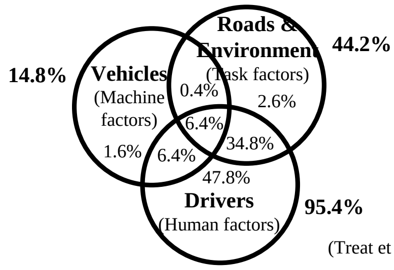
PSYC305

Applied Cognition & Neuroscience

Road Transport I

85-95% of crashes are attributed to ***human error***



(Treat et al., 1977)

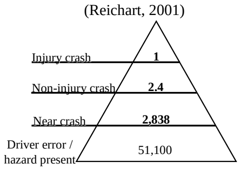
There is usually no single cause of a crash

(blaming the driver makes us feel better but the system doesn't get fixed)

Human Error

Common cause hypothesis: errors and crashes have the same causal mechanisms – can study driver errors as proxy variables for crashes

(Reichart, 2001)



(Dingus, 1999)

3 Types of Error

Mistakes: unskilled actions, due to inexperience, intentional but *wrong*

Violations: intentional errors, shortcuts, breaking the rules [largest cause of fatalities]

Action slips & lapses: well-practised automatic actions (open-loop/unintentional) [largest cause of error & crashes]

Because so many errors are due to slips & lapses, regulations and reminders have limited effectiveness in error prevention ("*Be careful*" only works so far)

Error is ubiquitous - it's part of being human
(Doctors & nurses make an average 1.7 errors per patient)

Driver Errors

(Charlton, Newman, & Baas, 2003)

"Slips" most common, followed by "violations", "mistakes" least frequent

Young drivers reported most "mistakes"

Women reported most "slips"

Men reported most "violations" & "aggressive violations"

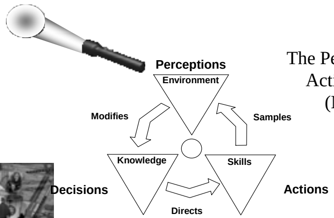
Violations negatively correlated with age and positively correlated with amount of driving

Older drivers reported fewest violations

Young + rural + male = most violations

The Task of Driving

"Driving is a skill-based, rule-governed, expressive activity involving balancing capability and task difficulty to avoid loss of control and ongoing real time negotiation with co-present transient others to avoid intersecting trajectories while maintaining and enhancing your self-image" *Stephen Stradling 2005*



The Perception-Decision-Action (PDA) Cycle (Neisser, 1976)

1) Perception stage – effective field of vision

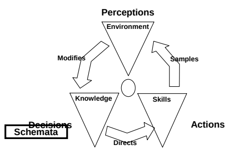
The driver's eye cannot take in the whole roadway with acuity
Foveal vision is 2° - 4°

Drivers use rapid fixations to take in the scene
100 – 300 msec for lane position
2 sec for estimating speed and distance or reading road signs

50 km/h = 14m per sec 100 km/h = 28m per sec

Horizontal field of vision = 150° at 50 km/h
Horizontal field of vision = 50° at 100 km/h
Effective field of vision becomes narrower and deeper

The Task of Driving



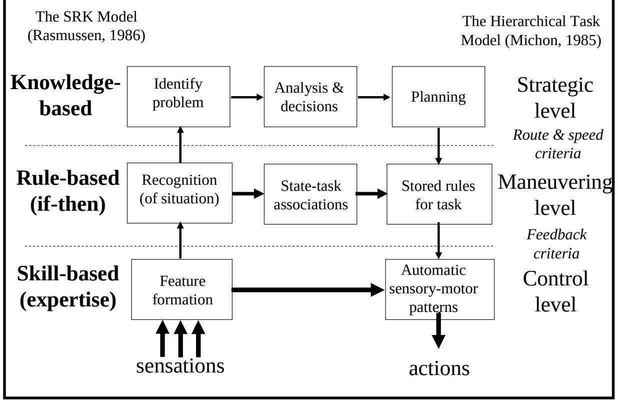
10,000 PDA cycles per hour
on a straight road
20,000 + on a demanding road

Highly practised tasks become automatic

Individual thoughts and actions repeated together often enough become combined into a single unit an ***open-loop*** (ballistic) program or script

Driving Without Awareness

Bypassing the decision stage



Combining the two models (Ranney, 1994)

Conscious attention required while driving

	Strategic / planning	Tactical / maneuvering	Control / procedural
Knowledge-based	Navigating in an unfamiliar area	Controlling a skid on ice	Learner driver first lessons
Rule-based (if-then)	Choice between familiar routes	Overtaking other vehicles	Driving an unfamiliar vehicle
Skill-based (expertise)	Route used for daily commute	Negotiating a familiar intersection	Vehicle handling on curves

More ↑ ↓ Less

Driving Without Awareness

Percent of time spent driving at each level

			Error Types
10%	Supervisory level: knowledge-based & rule-based strategy & tactics (closed-loop choices)	navigating in an unfamiliar area, overtaking, controlling a skid on ice, learning to drive	**Mistakes** brake too quickly, underestimate speed **Violations** deliberate speeding, overtaking on curves
90%	Procedural level: skill-based expertise automatic scripts & sensory motor patterns (open-loop)	speed maintenance, lane position & steering, eye scanning, negotiating a familiar intersection, headway distances, handling around curves, brake reaction times	**Slips & lapses** inadvertent speeding, starting in wrong gear, backing or change lanes without looking, switch on wipers instead of indicators

Can't we fix to roads to prevent driver error?

Make roads wider, smooth out dangerous corners, equip cars with centre high-mounted brake lights, seatbelts & airbags

The Problem of Behavioural Adaptation

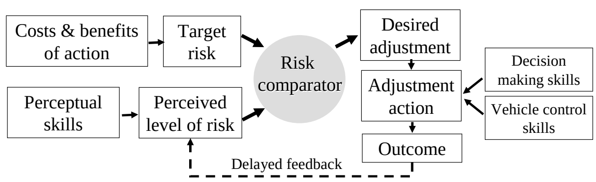
Road safety interventions often have unanticipated (& contrary) consequences
e.g. result in higher speeds & shorter headway distances

Risk Homeostasis Theory (RHT)

(Wilde, 1982)

People have a "set-point" for acceptable risk
if current risk is perceived as below the set-point, people act to increase the risk

Crash rates per amount travelled remain constant despite improvements *(no point in improving the system?)*



(Wilde, 1994)

Task-Capability Interface (TCI) Model

(Fuller, 2000)

People have a “set-point” for acceptable workload
if current taks difficulty is perceived as below the set-point, people act to increase the difficulty

If a driver can increase speed without increasing difficulty, they will do so. If conditions exceed the workload threshold, the driver will avoid those conditions

Time pressure / Motivation / Social forces / Competence → Target workload → Comparator ← Perceived task difficulty

Comparator → Decision → Action → Effects on speed & position - - → Perceived task difficulty

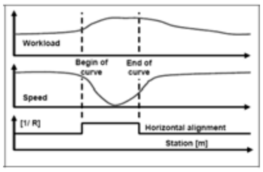
(Fuller & Santos 2002)

Task-Capability Interface (TCI) Model

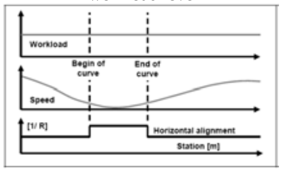
(Fuller, 2000)

People have a “set-point” for acceptable workload

On a poorly designed curve, as difficulty increases through the curve, workload increases, & driver quickly reduces their speed



On a well-designed curve, early cues about curve difficulty are provided & a driver can adjust their speed early to maintain desired workload level



(Fuller, 2005)

Zero Risk Theory

(Naatanen & Summala, 1976)

All drivers act to minimise risk (keep it close to zero) crashes result from underestimation of risk & overestimation of one’s own driving skill

Motivation module: mobility needs, time availability, expected speed of travel → Trip decisions → Time margins

Target speed / Route choice; Speed maint / overtaking / gap accept.; Safety margins

Plenty of time/safe: effortless, proceduralised task

Unexpected delays → Feedback processes: Risk of lateness (emotional), Driving risk (rational)

Most of the time driving is automatic with no concern of risk

Maintaining progress at target speed is important motivator

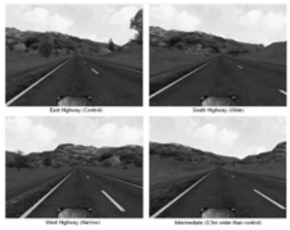
Explicit & Implicit Processes in Behavioural Adaptation

2005 B Lewis-Evans Masters’ Thesis
(Lewis-Evans & Charlton, 2006)

Is behavioural adaptation due to explicit decisions (risk) or implicit (automatic) perceptions of speed?

Speeds decrease with road width, without any explicit awareness of changes in road width
(or awareness of changes in driving speed)

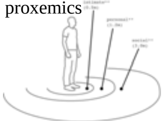
Risk ratings (and preference ratings) change also but they are retrospective and not attributed to width changes (stated reasons include more traffic sharper curves, etc.)

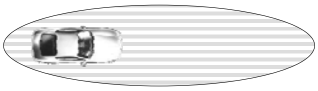


Safety Zone / Time-To-Collision (TTC)

People maintain a personal safety bubble, and drivers change their relative speed and position to maintain it

proxemics



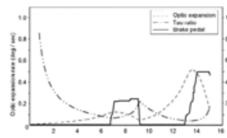


Two interpretations:

Optic expansion rate: ‘looming’ stimulus automatically captures attention (Gibson, 1979)

TTC *Tau* ratio: explicit (conscious) judgement of time-to-collision (Lee, 1976)

Following distance / braking distance study shows early braking guided by explicit TTC, distraction task interferes with early braking, automatic detection of looming stimuli happens late (too late?)



2006 H. Terry Masters’ thesis
(Terry, Charlton & Perrone, in press)

The most common engineering approach to managing drivers’ speeds is via road signs

What attracts drivers’ attention?

(Hughes and Cole 1986)

Attentional Conspicuity

1. Physical characteristics of the object, size, colour, motion, location, etc.
2. Information value (esp. unfamiliar, unexpected, or unusual).
3. Information needs of the driver.

Search Conspicuity

1. Ratio of targets to distractors (*display size effect*)
2. Similarity of target & distractors (f*eatural singletons)*

What attracts drivers' attention?

Attentional conspicuity

50 – 70% capacity expended on driving-related objects: road, markings, traffic control devices, & other vehicles

"Spare" 30-50% expended on trees, buildings, rubbish containers, advertising signs, etc.

Traffic signs = 15 – 20% of capacity

but only 1 in 10 of traffic signs present (Hughes & Cole 1986)

Memory for signs

6% correct recall, 9% correct recognition,
up to 16.5% at night (Drory & Shinar, 1982)

Performance effects

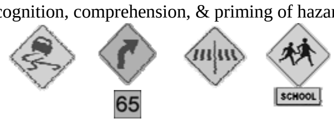
56% - 72% of <u>signs noticed</u> are accompanied by action

39-43% of unnoticed signs were accompanied by appropriate action (Fischer, 1992)

Assessment of Hazard Warning Signs

(Charlton, 2006)

Participants "drove" video road scenes and signs' were assessed for attentional conspicuity, search conspicuity, implicit & explicit recognition, comprehension, & priming of hazards



Why are so few road signs noticed?

Driving without awareness

The signs aren't novel

There are lots of other signs

The information may be redundant

They don't meet the drivers' current information needs

road warnings are often not noticed because the situation is not perceived as hazardous

Some types of warning signs do appear to work

Curve warnings that highlight the perceptual features of the curve work best, particularly in cognitively demanding situations (i.e., when drivers aren't paying attention)

Gateways & Urban Thresholds
combination of physical & visual features

Some threshold treatments worked well

Some had little effect on drivers' speeds

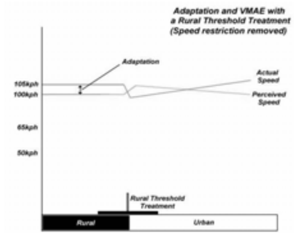
Some increased drivers' speeds 'downstream'

Which features work best & why?
Attention vs Perception

Speed Change Treatments

Gateways & Urban Thresholds
combination of physical & visual features

Thresholds work even without speed restriction information (i.e., blank signs)



But, because of VMAE, 250 m after passing threshold drivers' speeds return to a level higher than before

because of VMAE a gateway placed at the 1st house in town is much more effective than a gateway placed at a city or village boundary

Speed Change Treatments

Physical obstacles produce the largest reductions in speed, but they are unpopular (drivers will route-switch)

Combination treatments (attentional & perceptual) can also produce large speed reductions, and are more widely accepted

Downstream effects of gateways and thresholds are much more effective (3-4x) when combined with speed maintenance treatments

Speed Maintenance Treatments

Roadside features

Lane width & road width

have some of the largest speed maintenance effects

Optic flow pattern

drivers use edge rate in the visual environment to judge their speed (preconsciously)

increasing the visual edge rate increases drivers' sense of speed

We can use edge rates to maintain desired speeds

Perceptual Countermeasures

Dragon's teeth, herring bones, transverse lines, etc.

Subject to habituation (within 250m) and visual motion after effects (VMAE)

1970s – 'Traffic calming' first introduced in the Netherlands and Germany

Treatments principally relied on physical obstacles

Chicanes & "build outs"

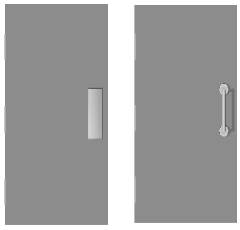
Speed humps
(sleeping policemen)

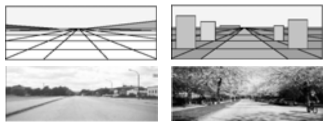
Forcing functions try to eliminate incorrect behaviour by means of interlocks & obstacles

People don't like forcing functions

When confronted with a forcing function many people will find another way around

Affordances: perceptual properties that function as "built-in" instructions





Choosing road widths, delineation, & road furniture designed to ***afford*** a desired speed & lane position

Self-explaining roads -- Self-enforcing roads (SER)

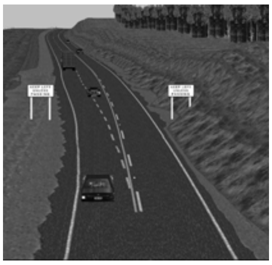
Using perceptual properties to affect the **"look & feel"** of a road

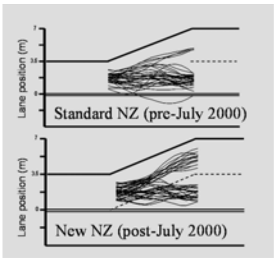
Perceptual properties processed *without awareness*

Self-explaining roads aren't just for speed management

Addition of a continuity line ***affords*** staying left at overtaking lanes

(Charlton, 2007)





Lane delineation is used by the implicit (automatic) driving script to maintain lane position

Delineation Treatments to Improve Lane Position

South Waikato and Taupo Target (SWATT) 2010 study team identified 2 trends in crash data:

1. Drivers losing control/failing to stay on road
   adverse conditions combined with inattention, speed & alcohol

2. Crossing centre line/head-on crashes
   resulting from loss of control & inappropriate overtaking

Recommended Enhanced delineation: wider, profiled, edge & centrelines & increased use of no-passing lines

Systematic treatment approach to achieve consistent "look & feel" through corridor

Sustainable Safety – The Netherlands

Three speed management principles

Predictability – preventing uncertainty among road users

Homogeneity – preventing major variations in speed, direction and mass of vehicles (at moderate & high driving speeds)

Functionality – preventing unintended use of the infrastructure

Road environment hierarchy – 3 levels

Roads with an access function – access to homes and shops while ensuring safety of the street as a meeting place

Roads with a distributor function – distribution of collection of traffic to and from different districts and residential areas

Roads with a through function – rapid movement of through traffic

Road Hierarchy for Speed Management
The United Kingdom

Tier 1: Through routes of national or regional importance priority given to the safe and efficient movement of vehicles

Tier 2: Mixed use roads – catering primarily to motorised traffic with a limited number of vulnerable road users and occasional access (rather than frequent access) to properties, physical separation from vulnerable road users.

Tier 3: Local roads – primarily for access, and where vulnerable road users are to be expected

"*The hierarchy should be largely self-enforcing and to achieve this it is important for the designated speed environment to be obvious to road users, as well as acceptable to them.*"

Self-Explaining Roads in New Zealand

National Speed Management Initiative

*“The emphasis is not just on speed limit enforcement, it includes perceptual measures that influence the speed that a driver feels is appropriate for the section of road upon which they are driving – in effect the ‘**self-explaining road**’”*

National Road Safety Cttee/Ministry of Transport 2004

Roads shouldn’t need an instruction manual

Another (engineering) approach

"... speaking mathematically, he (man) is best when doing least." (Birmingham & Taylor, 1954)

Intelligent Vehicle-Highway Automation

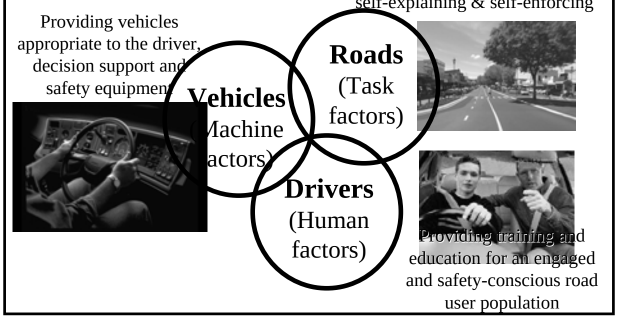
The Paradox of Automation

As the level of automation is increased, so are the consequences of any single human error.

A Human Factors approach

Designing the system to fit human capabilities *and quit blaming the victims*

Our Road Transport System



Laboratory assignment #1

Class experiment on road transport

If so many drivers insist on using cell phones while they drive, can we modify the technology to alert drivers to the presence of potential road hazards?

Hypothesis: *Hazard warning tones broadcast on cellphone frequencies will overcome the negative effects of cell phone conversations on driver performance*

Laboratory assignment #1

Class experiment on road transport

Two groups of participants:

1. Drivers conversing on cellphones
2. Drivers conversing on cellphones that emit hazard warning tones

Materials:

TARS driving simulator equipped with hands-free cell phone

Simulated 21 km road

Laboratory assignment #1

Class experiment on road transport

Procedure:

Participants self-assigned into pairs

Participant pairs randomly assigned to each group

Pairs drive simulated road (book sim time with me)

Analysis:

Record & plot speed and RT data for 5 locations on road (from simulator data files)

Transcribe & count conversation elements at same 5 locations (from video recordings)

Examples of both provided on Moodle

Laboratory assignment #1

Class experiment on road transport

Report:

Locate and summarise 3 recent journal articles on the subject of cellphones & driver distractions

Describe class experimental procedure

Describe your pair's results (speed, RT, & conversation)

Compare individual results to group results

7-10 pages total (typed & double-spaced)

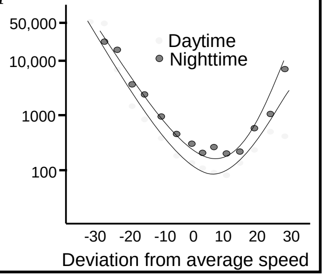
Data forms due 20 March (via email) – Reports due 3 April (via FIC)

Myth: If everybody else is speeding it is safer to keep up with them

(Travelling faster than the surrounding traffic provides greater manoeuvrability)

Solomon's (1964) "*Accidents on main rural highways related to speed driver & vehicle*"

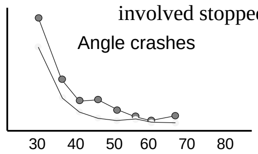
Found a U-shaped curve of crash rates, lowest for travel speeds near the mean speed of traffic

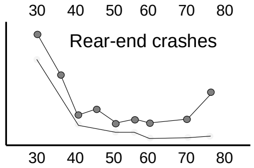


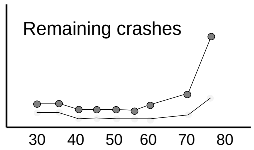
Solomon's (1964) "*Accidents on main rural highways related to speed driver & vehicle*"

But... Solomon's data were from 1950s era roads, which lacked turn lanes and passing lanes

many crashes occurred at intersections and involved stopped or slowing vehicles





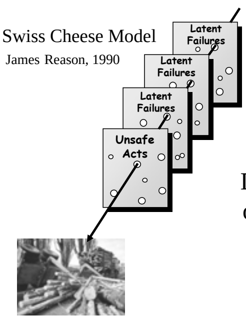


Cowley (1987) "*Risk of injury crashes & speed*"

Latent Failures – *Failures of Design*

The Swiss Cheese Model

James Reason, 1990



Latent failures set the stage for unsafe acts (active failures); appropriate safeguards are missing

Designs that fail to prevent, or contribute to, user errors

Myth: Talking on cellphones while driving is no riskier than conversing with a passenger

Conversational suppression – when the passenger sees an approaching hazard, they stop talking

SA enhancement – passengers often alert the driver to hazards, often discuss the road ahead

Intelligibility – passengers are easier for drivers to hear & understand than cellphone conversors

Myth: Talking on cellphones is similar to other distractions like radios and eating

Radio tuning & eating are self-paced and discrete
Conversations are externally-paced and continuous

On-going & externally-paced distractions increase mental workload & decrease situation awareness

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Myth: Hands-free cellphones are safer than hand-held

Cellphone conversations typically <u>do not</u> produce major disruptions in lane keeping & speed (automatic)

Manipulation of the phone can impair maneuvering, but <u>is not</u> the major source of impairment

Cellphone conversations <u>do</u> slow reactions to traffic & hazards

85% of cellphone owners use them while driving

Cellphone conversations slow drivers' reactions to traffic & hazards

Cellphone conversations impair memory for road signs

Cellphone conversations increase crash probability 400%

Cellphone conversations as dangerous as 0.08 BAC

Cellphone use while driving has been banned or restricted in 46 countries