths vary by stimulus and task but might (for example) range from 500 ms to 3 s for a task like "tuning the radio" (see Reference [11]).

Note 2 to entry: See F.1 to F.4.

3.1.7
saccade
brief, fast movement of the eyes that changes the point of *fixation* (3.1.4), within an *AOI* (3.1.1) or between different AOIs

Note 1 to entry: Saccades reach velocities as high as 500°/s (see Reference [10]), whereby the mean saccade ranges between 1° (text reading) to 5° (scene perception) (see Reference [14]).

Note 2 to entry: See F.1 to F.4.

3.1.8
smooth pursuit movement
smooth continuous movement of the eyes made to closely follow/pursue a moving object or signal

Note 1 to entry: Humans generally perform smooth pursuit movements better in the horizontal than vertical dimension, and better in the downward than upward direction. Smooth pursuit movements can have a velocity as high as 90°/s (see Reference [9]).

3.1.9
sample interval
the epoch of time over which measurements are taken

EXAMPLE The duration of an in-vehicle task on entering a destination into a route guidance system, where the evaluation in interest is to evaluate the driver behaviour when the driver performs a task of entering the destination.

Note 1 to entry: Usually, this will be the contiguous epoch of time that is associated with an event or task that is of interest in the study. The sample interval is the period of time (from start to end) during which data are extracted.

3.1.10
transition
change in eye *fixation* (3.1.4) location from one defined *area of interest* (3.1.1) location to a different defined area of interest

Note 1 to entry: A transition could be composed of a large *saccade* (3.1.7) with further head movements to compensate the required total amount of viewing deviation when changing from one AOI to another. E.g. visual task to observe mirror, diverted from the main task while observing the road ahead.

Note 2 to entry: See F.1 and F.2.

3.1.11
visual angle
angle subtended at the eye by a viewed object or separation between viewed objects

Note 1 to entry: The figure below shows the visual angle α.

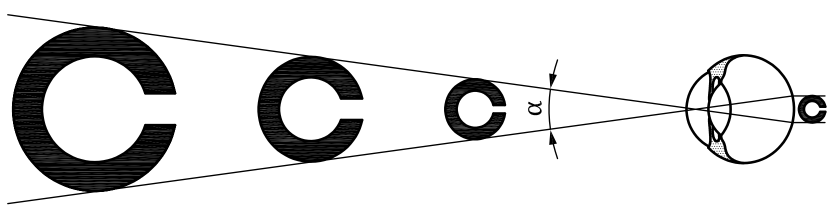


Figure 2 — Visual angle α

3.1.12
visual demand
degree or quantity of visual activity required to extract information from an object to perform a specific task

Note 1 to entry: This can be determined by, e.g. *number of glances* (3.2.2.6), *total glance time* (3.2.2.11). See F.1.

3.1.13
visual display
device used to present visual information

Note 1 to entry: See F.1.

3.2 Terms for metrics

3.2.1 Basic direct metrics

3.2.1.1
duration of diversion
period of *glance duration(s)* (3.2.1.3) associated with directions of gaze away from one *area of interest* (3.1.1) to another area of interest during a defined period of interest

Note 1 to entry: See F.3.

3.2.1.2
dwell time
sum of consecutive individual *fixation* (3.1.4) and *saccade* (3.1.7) times to an *AOI* (3.1.1) in a single *glance* (3.1.6)

Note 1 to entry: See F.4.

3.2.1.3
glance duration
time from the moment at which the *direction of gaze* (3.1.3) moves towards an *AOI* (3.1.1) to the moment it moves away from it

EXAMPLE The inside rear-view mirror.

Note 1 to entry: Under certain specific conditions, this may be operationalized differently. See F.2.

3.2.1.4
minimum glance duration
shortest possible duration for a *fixation* (3.1.4) to an *AOI* (3.1.1)

Note 1 to entry: The "small fixations" observed to an area of interest of ≤120 ms are classified as *fly through* (3.1.5).

Note 2 to entry: Fixations to an area of interest ≤120 ms are physically not possible. If an eye tracker is in use and records such duration it can be classified as part of a *transition* (3.1.10) between areas of interest and it is not taken into a *glance* (3.1.6) period.

3.2.1.5
transition time
duration between the end of the last *fixation* (3.1.4) on an *AOI* (3.1.1) and the start of the first fixation on another AOI

EXAMPLE Visual task to observe mirror, diverted from the main task while observing the road ahead.

Note 1 to entry: A *transition* (3.1.10) could be composed of a large *saccade* (3.1.7) with further head movement to compensate the required total amount of viewing deviation when changing from one AOI to another.

3.2.2 Glance derived metrics

3.2.2.1
glance location probability
probability that the eyes are fixated at an *AOI* (3.1.1) (or set of related AOIs) during a condition, task, subtask or sub-subtask

EXAMPLE 7,85 %.

Note 1 to entry: Glance location probability = *number of glances* (3.2.2.6) to an AOI during a condition, task, subtask or sub-subtask) / (number of glances to all AOIs during a condition, task, subtask or sub-subtask) × 100 %; unit [%].

3.2.2.2
glance rate
number of glances per unit of time
number of glances (3.2.2.6) divided by the duration of condition, task, subtask or sub-subtask

EXAMPLE 0,53 glances/s.

Note 1 to entry: Unit [number of glances/s].

Note 2 to entry: To obtain the glance rate of a task, only glances to the task are counted and divided by the duration of condition, task, subtask or sub-subtask. To obtain the glance rate to all locations during a test scenario, all glances to all locations are counted and the total divided by the total length of the condition, task, subtask or sub-subtask.

3.2.2.3
link value probability
probability of a *glance* (3.1.6) *transition* (3.1.10) between two different *AOIs* (3.1.1) during a condition, task, subtask or sub-subtask

EXAMPLE 17,39 %.

Note 1 to entry: Link value probability between AOI A and AOI B = (number of glance transitions from A to B + the number of glance transitions from B to A) / (number of glance transitions between all AOIs) × 100 %; unit [%].

3.2.2.4
maximum glance duration
longest *glance duration* (3.2.1.3) to an *AOI* (3.1.1) (or set of related AOIs) during a condition, task, subtask or sub-subtask

EXAMPLE 2,12 s.

Note 1 to entry: Maximum glance duration = max [glance duration1, glance duration2, ..., glance duration *n*]; unit [s].

3.2.2.5
mean glance duration
mean duration of all *glance durations* (3.2.1.3) to an *AOI* (3.1.1) (or set of related AOIs) during a condition, task, subtask or sub-subtask

EXAMPLE 1,28 s.

Note 1 to entry: Mean glance duration = [t*otal glance time* (3.2.2.11)] / [*number of glances* (3.2.2.6)] during a condition, task or subtask; unit [s].

3.2.2.6
number of glances
count of *glances* (3.1.6) to an *AOI* (3.1.1) (or set of related AOIs) during a condition, task, subtask or sub-subtask

EXAMPLE 9 glances.

Note 1 to entry: Unit [count].

3.2.2.7
percentage time on AOI
ratio representing the percentage of time *glances* (3.1.6) are within an *AOI* (3.1.1) (or set of related AOIs) during a condition, task, subtask or sub-subtask

EXAMPLE 53,47 %.

Note 1 to entry: Percentage time on AOI = Σ (glance duration 1, glance duration 2, ..., glance duration n)/(duration of condition, task, subtask or sub-subtask) × 100 %; unit [%].

3.2.2.8
percentage of eyes off road time
PEORT
percentage of time during a condition, task, subtask or sub-subtask [i.e. during a *sample interval* (3.1.9) of interest] that *glances* (3.1.6) are not on the road scene ahead

EXAMPLE 41,29 %.

Note 1 to entry: Percentage of eyes off road time = [*TEORT* (3.2.2.10)] / (duration of condition, task, subtask or sub-subtask) × 100 %; unit [%].

3.2.2.9
percentage transition time
percentage of time during a condition, task, subtask or sub-subtask (i.e. during a *sample interval* (3.1.9) of interest) during which the eyes are in *transition* (3.1.10) (or are in movement between areas-of-interest)

EXAMPLE 3,23 %.

Note 1 to entry: Percentage transition time = Σ[*transition time 1* (3.2.1.5), transition time 2, ..., transition time n) / (duration of condition, task, subtask or sub-subtask] × 100 %; unit [%].

3.2.2.10
total eyes off road time
TEORT
summation of all *glance durations* (3.2.1.3) to *AOIs* (3.1.1) other than the road scene ahead during a condition, task, subtask or sub-subtask

EXAMPLE 103,32 s.

Note 1 to entry: TEORT = Σ(glance durations to AOIs defined as off road-scene-ahead); unit [s].

Note 2 to entry: The road scene ahead excludes driver's rear-view mirror *glances* (3.1.6).

Note 3 to entry: This metric should be operationalized in an appropriate way for each study – since the concept of "not on the road" may comprehend different AOIs depending upon study objectives. When TEORT is utilized, clearly specify which AOIs are counted on the road-scene ahead and which AOIs are defined as off the road scene ahead.

3.2.2.11
total glance time
summation of all *glance durations* (3.2.1.3) to an *AOI* (3.1.1) (or set of related AOIs) during a condition, task, subtask or sub-subtask

EXAMPLE 17,88 s.

Note 1 to entry: Total glance time= Σ(glance duration 1, glance duration 2, ..., glance duration n) ; unit [s].

4 Trial planning and evaluation

4.1 General

Assessment of driver visual demand can be carried out in relation to many forms of TICS (transport information and control systems) applications and road environments. Consideration should be given to the factors/aspects influencing driver visual behaviour.