

# The Institute of Road Transport Engineers New Zealand

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## *Biomechanics of Driving: Stimulus, Response and Fatigue Issues*

By

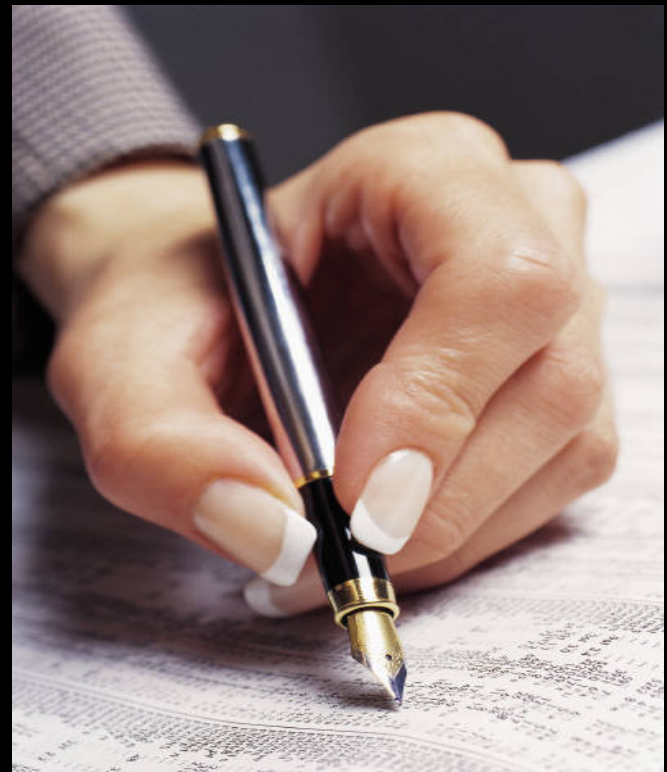
*Iain Seymour-Hart*

*Head, Department of Automotive Engineering*

*Hong Kong Institute of Vocational Education*

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*Please have 'pen n  
paper' ready for the  
Quiz [later on]  
Thanks!*



# Importance of Mobility



- Mobility is of critical importance to the economy of any country.
- People and product need to be moved from place to place in order to make the economy work.
- Delivering product from the manufacturer to the customer normally involves at least two journeys by road.
- A large proportion of people rely on land transport to get them to their place of work.

# Freedom to Travel



- People have got used to having the freedom to travel where and when they want.
- It seems that we humans, all over the globe, have become addicted to mobility.
- We humans tend to resist being restrained.
- Drivers in the USA spend over 1 Billion hours every week behind the wheel.
- There are now more than 900 million vehicles in the world.(Toyota manufactured 1.06 million units in 2001/02)
- The vehicle population is expanding rapidly.

# Private Motoring



- Most people view private vehicles as a necessity not a luxury.
- Many new towns and estates rely on the vehicle as the sole means of moving people and goods.
- Some like to race or rally vehicles.

Lord Roots once said:

*“ No other man-made device since the shields and lances of the ancient knights fulfils a man’s ego like an automobile.”*

# A Porsche Necessity or Luxury?

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# Another Great Car: Status? Speed? Excitement?





# Sports Utility Vehicle: Solid, Safe & Tough

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# Concept Motorcycle by BMW

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Why Do Men Die Younger?



Wallis  
DRESS TO KILL

# The Downside

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- Vehicle production consumes a large amount of the Earth's resources.
- Vehicles damage the Environment.
- Vehicle related air pollution shortens life-spans and causes sickness and premature death.
- Studies in UK are now finding significant deposits of heavy / precious metals along the edges of motorways thought to be blown out from Catalytic devices.
- Pollution from industrialized nations is suspected of causing famines in Africa.



# The Downside

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- In the US during 2000, there were over 6million road accidents and over 41,000 people lost their lives.
- Some 16,653 were killed in alcohol related accidents of which:
  - 10,216 were drivers,
  - 3,892 were passengers and
  - 2,545 were non occupants.



# The Downside

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- In UK during 2000, more than half a million people were injured in road accidents.
- Over 3,000 people died during the same year.
- Car crashes continue to be the main cause of brain and spinal injury.
- Car drivers are said to be 13-times more likely to get killed compared with heavy vehicle drivers.
- The heavy cost of road accidents is borne by society.



# The Downside

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- During 2001, accidents on China's roads killed 106,000 people.
- The first 5 months of 2002, 44,000 died and 233,000 were injured.
- The vehicle population in China is rapidly expanding.
- In cities such as Beijing and Shanghai bicycles are being discouraged in favour of cars [copying affluence of the west?]
- The number of bicycles is now contracting.



# High Cost?

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***It seems that we pay an enormously high cost for our mobility!***

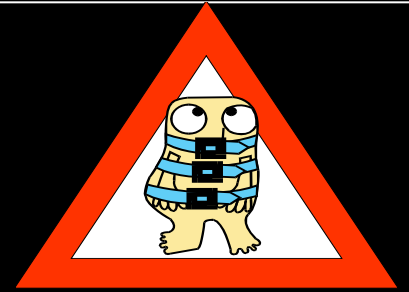
# On a lighter note: Does Your Computer Crash?

© 1999 Randy Glasbergen. [www.glasbergen.com](http://www.glasbergen.com)



**"It's the latest innovation in office safety.  
When your computer crashes, an air bag is activated  
so you won't bang your head in frustration."**

# Road Safety: A Dilemma



- Driving needs regulating to achieve a balance between people's freedoms, efficiency & safety.
- Driver training, road design, active & passive vehicle technology, licensing, speed limits, drivers hours, drink-driving laws and road signage are examples of the safety media now in place, with more likely to come.
- Legislation lags behind technology.
- Proliferation of hi-tech gadgetry such as cell phones, navigation, VCD players, facsimile machines could heighten driver distractions and lead to more crashes [National Traffic Safety Administration-USA]

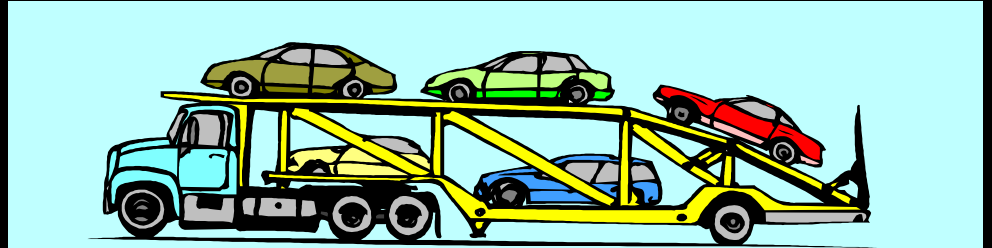
# Road Safety: A Dilemma

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- Mayer Hillman [Road Safety: The New Philosophy] has criticized the UK Transport Department whose thinking has been almost exclusively on reducing accidents rather than danger.
- Mayer says that they are wrong to claim that our roads are safer because accidents are going down and claims that the reason they are falling is because the roads are actually more dangerous (more and faster vehicles).



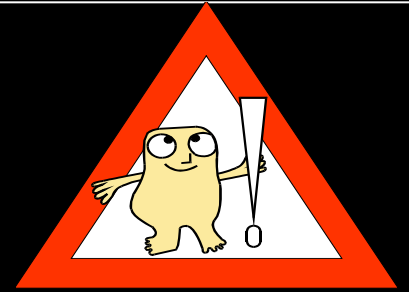
# Road Safety: A Dilemma



- Mayer criticized the way data is often presented. For example, seldom were the numbers of people killed by a certain type of vehicle shown.
- In his own survey he found that heavy vehicles were the safest form of transport because if you are driving one you are unlikely to be killed.
- He also found the heavy vehicle to be the most dangerous form of transport because if you are hit by one you are very likely to be killed.



# Road Safety: A Dilemma



- Mayer showed that in accidents involving lorries, 93% of the fatalities were other road users and not the lorry driver.
- The car was about 53% - for every driver killed someone else was killed too.
- Pedestrians were 0% so the safest form of travel was walking (later he added cycling to this category)
- He proposed that we start putting things the other way round, using the language of vulnerability. [e.g. walking or cycling aren't dangerous, pedestrians and cyclists are vulnerable]
- He argues that we need to prioritize transport modes to achieve social and environmental goals (not balance them as is often done in transport planning)

# Latest on BUSH?



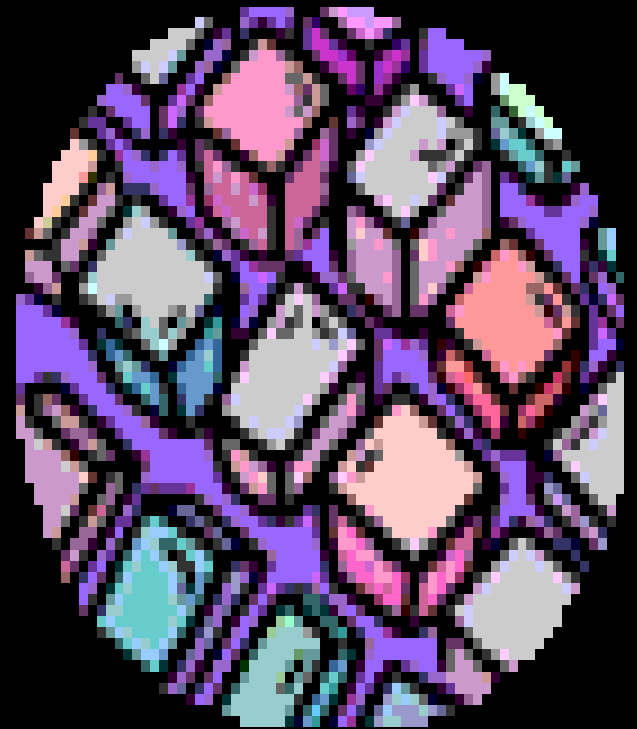
# Mentality of Drivers

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UK Road Safety Council Statistics suggest that:

- if you make traffic lanes wider drivers simply go faster.
- if you make bends safer drivers simply take-up the extra safety by driving faster.

***It has been established that “For every 1-foot (0.3metre) a traffic lane is widened, drivers drive 3mph (5km/h) faster.”***





# Mentality of Drivers

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- Drivers sometimes consider themselves to be more important than pedestrians. [Until they get out of the car and become a pedestrian]
- By installing safety related technology in vehicles, such as ABS, ESP, BAS, SRS, PWS and so forth, most drivers simply drive faster, closer to other vehicles and hence more recklessly.

*Quote: It is not what any particular driver does wrong that threatens safety, it is also the way in which other surrounding drivers behave.*

# Mentality of Drivers

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Another Quote: Pablo Picasso was once quoted as having said:

***“People who go out on the road are quite comparable to innocent victims put into a lunatic asylum. This is simply because they are surrounded by other people who all think that they are Napoleon”***



# Mentality of Drivers

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- Advanced vehicle technology plays a part in making drivers feel more and more invincible.
- Statistics show that drivers frequently flout the law, placing themselves and others at risk.
- Despite safety factors, higher fuel consumption and additional wear and tear, many drivers drive at a speed which is excessive.





# The Driver

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- Bad drivers do untold damage to Vehicle Systems.
- Bad drivers use a lot more Fuel.
- Bad drivers wear out tyres and brakes more rapidly.
- Bad drivers cause Traffic Accidents.
- Bad drivers give their company a bad name!
- Good drivers are worth their weight in Gold



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Why Do Men Die Younger?



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DRESS TO KILL

# Accident and Fuel Saving Interventions

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Michael Coyle (UK Researcher) proposes the following:

- Install an engine speed limiter.
- Agree on correct vehicle specifications.
- Minimize the width & height of the body.
- Monitor maintenance & fuel consumption (brim of the tank) to identify rogue vehicles and drivers.
- Monitor fuel stocks accurately.
- Develop a fuel efficiency culture and give feedback in terms of fuel and also emissions saved.

# Accident and Fuel Saving Interventions

## Michael Coyle Cont'd

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- Use spread sheet models to indicate the fuel efficiency costs and benefits of all decisions.
- Have the fourth needle of the tachograph activated to record engine speed.
- Constantly review all maintenance procedures.
- Take full advantage of any “free” driver training.
- Reinforce driver training for all staff.



# Vehicle Pollution: Historic Perspective

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## 1980's

- Wide Acceptance of the Need for Emission Technology
- Cleaner Fuels
- 3-Way Catalytic Converter
- Closed Loop Emission / Electronic Emission Controls
- OBD made a Requirement in California
- 10/15-Mode Test (Japan)
- Low Sulphur Diesel
- Fuel Vapour Recovery Systems
- Hybrid Vehicles



# Vehicle Pollution: Historic Perspective

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1990's to date

- Alternative Fuels
- Zero Emission Vehicles
- Systems Approach to Emissions Reduction / Improvement of Air Quality
- Fuel Cell
- Intelligent Transport Systems
- OBD introduced Nationwide (USA)
- CO2 Emissions Limited Voluntarily
- Kyoto Conference [rejected by USA]
- Extra Urban Driving Cycle and Off-Cycle Tests Introduced in Europe

# Less Polluting Vehicles

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- Bicycle
- Tram
- Light Rail Systems
- Electric Commuter Trains
- Electric Vehicles
- Trolley Buses
- Hybrid cars
- LPG Motorcycles, Scooters, Cars, Taxis and Light Buses
- CNG vehicles



# Zero Emission Detroit Tram: A Solution?





# Zero Emission Detroit Sky Train: A Solution?



# Zero Emission Electric Van: A Solution?

Courtesy of the Department of Automotive Engineering, Hong Kong





# Zero Emission Trolley Bus: A Solution?

Courtesy of Citybus Ltd of Hong Kong [coming soon, to New Zealand?]

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# Toyota Hybrid: A Solution?

Courtesy of the Department of Automotive Engineering, Hong Kong





# LPG Light Bus: A Solution?

Courtesy of the Department of Automotive Engineering, Hong Kong



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Why Do Men Die Younger?



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# Preventive Maintenance

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- A Schedule of Maintenance Recommended by the Manufacturer.
- Safety + Emission + Lubrication
- Regular Maintenance provides for a Safe, Fuel Efficient, Smooth, Reliable Operation.
- No matter what fuel powers a vehicle regular maintenance is essential if the intended benefits are to be fully realized.
- Use good quality fuel

# Practitioners Need Accurate Data

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- It is quite impossible to carry-out adjustments on modern vehicles without having the correct data to hand.
- We have put in place a comprehensive set of data, manuals and associated information.
- We have data for Traffic Accident Analysis!
- We call this the:

*The AE DataBase Centre*



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Please visit the:

# *AE DataBase Centre*

*~ NOW OPEN ~*

<http://aedatabase.vtc.edu.hk>

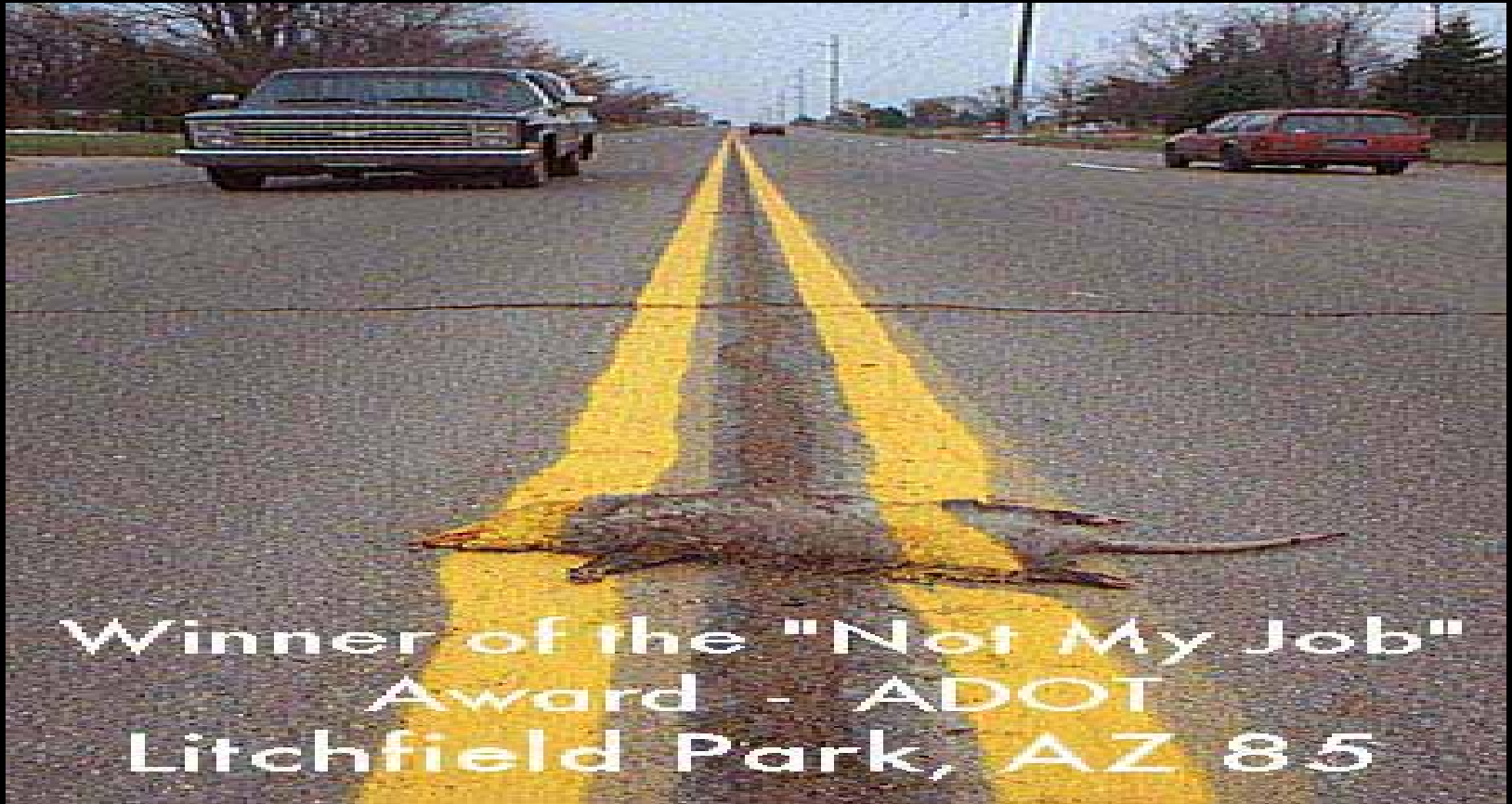
## *A Centre of Excellence*

*Subject to Continual Improvement*

*Join Now!*

# Know Your Job

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Winner of the "Not My Job"  
Award - ADOT  
Litchfield Park, AZ 85

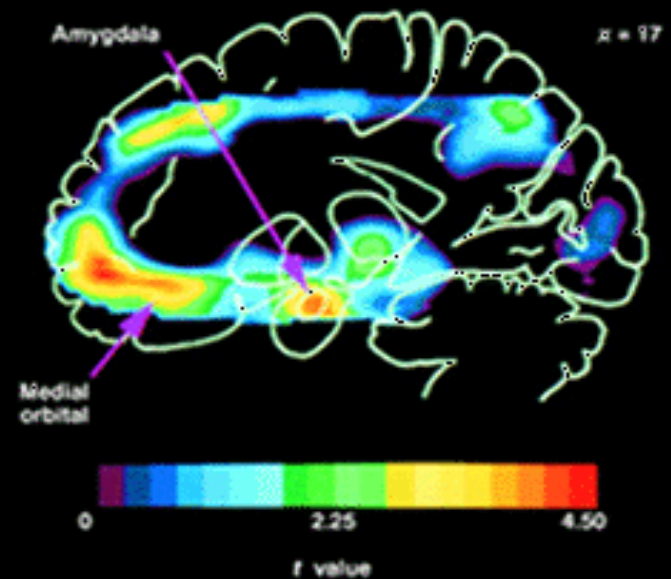


# The Brain

**THE BRAIN** and nervous system form an intricate network of electrical signals that are responsible for coordinating muscles, the senses, speech, memories, thought and emotion.

Today, data can be transmitted half way around the world in the same time as it takes a signal to move from our hand to our brain.

The centre portion is known as the reptilian brain. Over time our brain has increased in size as we became more civilised. Sometimes we regress to using our reptilian instincts during episodes of roadrage.



# Alertness to Driving

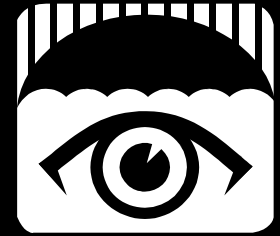
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- Attention to driving / concentrating on the task to hand.
- Driver must be in control of his/her emotion.
- The practice of driving becomes 'second nature' or quite boring.
- It's easy to be distracted, lose concentration or to even nod off at the wheel.
- Vision and alertness are vital elements whilst driving.



# Vision

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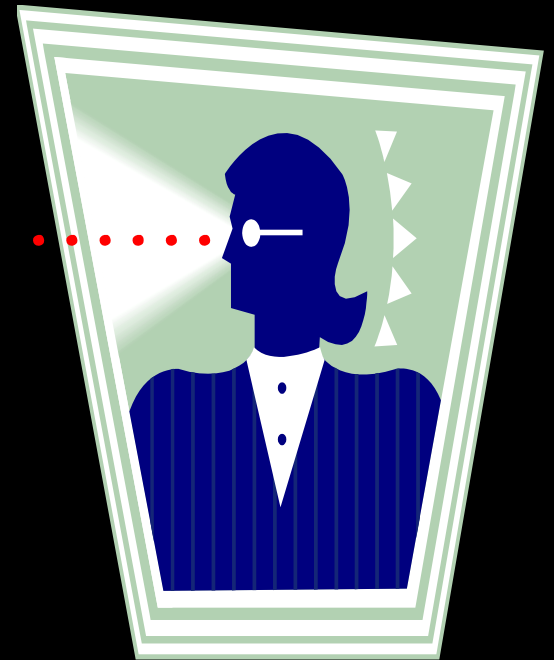


- Good vision is needed to spot a hazard whilst driving.
- A driver not paying attention might just as well be blind.
- 95% of the information required for driving is visual.
- We know very little about the processing of signals supplied to the brain by the eye.
- Out of the 5 senses vision takes up about 70% of the sensory part of the brain.
- Aging results in a loss of processing power / reduction in the quality of visual information collected by the eye.

# Vision

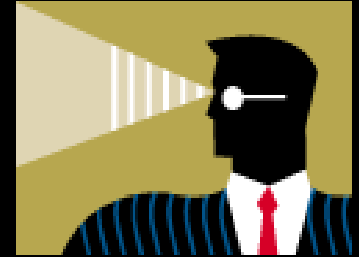
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- The potential for error increases with age due to eye disease, poor eyesight and reduction in the associated processing.
- Tiredness & fatigue affect all ages.
- In a UK study about 90% of drivers over 65 yrs of age were concerned about their vision.
- However, as an age group the 'over 65' ones did not suffer as many accidents compared with younger groups.



# Vision: Adaptation

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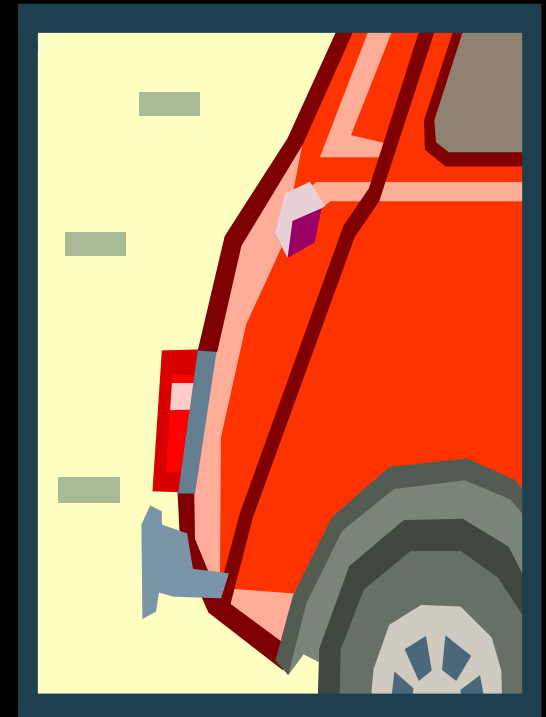


- Adjustment needed by the eyes whilst driving from a dimly lit tunnel into bright sunshine will take seconds.
- Dark adaptation happens when driving into a dark tunnel from a sunny environment and light adaptation is the opposite.
- Elderly drivers take longer to adapt and those with cataracts perhaps several seconds or more.
- When facing the strong headlights of an approaching car the unlit surroundings become much less visible.
- Progressive tunnel lighting, reactive glazing systems, sun visors, anti-glare rear view mirrors may all help against any blinding.

# Blind Areas

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- Drivers are subject to blind areas around their vehicle.
- This problem becomes more acute as the size of the vehicle increases.
- Interior and exterior mirrors cannot completely overcome this problem.
- Video cameras have been used to advantage here and more recently sonar devices have come to the vehicle accessory market.





# Blind Areas

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- Irrespective of the application of mirrors, video cameras and sonar some drivers hang all manner of things on their windscreens. Some even cover glazing systems with anti-dazzle material which interrupts vision and reduces the optical performance of the glass.
- Many developed countries outlaw any media which may affect driver sight lines and/or the optical performance of glazing systems.
- Keeping the glazed panels of a vehicle clean is also important.



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Why Do Men Die Younger?



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DRESS TO KILL

# Thinking Distance / Reaction Time

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- When braking the reaction time may be defined as the time taken in which to get the brakes on.
- This is a stimulus and response issue in that the hazard is the stimulus and applying the brakes ( or swerving etc) is the response.
- Braking reaction time consists of:
  - (i) perception time,
  - (ii) foot transfer time and
  - (iii) system time required to apply the brakes.

# Thinking Distance / Reaction Time

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- Perception time is heavily dependent on the degree of alertness of the driver as well as other factors.
- A driver distraction event could lengthen the perception time with sometimes fatal consequences.
- Only when a hazard has been perceived can a driver act on it.
- In certain instances drivers have been known to freeze on seeing a hazard and hence take little or no action at all.

# Factors Affecting Reaction Time

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- Any distraction event has the potential to adversely affect reaction time (NHTSA).
- Cell phones, pets, babies, dirty headlights/windows, misaligned mirrors, unfamiliar vehicle, reading maps, smoking, adjusting controls, talking, eye shopping, viewing scenery, eating or drinking, daydreaming and so forth.



# Factors Affecting Reaction Time

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- Reaction time increases during dusk, nighttime and dawn.
- Reaction time also increases due to the onset of tiredness, after drinking (alcoholic beverages) or taking certain kinds of drugs.
- It is extremely difficult for an accident investigator to establish what the reaction time was for a driver during an accident.



# Historical Perspective: Reaction Time

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- During the 1950s reaction distance was considered to be “1-foot per mph” or a reaction time of 0.68s
- By the mid 1960s 0.68s was taken to be the shortest possible reaction time.
- During the 1970s, after UK had adopted the SI system, reaction time was specified as “3metres per 10mph” or 0.67s indicating that the French were perhaps quicker to react than their English counterparts????
- As a result of experimentation the reaction time of the average driver is now widely accepted to be >0.85s



# Cell Phones

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- About 85% of the USA's 80million cell phone users use the device whilst driving.
- NHTSA estimated that cell phone distractions cause 150,000 crashes each year.
- Several countries [e.g. Germany, Spain, Switzerland, Hong Kong and some States] restrict the use of cell phones whilst driving. However, none ban their use.
- 'Hands free' devices are allowed.
- A number of fatal accidents have been blamed on cell phone use.

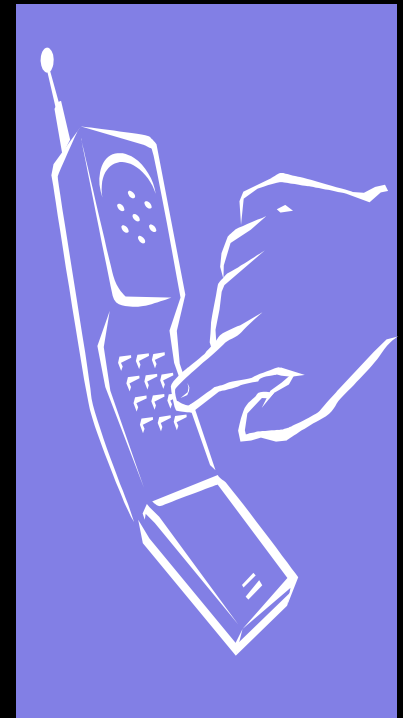


# Cell phones

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According to various researchers:

1. Drivers talking on cell phones are 4 to 5 time more likely to have an accident.
2. The use of cell phones has been rated as being almost as dangerous as being drunk behind the wheel.
3. 'Hands free' phones do not appear to be any safer compared with 'hand held' situations because the content of the cell phone conversation is believed to create varying degrees of distraction.



# Cell phones

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Yr 2002 research measuring drivers alertness while conducting cognitive tasks, such as talking on a cell phone found:

- A substantial decrease in the amount of neural activity allocated to driving.
- A 29% decrease in brain activity whilst listening to a conversation.
- Eye movement slowed significantly.
- Tunnel vision occurred which did not immediately correct after the conversation was finished.



# Cell phones

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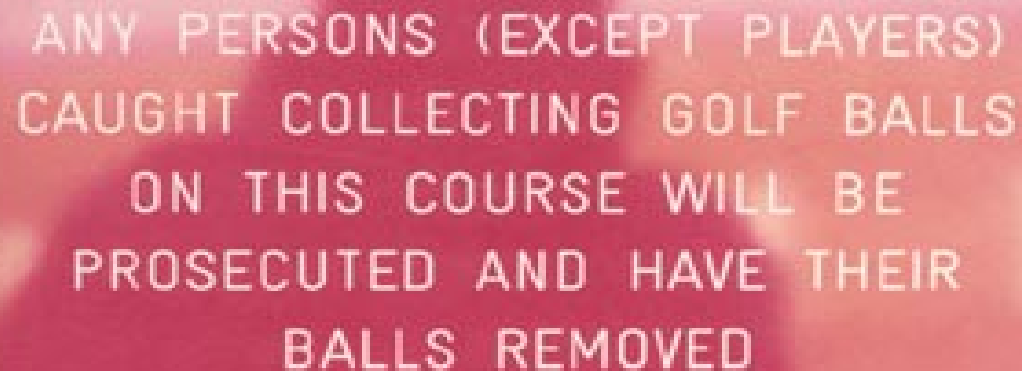
- Two main distractions, when using a cell phone whilst driving, which can cause breakdowns in attention, are therefore:
  1. The physical handling of the phone and
  2. The content of the conversation.
- *The requirement to use a 'hands free' device may go some way to resolving (1) but only a complete ban on the use of cell phones whilst driving can eliminate both (1) and (2).*

*Police may be able to prove that the use of a cell phone was the cause of an accident by comparing the cell phone log with the time of accident.*



# Have You Checked your balls?

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A rectangular red sign with white text is mounted on a dark blue, vertically-slatted background. The sign is held in place by four black screws, one in each corner. The text on the sign is centered and reads: "ANY PERSONS (EXCEPT PLAYERS) CAUGHT COLLECTING GOLF BALLS ON THIS COURSE WILL BE PROSECUTED AND HAVE THEIR BALLS REMOVED".

ANY PERSONS (EXCEPT PLAYERS)  
CAUGHT COLLECTING GOLF BALLS  
ON THIS COURSE WILL BE  
PROSECUTED AND HAVE THEIR  
BALLS REMOVED

# Ergonomics

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- This is to do with designing for comfort, efficiency and safety.
- Good ergonomic design can be of great assistance to the driver in terms of how quickly he may apply evasive actions when confronted with a hazard.
- A new technology is 'NIGHTVISION-SEE IT' This infra-red thermal imaging device enable the driver to see up to 5-times further than would have been the case with headlamps.



# Main Causes of Accidents Happening

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- In Germany Insurers found that, (i) In 15.3% of accidents drivers failed to apply the brakes, (ii) Even less attempted to steer out of trouble, (iii) 84.4% simply gave up to their fate.
- The major factors preventing drivers from acting were (a) inadequate skill, (ii) poor alertness and (iii) insufficient driving practice.

N.B. It is interesting to note that less than 3% of drivers, who had recently passed their test, admitted to having gained sufficient driving experience.

# Driver Fatigue

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- Fatigue is defined as the feeling of sleepiness, tiredness or exhaustion.
- It is physiological and psychological in nature.
- One of the symptoms is the decreased ability in a driver to judge his/her own level of tiredness.
- Other symptoms include, loss of concentration, drowsiness, yawning, slow reactions, sore / tired eyes, boredom, feeling irritable and restless, making fewer and larger steering corrections, missing road signs, having difficulty staying in the lane and micro-sleeps.





# Driver Fatigue QUIZ

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U.S. DOT-Federal Motor Carrier  
Safety Association  
Quiz

**Audience participation**

## Answer 'Y' or 'N'

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1. Coffee overcomes the effects of drowsiness?
2. I can tell when I'm going to go to sleep.
3. Rolling down the window or singing keeps me awake?
4. I'm a safe driver so it doesn't matter if I'm sleepy?
5. You can stockpile sleep on the weekends?
6. Most adults need at least 7 hours of sleep each night?

## Answer 'Y' or 'N'

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- 7 Being sleepy makes you misperceive things?
8. Young people need less sleep?
9. Wandering, disconnected thoughts are warning signs of fatigue?
- 10 Little green men in the middle of the road may mean the driver is too tired to drive?
- 11 On a long drive the driver should never take a break but try to arrive at the destination quickly?
- 12 A micro-sleep lasts 4 or 5 seconds?

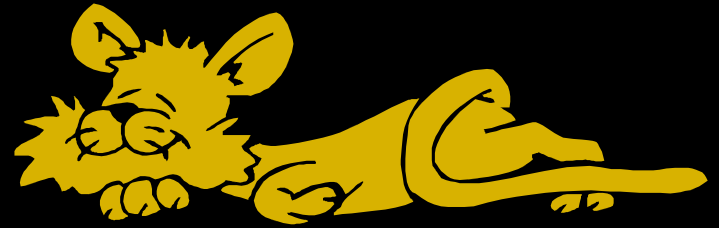
# Answers: -

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1. False! Effects of caffeine lasts only a short time.
2. False! Sleep is not voluntary.
3. False! Doesn't help for long.
4. False! Sleepiness leads to sleep.
5. False! Sleep is not money, you can't save it up.
6. True! Average persons needs 7 to 8 hrs.
7. True! Misperception is a warning sign of fatigue.
8. False! Young people need more sleep.
9. True! Time to take a break.
10. True! It's time to rest.
11. False! Take a break every 3hrs
12. True! At 70km/h vehicle will travel 78 to 97metres.

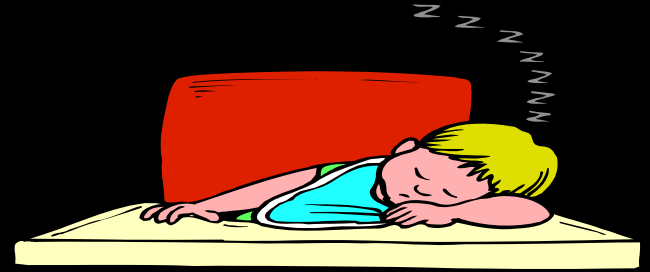
# Fatigue: Micro-sleeps

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- Brief unintentional episodes of loss of attention associated with events such as a blank stare, head snapping and prolonged eye closure [sometimes referred to as nodding-off]
- Unintended periods of light sleep typically lasting from 2 to 30 seconds.
- They intrude in the midst of ongoing wakeful activity.
- When carrying out a boring activity such as driving, micro-sleeps are likely to occur.

# Fatigue: Micro-sleeps



- Vast majority of people would have experienced micro-sleeps.
- In NSW [1996 - 2000] from 16% to 20% of fatal accidents per year involved driver fatigue.
- It is suggested that micro-sleeps at times related to the circadian rhythm.
- Early morning (4 to 8am) and afternoon (12noon to 2pm) are the times fatigue related accidents are the highest.
- Those who take frequent naps are most resistant to fatigue.

# Fatigue: Micro-sleeps

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- 53% of fatigue related fatal accidents happen in the daytime.
- They are likely to happen during public/school holidays.
- 63% of fatigue related fatal accidents happened on non-urban roads.
- 64% happened on roads with speed limits above 100km/h.
- 50% involved a vehicle traveling off the path into an object and 35% of all head-on accidents were fatigue related.

# Coffee won't help you concentrate!

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I've gotta cut back on the caffeine





# Attitudes to Fatigue

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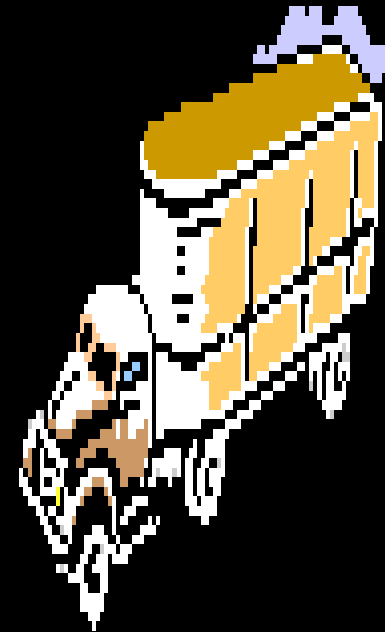


- Most drivers are aware of fatigue.
- They know how to avoid fatigue.
- Taking a break/sharing driving are more likely to be considered than planning ahead or ensuring rest prior to a trip.
- Taking breaks at certain time intervals or when feeling tired or losing concentration is acceptable.
- One or two drivers are likely to carry-on driving whilst fatigued if they are within 1-hour of their destination.

# Fatigue: Countermeasures

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- Legislation against speeding/ drink driving.
- Guidance on when to take breaks [car drivers]
- Education: How to recognize & deal with fatigue.
- Road design [crash barriers etc]
- Provide drivers with roadside rest places.
- Enforce driver's hours [Commercial vehicles]



# Fatigue: Countermeasures

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- Use of the tachograph.
- Use of the driver's logbook.
- Use of digital cameras / monitoring sites across a country to enforce average speeds.
- In-cab sensors [sight line / head drooping]
- Target management & staff.



# Latest Developments

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- Interventions between driver & controls (more drive by wire)
- Use of 'Simulators' for training / retraining
- Connecting cars permanently to the Internet (server becomes the "Black Box")
- First fuel cell car has recently been put on the market by a major manufacturer
- Driverless vehicle technology (currently being tested) enables roads to carry a higher density of vehicles in maximum safety / reduce the cost of increasing number of lanes.

**That's all  
folks!**

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**Thank you for your Attention  
and  
God Bless !**