Visual guidance, anticipation, and distraction in car driving

Heikki Summala

Driver Distraction and Inattention Conference,
Gothenburg, 4-6 September 2013

UNIVERSITY OF HELSINKI, INSTITUTE OF BEHAVIOURAL SCIENCES, TRAFFIC RESEARCH UNIT **TRU**

95 years ago in New York

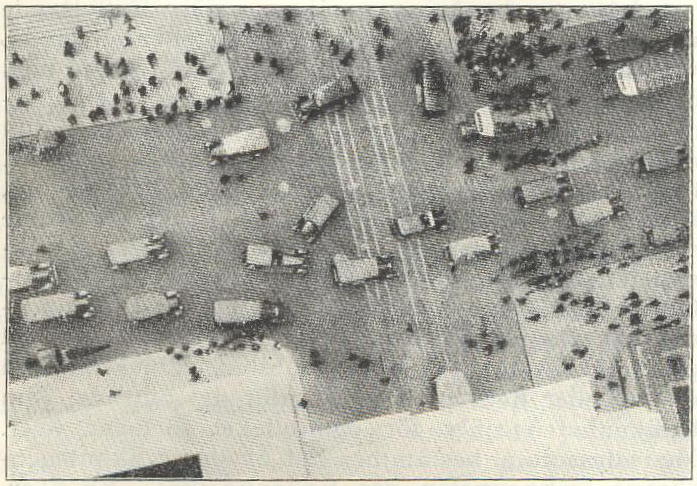


Fig. 7. Korsningen mellan femte avenyn och 42:dra gatan i New York City.

Chr. Sylwan, 1919

"Physical and psychological space"

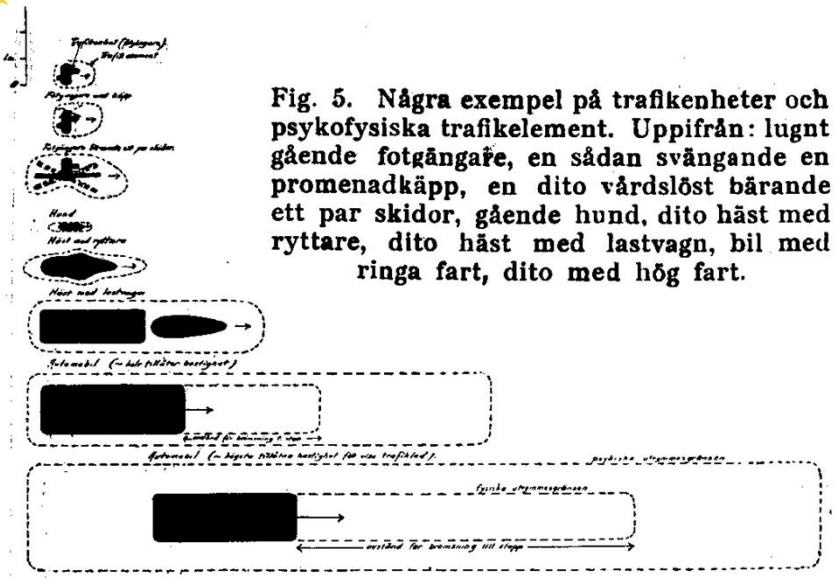
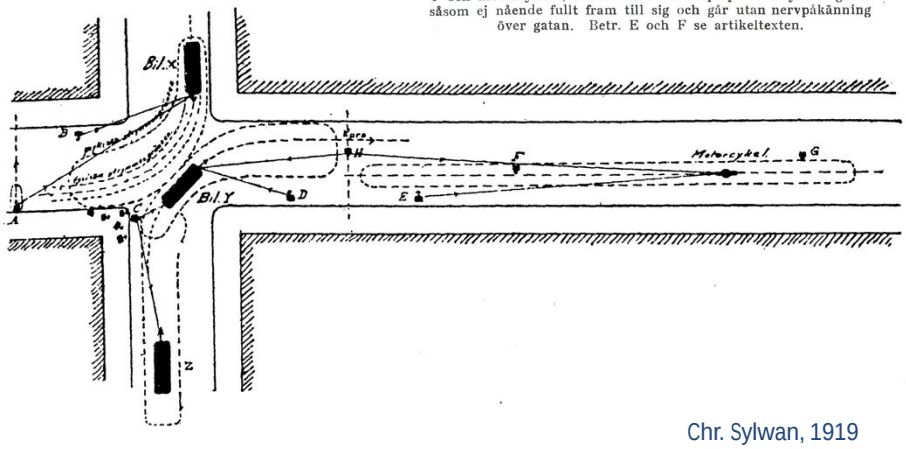


Fig. 5. Några exempel på trafikenheter och psykofysiska trafikelement. Uppifrån: lugnt gående fotgängare, en sådan svängande en promenadkäpp, en dito vårdslöst bärande ett par skidor, gående hund, dito häst med ryttare, dito häst med lastvagn, bil med ringa fart, dito med hög fart.

Chr. Sylwan, 1919

Predictions of other road users' behavior

Fig. 6. Fotgängare (A—H), biler (X—Z) och motorcykel som trafikelement i och vid en gatukorsning. A och B observera bilen X, den förre anser sig utan obehag av denna kunna passera över gatan, B hejdar sig däremot: bilens X psykofysiska utrymmesgräns når således fram till området mellan A och B. För C, som vill över till motsatta trottoaren, spärras gatan av bilernas Y och Z uppträdande. H, som befinner sig mellan bilen Y och motorcykeln, bedömer dessas resp. ps.-f. utrymmesgräns såsom ej nående fullt fram till sig och går utan nervpåkänning över gatan. Betr. E och F se artikeltexten.



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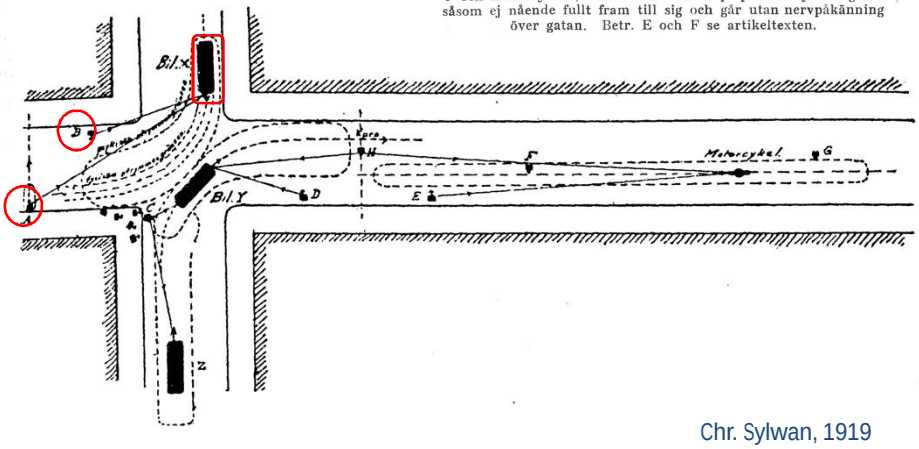

Chr. Sylwan, 1919

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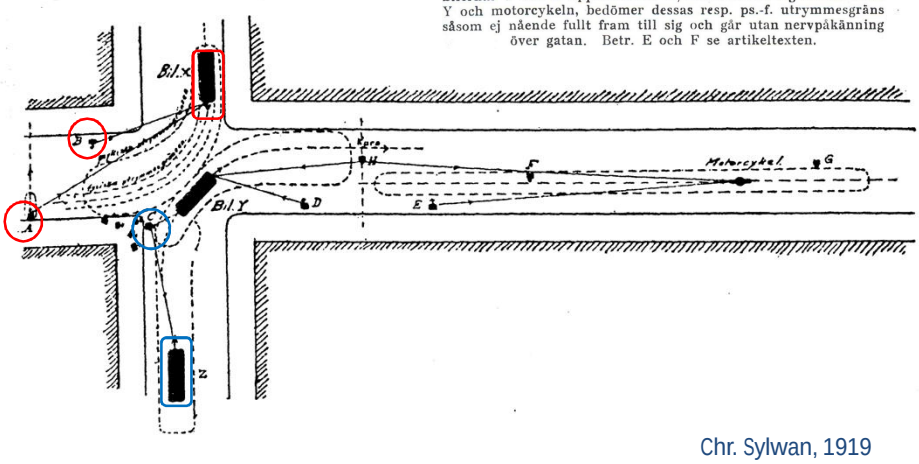

Chr. Sylwan, 1919

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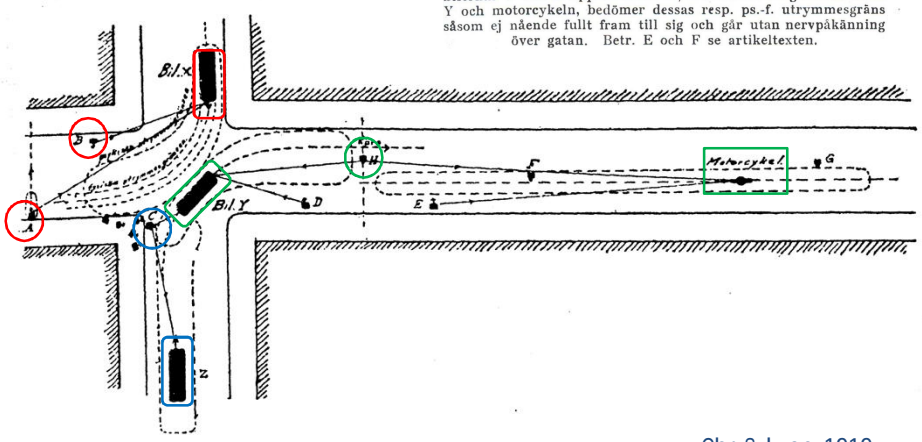
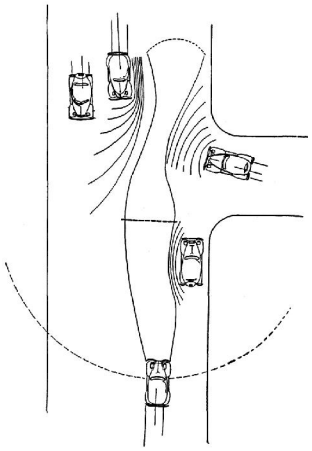


Chr. Sylwan, 1919

20 years later

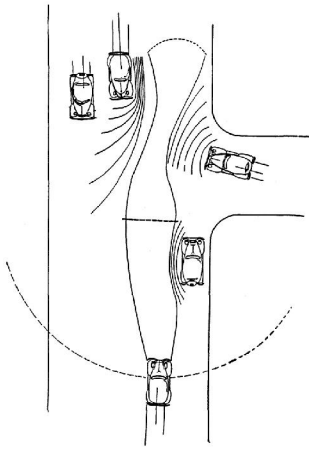
- Gibson and Crooks 1938,
- Field of safe travel, of possible paths which the car may take unimpeded
- The skillful driver recognizes the *valences* of obstacles quickly and automatically, and projects their clearance-lines correctly



Gibson and Crooks 1938

Gibson & Crooks 1938

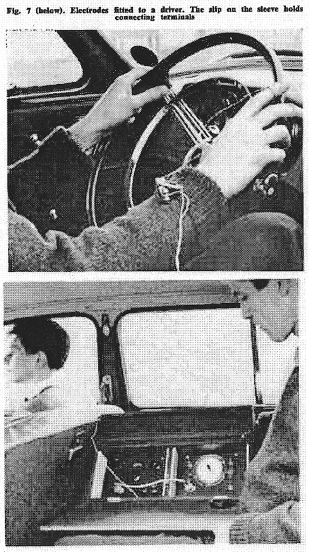
- For the experienced driver, the car is in a sense projected to its potential location at the front of the stopping zone.
- Hence, when the field of safe travel contracts by reason of an obstacle which encroaches upon it, *deceleration occurs in proportion as the forward margin of the field recedes toward the minimum stopping zone*.



Gibson and Crooks 1938

Taylor 1961-64

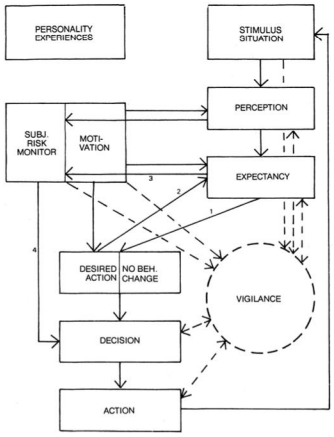
- Donald Taylor 1962, skin conductance responses (SCR, GSR) while driving
- Taylor 1964,
- Driving is a *self-paced task* governed by the level of emotional tension or anxiety which the driver wishes to tolerate



Taylor 1962

Näätänen and Summala 1974-76

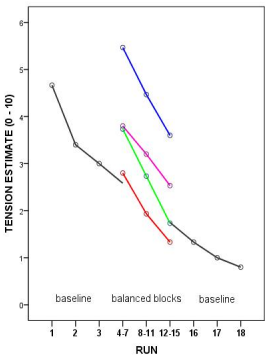
- A motivational model of driver behaviour
- "Emphasis on what the driver actually does in any given traffic situation rather than on his driving skills and/or traffic conditions as such"
- Simple control loop
- Drivers learn to control safety margins as based on expectancies
- Motives and emotions push towards higher speed and risk, towards the threshold margins that trigger "subjective risk monitor" - feeling of risk
- Habituation: drivers "adapt to risk", most of time in everyday driving they do not feel any risk ("zero-risk model")
- Full subjective control and self-confidence with practice



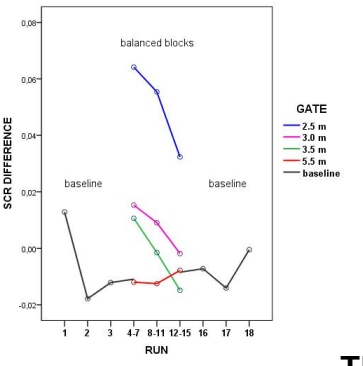
Näätänen and Summala, 1974, 1976

"Keep 50 km/, drive through the gate"

COGNITIVE (TENSION) ESTIMATE



SKIN CONDUCTANCE RESPONSE



Summala et al ICTTP2012

TRU

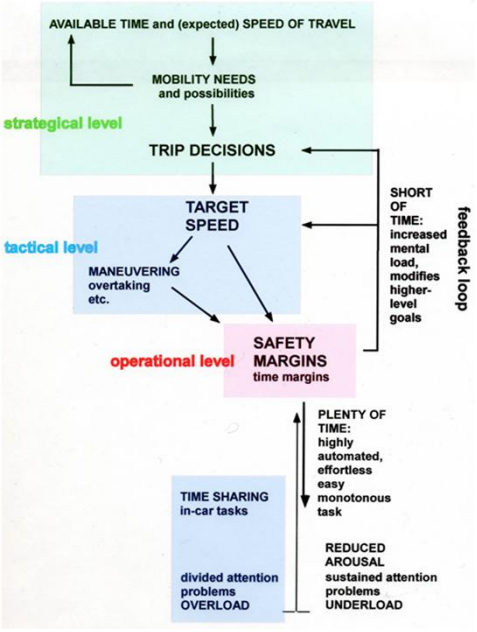
CTS: comfort through satisficing

- Sufficient space and time margins, for survival
- Sufficient progress of trip and in motion, for mobility
- Driving comfort: not too high accelerations or vibration
- Conforming to social and legal rules

Summala 2007

Safety problems

Time?



Summala 1997

Problems

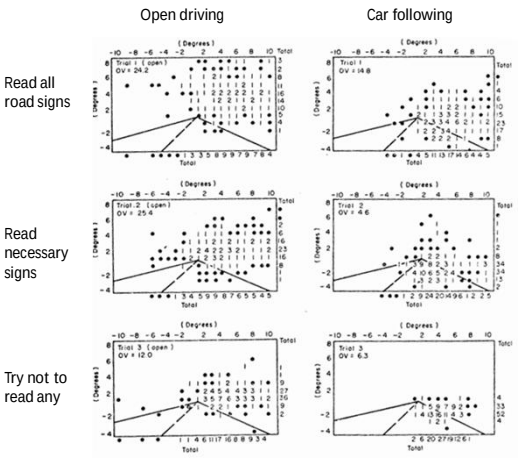
- Full subjective control, feeling of safety
- Plenty of time,
- Monotony, drowsiness
- Driver distraction
- Selective and deceptive skills: subjective and objective

- Fun of driving

Visual guidance

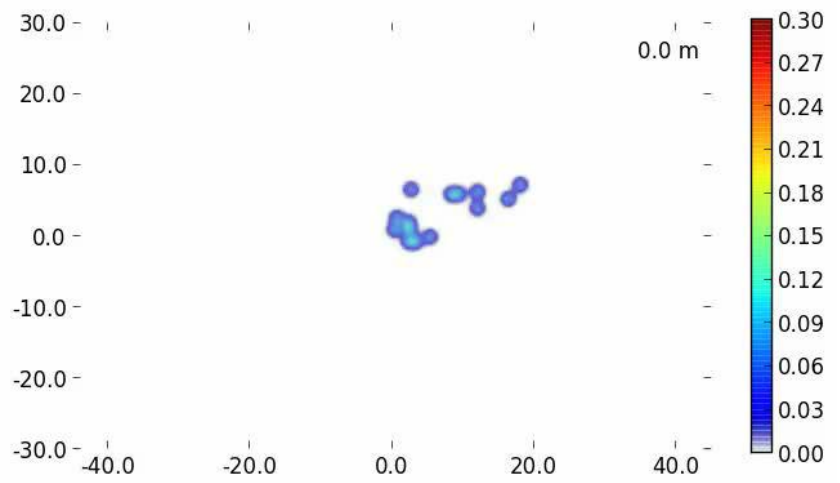
Visual guidance and eye movements

- Early eye-movement research
- Mourant & Rockwell 1969, Drivers' eye movements and visual workload



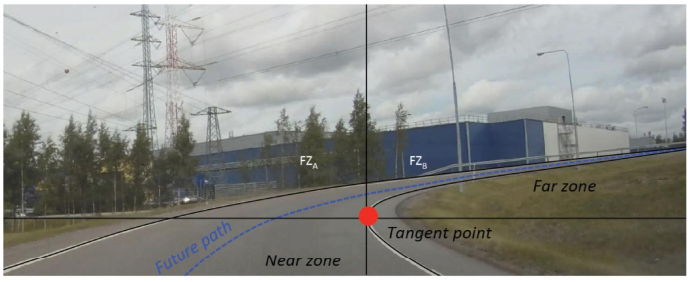
Mourant & Rockwell 1969

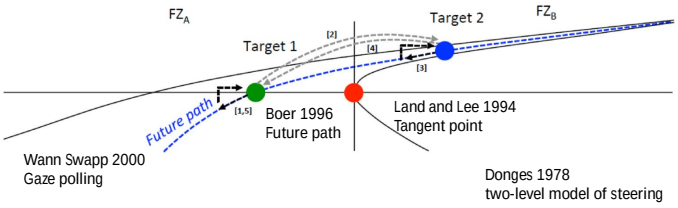
Visual guidance: dynamic modelling



Lappi et al Journal of Vision in press

Future path - Tangent point

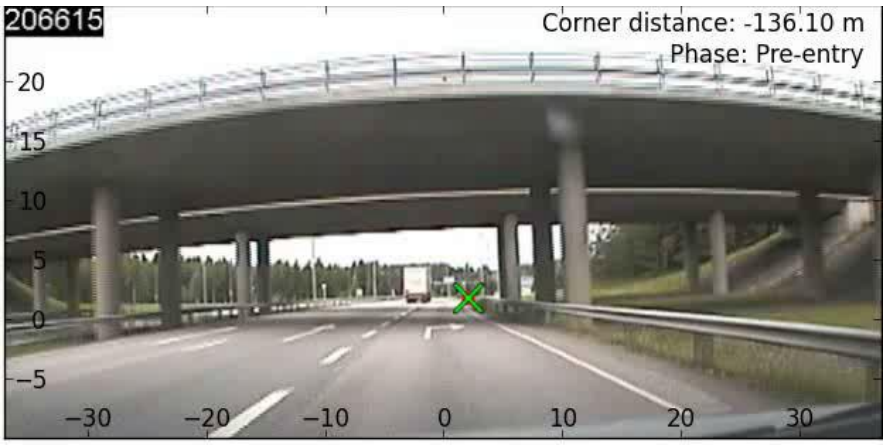




Lappi et al PlosOne 2013

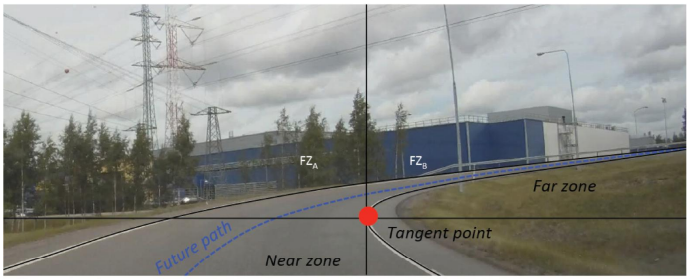
Ramp experiments

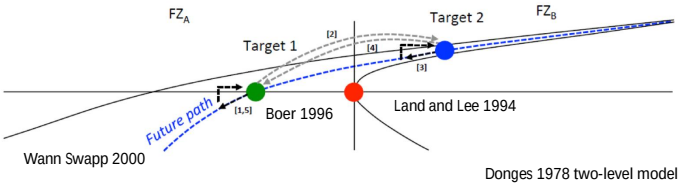
Lappi et al PlosOne 2013



Lappi et al PlosOne 2013

Saccades – Pursuit eye movements (OKN)

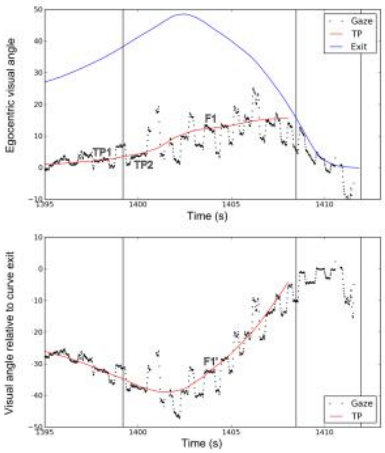




Donges 1978 two-level model of steering

Lappi et al PlosOne 2013

Egocentric - allocentric coordinates

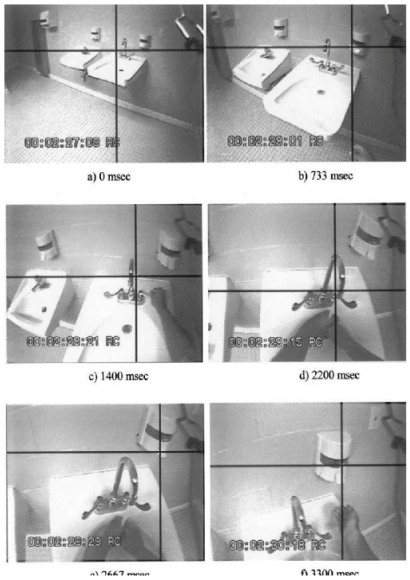


Lappi & Lehtonen JEMR 2013

Guiding and look-ahead fixations

Guiding and look-ahead fixations

- In hand washing
- Orienting
- Guiding the current subtask
- Anticipating the next subtask in sequence



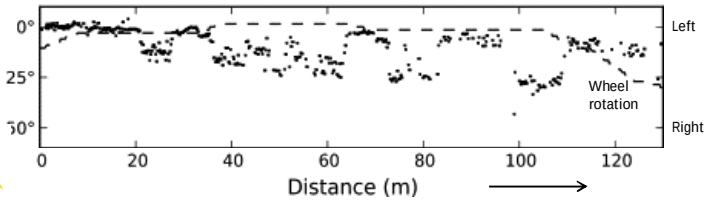
Pelz & Canosa 2001

Guiding and look-ahead fixations

Lehtonen et al TRF 2012

Guiding and look-ahead fixations

Gaze eccentricity / wheel rotation



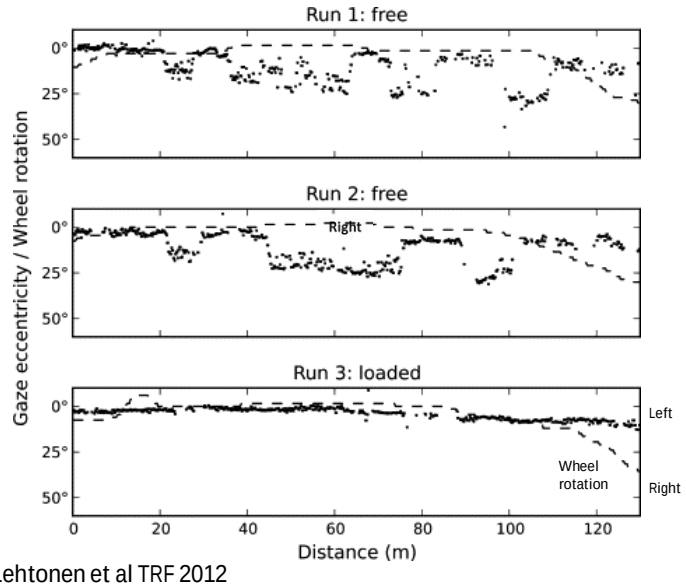
Lehtonen et al TRF 2012

Cognitive non-visual load vs. control

- Self-paced additive serial task (Lamble et al 1999)*, listening to a series of numbers, ”add the two last numbers continuously”
- Cf. N-back, listening to a series of numbers, repeat it (N-0) or an earlier one (N-1, N-2, etc.)**

*original PASAT Sampson 1956, Gronwall 1977
**e.g. Reimer & Mehler 2011

Cognitive load: SPASAT

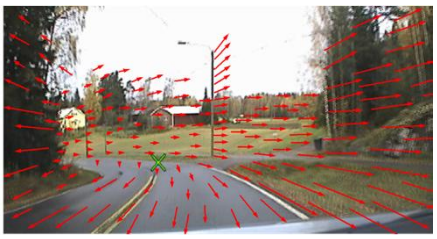


Lehtonen et al TRF 2012

Focal and ambient vision

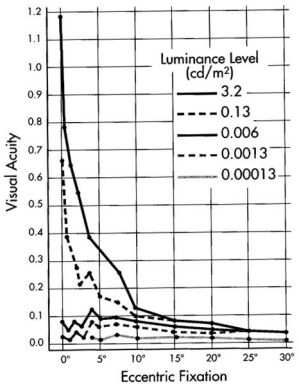
Focal and ambient vision

Optic flow



Lappi 2013

Visual acuity



Mandelbaum Sloane 1947

Peripheral vision in lane keeping

- Mourant & Rockwell 1970, lane keeping with peripheral vision
- Mourant & Rockwell 1972, novices look closer to vehicle

”Maximum performance” experiments

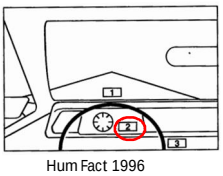
”Forced peripheral vision driving paradigm”

Lane keeping

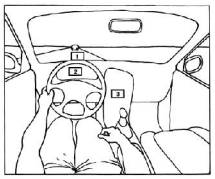
Car following

Lane keeping vs. Car following

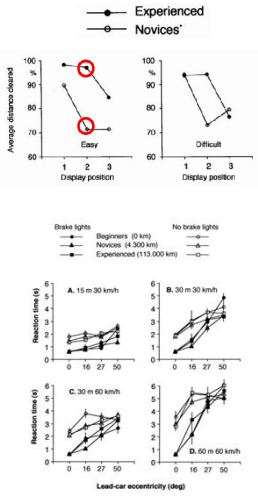
- Illusory effect
- With practice, drivers learn
- to keep the car in lane when looking away from road, *
- but not to detect braking or deceleration of the lead car



Hum Fact 1996



AAP 1998



*no experience differences when blindfold

”Everyday performance”: Time sharing while driving

- Zwahlen, 1988
- Wierwille 1988

- Vision in Vehicles 1988

”Everyday performance”: Time sharing while driving

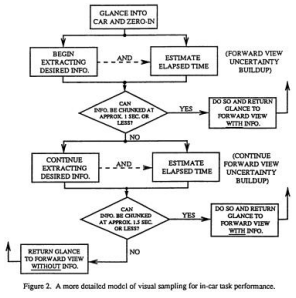
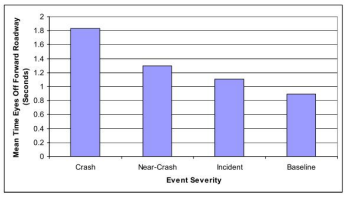


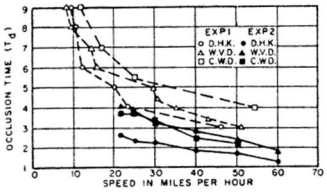
Figure 2. A more detailed model of visual sampling for in-car task performance.

Wierwille VIV 1993

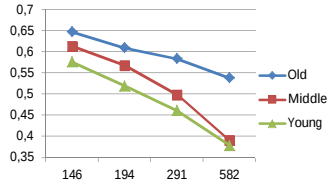


Klauer, Dingus et al 100-car naturalistic study

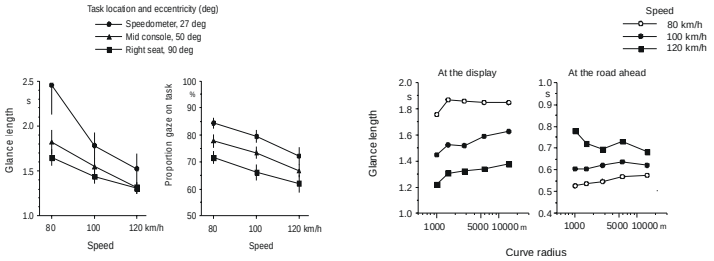
Visual demand/available time



Senders 1967, speed by visual occlusion

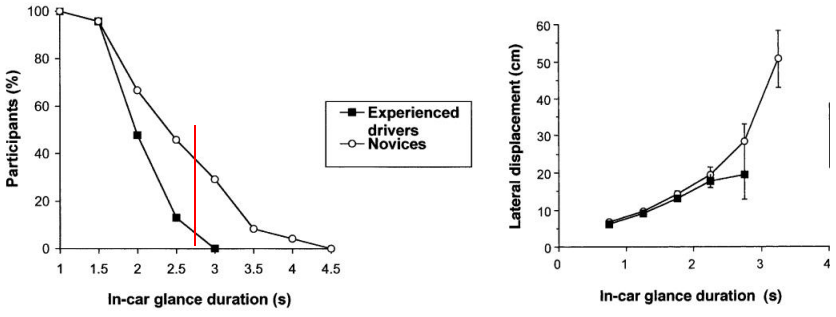


Tsimhoni & Green 1999, visual occlusion by curve radius, proportion time eyes on road



Wikman et al 1997, continuous visual in-car task on a motorway, by curve radius, speed, and target eccentricity

The experience effect



Wikman et al Ergonomics 1998, mobile phone, radio adjustment, cassette change

Task switching strategy and age

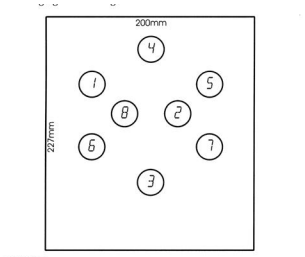
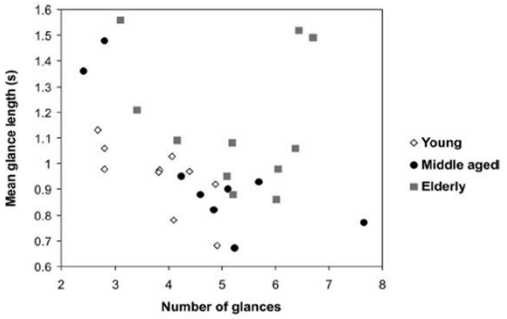


FIGURE 1.
Varied mapping keyboard used in the experiments. When the participant had keyed numbers 1 to 8 consecutively, they were rearranged and the task continued similarly.

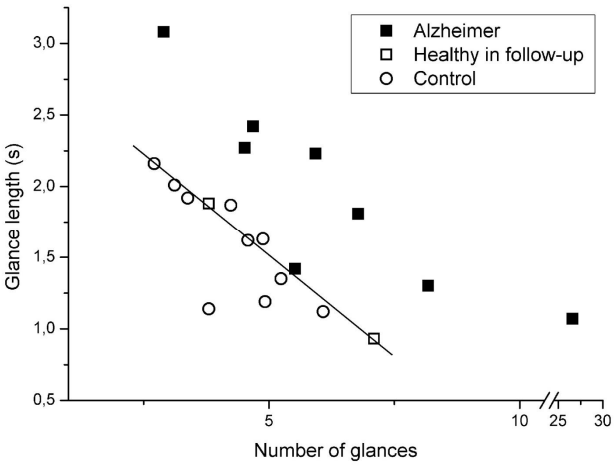


Glance length and number of glances per trial for each participant by age group.

Wikman & 2005 Optometry & Vision Science

On chunking and interruptions,
also e.g. Brumby et al 2009, Kujala 2010

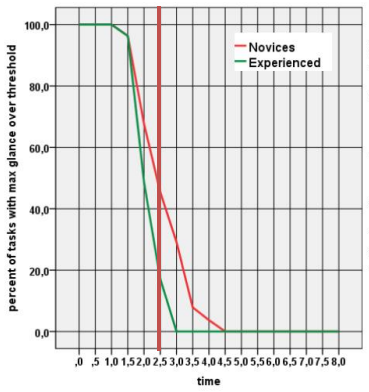
Task switching strategy and Alzheimer



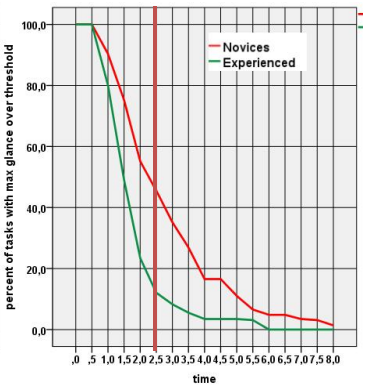
Summala, Wikman, Warjus, Elomaa, Harjula, Sulkava, unpublished

The experience effect: on-road vs. simulator

On road (Wikman et al 1998)



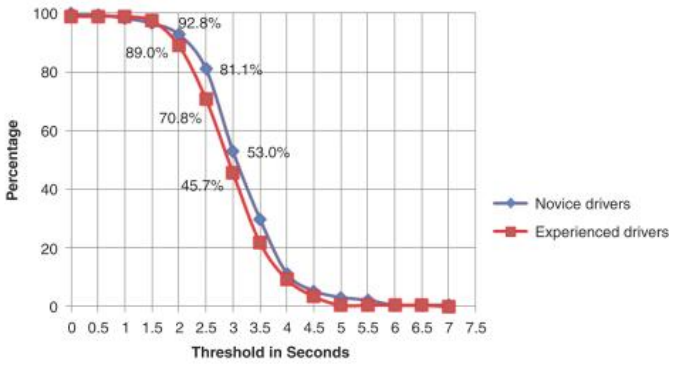
Simulator (Chan et al 2010)



Can we generalize these results to outside-vehicle targets?

Dukic et al TIP 2013

Outside-vehicle targets: billboards in a simulator



Divekar et al 2012

External task distracts hazard perception also among experienced drivers

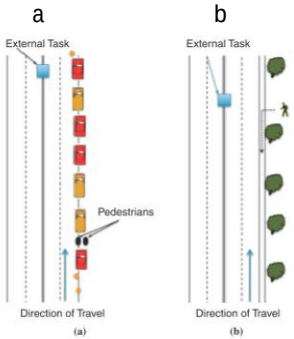


FIGURE 2 Anticipation scenarios: (a) passive hazard, cars parked on the side of the road in the presence of an external task, and (b) active hazard, previously obscured pedestrian running toward the sidewalk after the external task is presented.

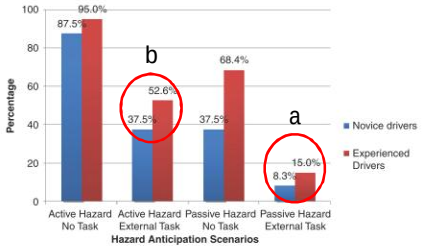


FIGURE 5 Percentage of scenarios in which novice drivers and experienced drivers recognized the risk.

Divekar et al 2012

In-vehicle vs. outside-vehicle targets

- Egocentric vs. allocentric reference
- Visual field asymmetry
- More information available
- Practice in primary and secondary task
- Illusion of control

Dukic et al TIP 2013

Summala 1997

Summary

- Modern eye recording facilities already make possible focussed real-life research and modelling of dynamic visual guidance and anticipation -

however, with considerable amount of work

Summary

- Visual guiding in curve driving:
- The first detailed real-life data to solve the future path vs. tangent point debate

Summary

- Visual guiding in curve driving:
- Drivers plan a future trajectory, follow it with guiding fixations and anticipate further up with look-ahead fixations;
- the latter however drop out when the driver is cognitively loaded

Summary

- Experience effect in the use of peripheral vision not unproblematic:
- Learning to keep the car in lane with peripheral vision facilitates time sharing with in-car targets,
- but may deceive an experienced driver in car following

Summary

- Inside-vehicle vs. outside-vehicle target difference:
- Outside-vehicle targets may deceive experienced drivers even though they have learned to manage with inside-vehicle targets.
- One proposed explanation is their location in the allocentric (world) coordination that supports the primary lane keeping task.
- More research is needed on egocentric vs allocentric/car vs world /peripersonal vs extrapersonal space

Thank you

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Liikennetutkimus-yksikkö

KÄYTTÄYTYMISTIETEIDEN LAITOS HELSINGIN YLIOPISTO

Helsingin yliopiston Liikennetutkimusyksikkö on perustettu vuonna 1971.

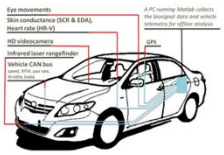
Yksikön perustehtävät ovat korkeatasoinen käyttäytymistieteellinen perustutkimus ja siihen perustuva korkein opetus, sekä liikkuvien ihmisten hyvinvointia edesauttavan tutkimustiedon tuottaminen ja levittäminen

Tutkimuskohteena on ihmisen käyttäytyminen riskialttiissa luonnollisessa toimintaympäristössä, ja sen taustalla olevat kognitiiviset ja hermostolliset mekanismit.

Tutkimusmenetelminä käytämme kvantitatiivisiin mittoihin perustuvaa kenttätutkimusta, laboratoriokokeita ja simulaatioita, psykologisia testejä, onnettomuusanalyysiä sekä liikennekäyttäytymisen ja liikennekognition laskennallista mallintamista.

Tutkimme ihmistä läpi koko elämänkaaren, ja oppimista läpi kaikkien taitotasojen aloittelijasta eksperttiin.

Tutkimustiedolla on sovelluksia ajo-opetuksen kehittämiseen, ajokyvyn arviointiin, liikenteen suunnitteluun ja ohjaukseen, sekä liikennekuolemien ennaltaehkäisyyn.



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Traffic Research Unit

INSTITUTE OF BEHAVIOURAL SCIENCES UNIVERSITY OF HELSINKI

The Traffic Resarch Unit of the University of Helsinki was founded in 1971.

The unit's mission is to conduct high quality basic research in behavioural science, to provide research-based higher education, and to produce and disseminate research results conducive to the well-being of people on the move.

The object of our research is human behaviour in a natural hazardous activity, and the cognitive and neural mechanisms behind it.

The research methods used include quantitative measurements in the field, laboratory experiments and simulations, psychological tests, accident analysis, and computational modeling of road-user behaviour and traffic cognition.

We study human behaviour across the entire lifespan, at all levels of skill, and the learning process from novice to expert.

The research has applications in driver education, driver assessment and licensing, road and traffic design, vehicle design, legislation, and in the prevention of road fatalities.

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