Institute for Transport Studies
FACULTY OF ENVIRONMENT
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Safety of Road Transportation

The role of human factors in road accident causation

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Outline

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Human Factors
Driver characteristics
Driver behaviour
Measurements
In-depth study

- Human Factors
- Driver characteristics
- Driver behaviour
- Measurements
- Example in-depth study

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Humans...

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Driver characteristics
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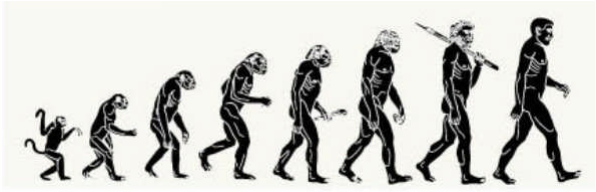
2009: 200th anniversary of Darwin's birth
150th anniversary of the publication 'On the Origin of Species'

Humans are the product of a long evolution

Both biology and psychology play a role



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Humans and traffic

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Driver behaviour
Measurements
In-depth study

Humans evolved for walking

Not for :

- moving at high speeds
- controlling technology

However, evolution made humans fit for:

- adapting
- learning

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Spot The Danger On The Street

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Human Factors

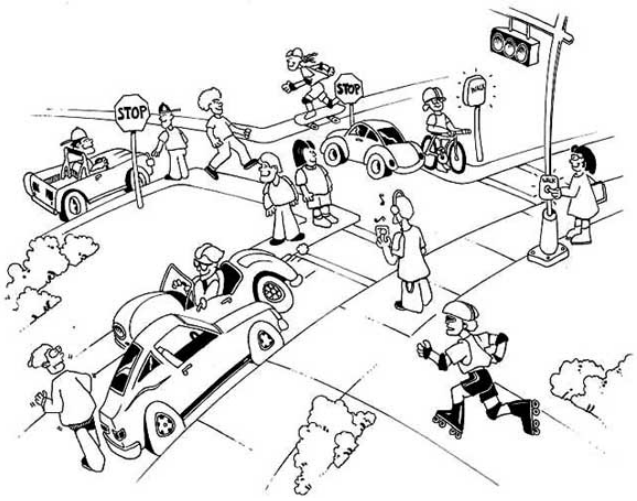
Driver characteristics

Driver behaviour

Measurements

In-depth study

From: the Calgary Police Service



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Overall Role of Human Factors

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Human Factors

Driver characteristics

Driver behaviour

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In-depth study

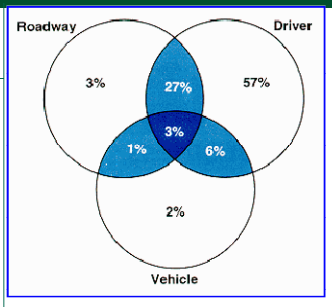

Figure 3 - Venn diagram showing the causes by percentage, of road accidents in the United States. (8)

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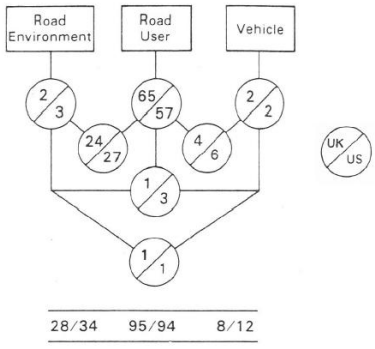

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Human Factors

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- Perception: vision, hearing etc.
- Information processing
- Memory
- Personality traits
- Age and gender
- Motivation
- Trust
- Stress
- Workload
- Attention and distraction
- Situation awareness
- Automation
- Errors
- Fatigue
- Disabilities
- Mental and physical state
- Use of alcohol, drugs and medicines

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Road user characteristics

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Demographic characteristics: gender, age, country, educational level, income, socio-cultural background, life and living situation.....

Personality traits and physical characteristics: sensation seeking, locus of control, cognitive skills, physical impairments or weaknesses .....

Attitudes and intentions: attitudes towards speeding, safety, environment, technology.....

Experience, and traffic participation and motivation: experience in years and in mileage, professional, tourist, with or without company.....

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ITERATE Model of Driver Behaviour

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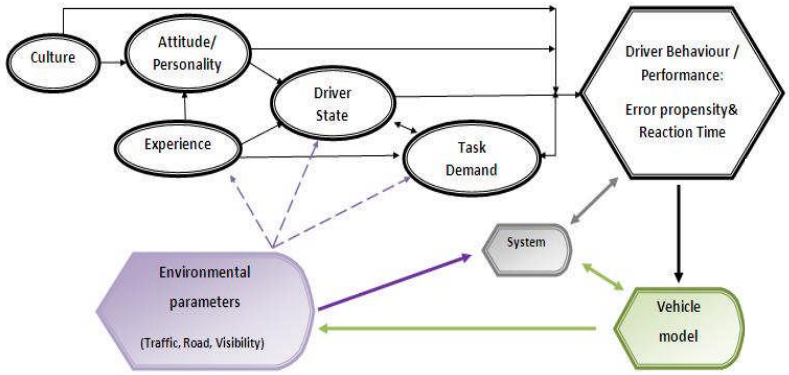
Human Factors

Driver characteristics

Driver behaviour

Measurements

In-depth study



ITERATE (2009). *Deliverable 1.2: Description of Universal Model of Driver behaviour (UMD) and definition of key parameters for specific application to different surface transport domains of application*. The ITERATE consortium.

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Personality: Sensation seeking

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a trait defined by the seeking of varied, novel, complex, and intense sensations and experiences and the willingness to take physical, social, legal, and financial risks for the sake of such experiences (Zuckerman, 1994 p. 27).

SS test factors:

- Thrill and adventure seeking: strongest relation with risky driving
- Experience seeking
- Boredom susceptibility
- Disinhibition

http://www.bbc.co.uk/science/humanbody/mind/surveys/sensation/

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Personality: Locus of control (Rotter, 1966)

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- Internal locus of control (internals) tend to perceive events as a consequence of their own behaviour
- External locus of control (externals) tend to believe events are under the control of external factors or powers that cannot be influenced
- Externals may be more likely to be involved in traffic accidents since they are less likely to take precautionary steps and engage in responsible driving
- Internals may overestimate their skills and since they believe that accidents are a consequence of their own behaviour engage in risky behaviour, confident that they possess the skills to avoid an accident

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Personality: Traffic Locus of Control Scale (T-LOC):

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- Other Drivers (causes of accidents attributed to other drivers)
- Self (causes of accidents attributed to oneself)
- Vehicle and Environment (causes of accidents attributed to external factors)
- Fate (causes of accidents attributed to fate or bad luck)

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Theory of planned behaviour

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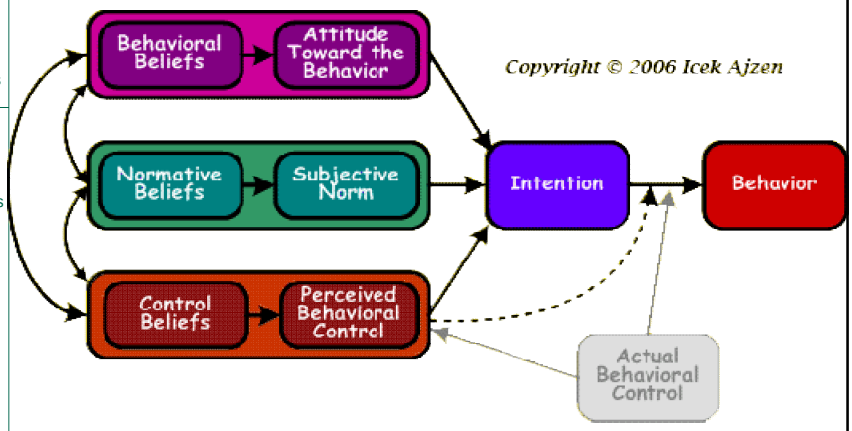
Measurements
In-depth study



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Younger and older drivers
Will vs skill examples

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In-depth study

<u>Older drivers:</u>

Will problems: Not accepting deterioration of abilities as a consequence of age, consequently, overestimation of own capability

Skill problems: problems of a psycho-physical nature due to age including:

- decline of perceptual, cognitive and physical abilities
- reduction in vision and peripheral vision
- difficulties in performing certain movements such as turning the head
- processing information could become more difficult

14 Risser, R., & Spyropoulou, I. (2011)

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Younger and older drivers Will vs skill examples

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Younger novice drivers:

Will problems:

- Sensation seeking
- Driving as a means to gain respect or impress peers
- Demonstrating illegal behaviour

Skill problems:

- Communication skills (event anticipation, risk perception)

15 Risser, R., & Spyropoulou, I. (2011)

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Protecting the driver

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In-depth study

Avoidance of crashes:

- Infra-structure, e.g. road lay-out, lighting
- Training and awareness raising, e.g. driver training, anti-alcohol campaigns
- Automation in vehicles, e.g. forward collision warning, intelligent speed adaptation

Mitigation of consequences of crashes, e.g. seat belts, airbags

Adequate and speedy healthcare, e.g. e-Call, trauma-helicopters

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Examples of possible ITS solutions

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In-depth study

Will problems:

- Alco-lock
- Intelligent Speed Adaptation

Skill problems:

- Collision warning
- Intersection warning
- Lane departure warning
- Systems providing video-supported rear view (e.g. vision enhancement system)
- Cooperative systems taking over in risky situations

17 Risser, R., & Spyropoulou, I. (2011)

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The three-level model of the driving task (Michon, 1979)

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Driver behaviour

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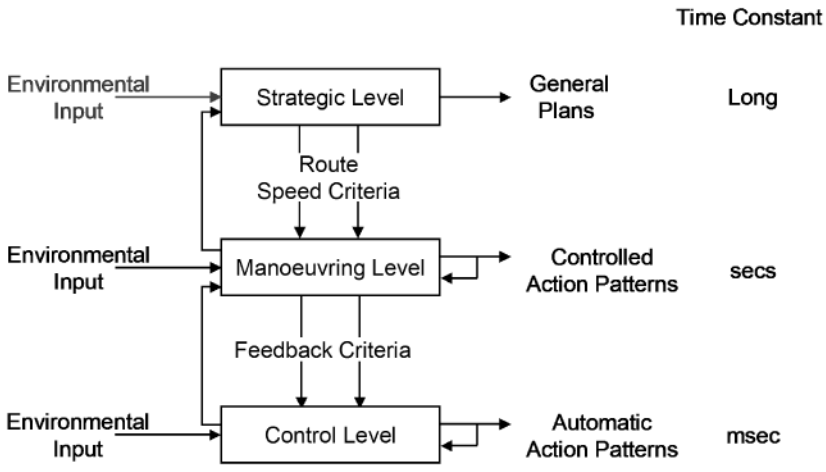
In-depth study



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Human Machine Interaction (HMI)

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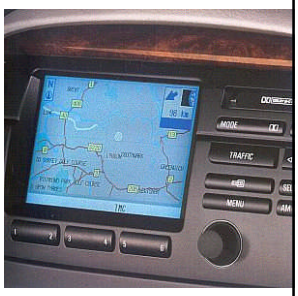
Human Factors
Driver characteristics
Driver behaviour
Measurements
In-depth study

Interaction between the user and the system

- usability
- safety implications



Primary task — driving

Secondary task — use of a system

Errors:

Driving errors

Secondary task errors

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Human Errors

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Driver characteristics
Driver behaviour
Measurements
In-depth study

(Reason et al., 1990):

1. Slips and lapses – deviating from the intended action without being aware of it
2. Mistakes – the planned action is wrong but one intended to follow the rules
3. Violations – the planned action is deliberately against the rules

Fatigue leads to increases in (1) and (2)

Alcohol produces all 3 as well as reduced capacity

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Young drivers

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One in five newly qualified drivers is involved in at least one crash during their first year of driving

The first 6 months after licensing are the most dangerous period, with the rate of collisions dropping thereafter

Young men aged between 17-25 years are over-represented in crashes

See: http://www.fmg.org.uk/

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Reasons for safety problems of young drivers, esp. young men

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They are more likely to speed

Drive whilst under the influence of drugs and alcohol

More liable to over-estimating their driving ability

Less likely to wear a seatbelt

Lack of experience, e.g. negotiating curves

Driving at night

Lack of sleep

Influenced by passengers

Old and cheap cars

Distraction by phone use

....

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Workload

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Normally we operate well within our capacities and have some left over for other activities, e.g. conversation

In crisis situations we devote all our capacity to the driving task

Problems will arise when either:

- capacity is reduced
- demands of task become too great

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Situation Awareness

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Driver behaviour
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In-depth study

Situation awareness can be regarded as consisting of three levels:

1. perception of elements in the current situation
2. comprehension of the current situation
3. projection of future status

Endsley, M.R. (1995)

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The Spare Capacity Model

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Driver characteristics

Driver behaviour

Measurements

In-depth study

Each person has a certain mental capacity. When a road user's capacity is exceeded, that person will make mistakes.

Capacity is used up in:

- The various levels of the driving task, e.g. controlling the vehicle (steering, changing gear, braking, etc.)
- The sequence:
  perceive → judge → decide

  (situational awareness)
- Any secondary tasks that the driver is engaged in, e.g. using a mobile phone, changing CDs

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The Yerkes-Dodson "Law" (1908)

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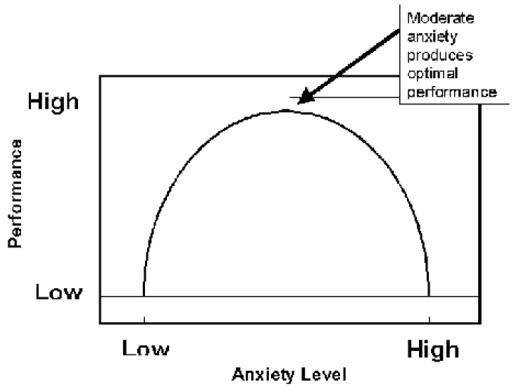

Too much arousal is bad

Too little arousal is also bad

Optimum performance is in the middle

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Fatigue

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Driver behaviour
Measurements
In-depth study

Risk of falling asleep at the wheel increases with hours of driving

U.S. study of truck accidents found that the risk of falling asleep increased measurably after 4 hours of driving

"circadian rhythm" (= biological clock):

- At 5am the risk of a truck driver falling asleep is 5–10 times as great as the average risk over the whole day.
- Not only night accidents, but also the "dawn phenomenon".

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The three-level model of the driving task (Michon, 1979)

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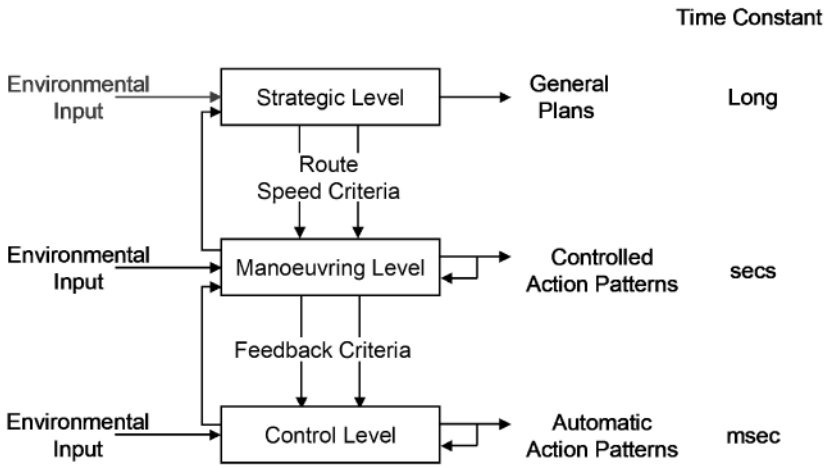

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How to study the driving task

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Task Level	Behaviour	Examples of Study Methods
Strategic	Knowledge Based	Observation, Survey
Manoeuvre	Rule Based	Verbal Protocols, Interviews, Questionnaires, Observations, etc.
Control	Skill Based	Eye Movements, Control Movements, Speed, Headways, etc.
Autonomic	Reactive	ECG (Electro CardioGram), GSR (Galvanic Skin Response), Heart Rate Variability, etc.

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Self reported behaviour

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The Driver Behaviour Questionnaire (DBQ)

(Reason et al. 1990)

Items describing errors, lapses and violations.

Indicate on 6 point scale the frequency with which you committed each type of aberrant behaviour.

Example item:

“Misjudge speed of oncoming vehicle” (0 = Never to 5 = nearly all the time)

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Driving performance indicators

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- steering wheel reversals
- speed (mean, max, SD, compliance with limits)
- lateral position (actual, SD)
- crossings of lane markings
- headway (min, max, mean)
- reaction time

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Visual performance

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Distribution of glance patterns

- road ahead
- dashboard
- mirrors (interior, left, right)
- system display

Number of glances

Average length of glance

Duration of maximum glance

Total glance time

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Metrics for Situation Awareness

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SART (Situation Awareness Rating Technique):

- subjective rating method for quantifying situation awareness
- uses post-hoc ratings by operators of perceived task demand, attentional resources, and comprehension

SAGAT (Situation Awareness Global Assessment Technique)

- direct query of SA in simulated tasks by freezing the simulation and obtaining answers from operators to probe questions (e.g. recall of location, objects in scene)
- inference from behaviour

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RSME Self-Report Measure (Unidimensional)

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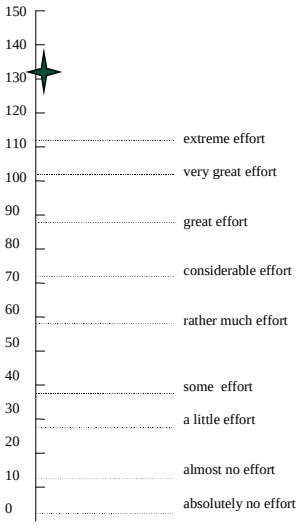
Rating Scale Mental Effort



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NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name	Task	Date

Mental Demand — How mentally demanding was the task?
Very Low — Very High

Physical Demand — How physically demanding was the task?
Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?
Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?
Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?
Very Low — Very High

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Physiological response

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In-depth study

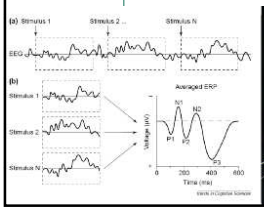
Galvanic skin response (GSR) *(stress)*

ECG (Electro-Cardiogram) e.g. heart rate variability *(workload)*

The higher the load, the more regular the heart rate becomes, increase in heart rate caused by a demanding situation is often accompanied by a decrease in heart rate variability

EEG (Electro-Encephalogram) e.g.

	<u>indication of :</u>
Alpha (8-12 Hz)	reduced vigilance
Delta (1-4 Hz)	sleep
Beta (12-30 Hz)	alertness



Taken from Wilschut, E. & De Waard, D. (2011) Psycho-physiological Measures of Driver State. In: Y. Barnard, R. Risser, and J. Krems (Eds.) Safety of Intelligent Driver Support Systems: Design, Evaluation, and Social perspectives. Franham: Ashgate Publishers

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Subjective opinion

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Ask the opinion of the user:

Before the drive: e.g. questionnaires on personal data, tests on knowledge, technology acceptance

During the drive: e.g. indications on workload scale, rating of difficulty of task, think aloud protocols

After the drive: e.g. interview and feedback, test of acceptance and perceived functionality of systems

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In-depth study of urban accidents in Leeds

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Human Factors
Driver characteristics
Driver behaviour
Measurements
In-depth study

Carsten, O.M.J.; Tight, M.R.; Southwell, M.T. *Urban accidents: Why do they happen?* 1989

Aim: to look at the causation of urban road accidents with particular emphasis on the role of human factors

Study Cases

1254 accidents in north Leeds in 1988, involving:

- 1963 adult drivers and riders
- 297 adult pedestrians
- 166 child pedestrians
- 28 child cyclists

Total of 2454 participants

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Data sources

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- Police reports
- National accident database
- Interviews with accident participants
- Site visits
- Case conferences to determine **contributory factors** for each accident participant

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Driver and rider factors

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At the top (immediate) level, the most common failures for "non-innocent" drivers and riders were:

- Failure to yield (16%)
- Loss of control (7%)
- Manoeuvre problems (mainly inappropriate overtaking) (4%)
- Failure to stop (2%)

At the explanatory level:

- Perceptual error (16%)
- Cognitive (judgement) error (12%)
- Unable to see (12%)
- Lack of skills (3%)
- Attitude (2%)

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Urban accidents motorcycles

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MAIDS : Motorcycle Accidents In Depth Study on Powered Two-Wheelers (PTWs) accidents in Europe. The investigation was conducted during 3 years on 921 accidents from 5 countries using the OECD common research methodology http://www.maids-study.eu/index.html

Primary contributing factor - Human PTW rider	L1		L3		PTW	
	N	%	N	%	N	%
Perception failure	59	44.0	30	29.7	89	37.9
Comprehension failure	10	7.5	15	14.9	25	10.6
Decision failure	46	34.3	30	29.7	76	32.3
Reaction failure	14	10.4	19	18.8	33	14.0
Avoiding a different collision	2	1.5	2	2.0	4	1.7
Failure of unknown type	3	2.2	5	5.0	8	3.4
Total	134	100.0	101	100.0	235	100.0

MAIDS - In-Depth Investigation of Motorcycle Accidents, The Association of European Motorcycle Manufacturers (ACEM), 2009, www.esum.eu/files/ap/MAIDS_Urban_Accident_Report.pdf

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Urban accidents motorcycles

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Accidents caused by drivers of other vehicles

Primary contributing factor - Human OV driver	L1		L3		PTW	
	N	%	N	%	N	%
Perception failure	133	80.1	127	71.3	260	75.6
Comprehension failure	6	3.6	4	2.2	10	2.9
Decision failure	25	15.1	43	24.2	68	19.8
Reaction failure	1	0.6	1	0.6	2	0.6
OV post-crash motions from a prior collision	0	0.0	2	1.1	2	0.6
other vehicle avoiding a different collision	0	0.0	1	0.6	1	0.3
other vehicle driver failure, unknown type	1	0.6	0	0.0	1	0.3
Total	166	100.0	178	100.0	344	100.0

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