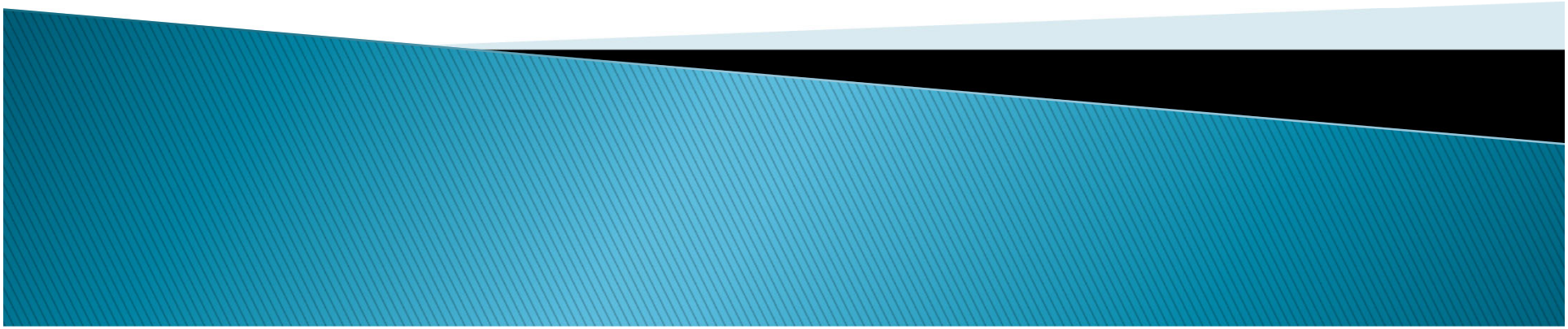
Human Factors in Traffic Safety

Fall 2021



Important Resources

Evans, L. (2004) ***Traffic Safety****. Science Serving Society. Bloomfield Hills, MI* (see also Evans, L. (1991) Traffic Safety and the Driver. Van Nostrand Reinhold. New York, N.Y.)

Smiley, A. (editor) (2015) ***Human Factors in Traffic Safety****. 3rd edition, Lawyers & Judges Publishing Company, Inc., Tucson, AZ.* (see also Dewar, R.E., and P.L. Olson. (2007) Human Factors in Traffic Safety. 2nd edition, Lawyers & Judges Publishing Company, Inc., Tucson, AZ.)

Shinar, D. (2017) ***Traffic Safety and Human Behavior****. 2nd edition. Emerald Group Publishing Limited, Bingley, UK.* (see also Shinar, D. (2007) Traffic Safety and Human Behavior. Emerald Group Publishing Limited, Bingley, UK.)

Human-Environment-Vehicle System

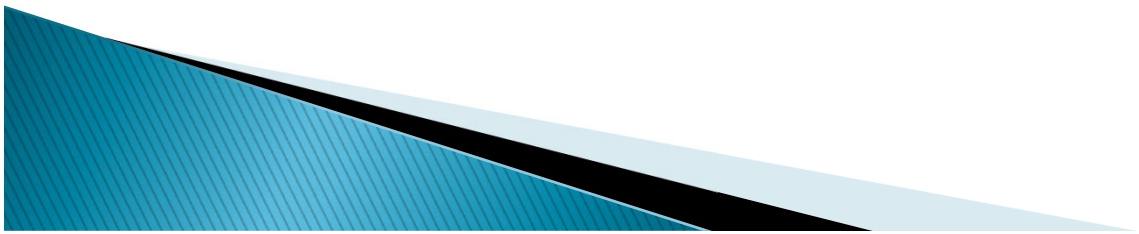
Provide a conceptual framework to analyze motor vehicle collisions.

Example: A 20-year old man with little driving experience, is taking an unfamiliar road on his way to an interview. His vehicle is not properly maintained. In fact, the tires are in poor shape. At some point on the trip, the rain starts to fall. Shortly thereafter he enters a horizontal curve with a radius below minimum standards, loses control of the vehicle and run off the road into a tree located within a few feet of the traveled way.

Question: What are the contributing factors that have lead to this crash?

Human-Environment-Vehicle System

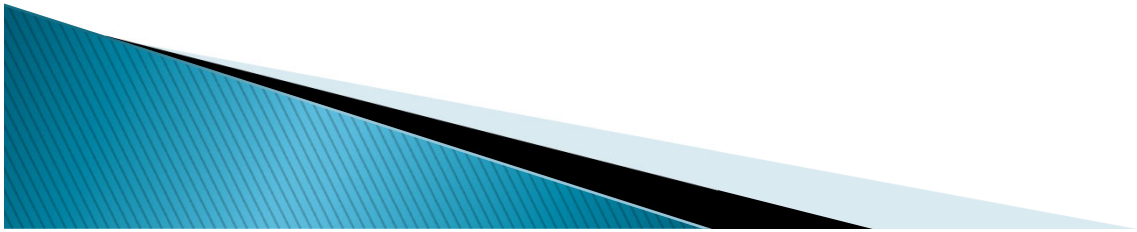
System Component	Event	Circumstance
Human	Trip	Young, inexperienced, stressed
Vehicle	Choice of vehicle	Tires in poor condition
Environment	Rain	Wet and slippery surface
Environment	Curve	Below standard
Human	Steering maneuver	Oversteering
Human	Loss of control	Unstabilized shoulder
Environment	Roadside conditions	Tree too close traveled way
Outcome	Impact (crash)	



Crash Contributing Factors

TABLE 2.1 Critical reasons for crash occurrences (NHTSA, 2018).

Crash causation	Percentage (standard error)
Drivers	94% (2.2%)
Vehicles	2% (0.7%)
Roadways	2% (1.3%)
Unknown	2% (1.4%)
Total	100%



Crash Contributing Factors

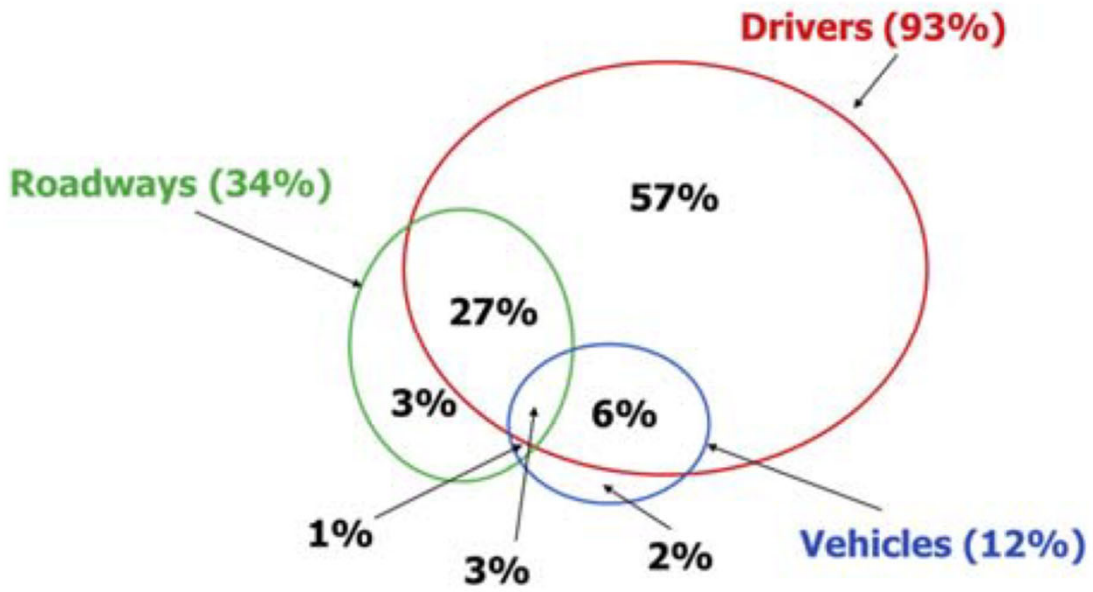


FIGURE 2.1 Precrash causation factors for roadways, drivers, and vehicles (Rumar, 1985).

http://cyberlaw.stanford.edu/blog/2013/12/human-error-cause-vehicle-crashes
https://www.fhwa.dot.gov/publications/publicroads/95winter/p95wi14.cfm

Haddon Matrix

	Agent	Host	Physical Environment	Social Environment
Pre-event				
During the event				
Post-event				

William H. Haddon, Jr., came up with a Matrix to systematically analyze car crashes in a 1972 paper.

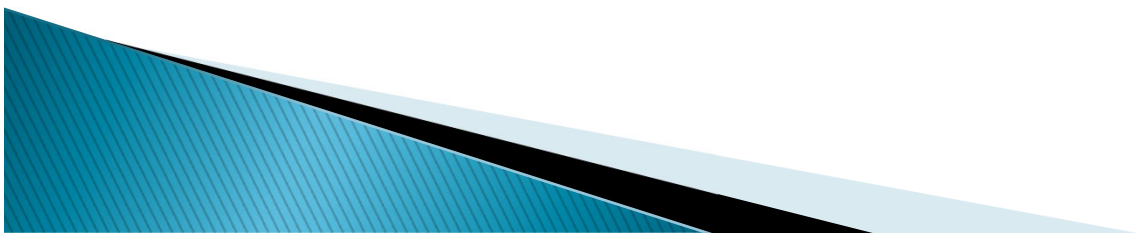
Using the Haddon Matrix

TABLE 2.2 Haddon matrix for urban crashes (Herbel et al., 2010).

Event	Driver	Vehicle	Roadway	Social environment
Precrash	Poor vision, speeding	Failed brakes, worn out tire	Poorly timed traffic lights	Speeding culture, red light running
Crash	Failure to use seatbelt	Air bag failure	Poorly designed brake-away pole	Lack of vehicle regulations
Postcrash	Age (to sustain injury), alcohol	Poorly design fuel tank	Poor emergency communication	Lack of support for EMS trauma systems

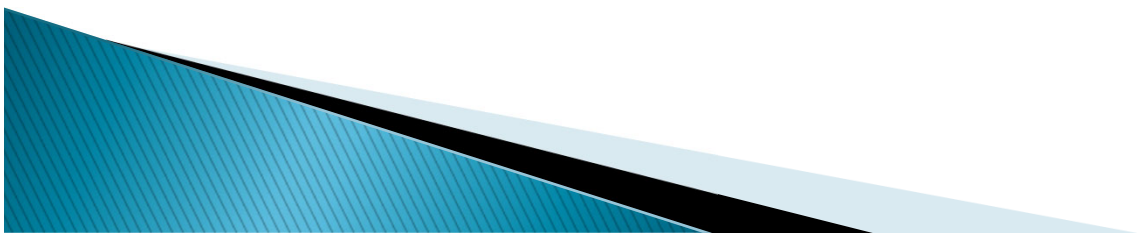
System Elements: The Road User

- Myth: “accident prone” individuals
- Safe and successful operation is influenced by factors: physical, psychological and cognitive.
- “Spare mental capacity”
- Human errors: rule based, knowledge base, and skill based
- Drivers capable of adapting to driving situations: strategic, tactical and operational



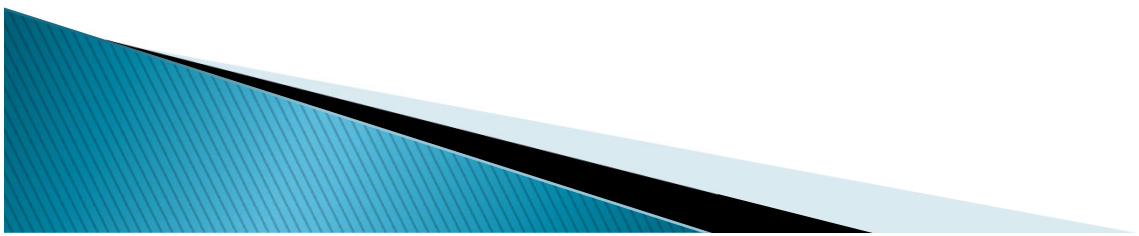
System Elements: The Vehicle

- Design of the vehicle: seats, easy ingress and egress, essential controls within reach
- Vehicle is dynamic device (must be in accordance to driver expectancy)
- Uniformity in operation of controls and displays (not always uniform from one vehicle to the next)

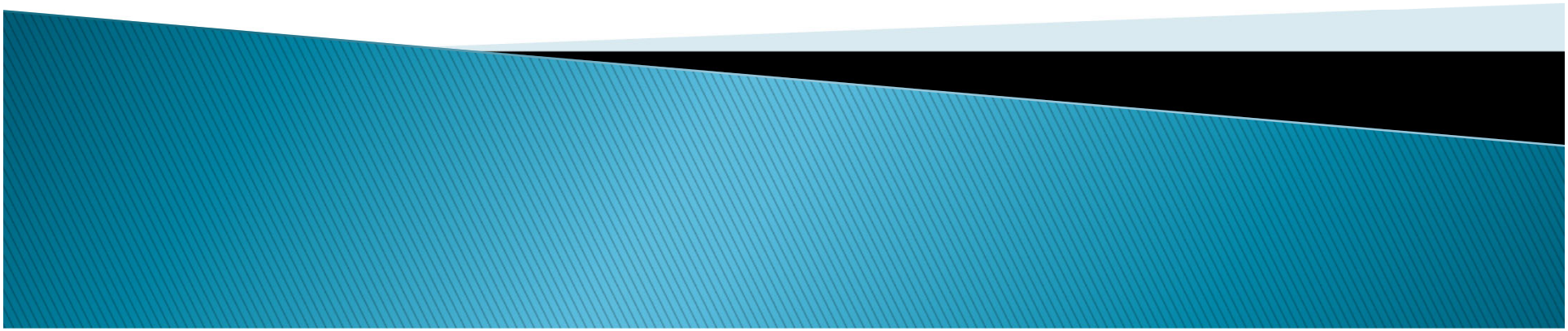


System Elements: The Road

- Uniformity for highway design and traffic control devices
- Provide proper navigational information
- System still not fully adequate
- Research still on-going for understanding the relationship between road design (geometric, control devices, etc.) and safety. Some relationships are better understood than others.

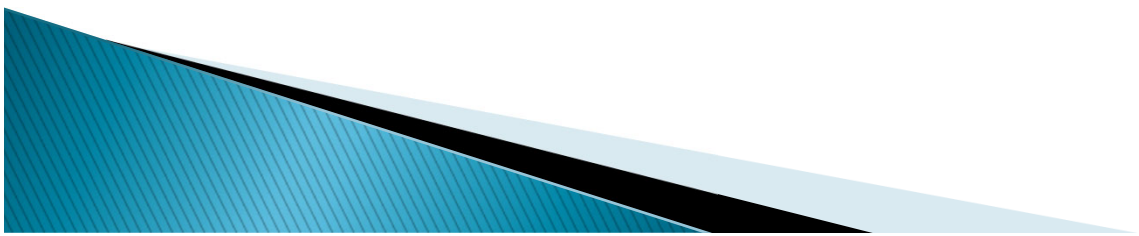


Perception and Information Processing

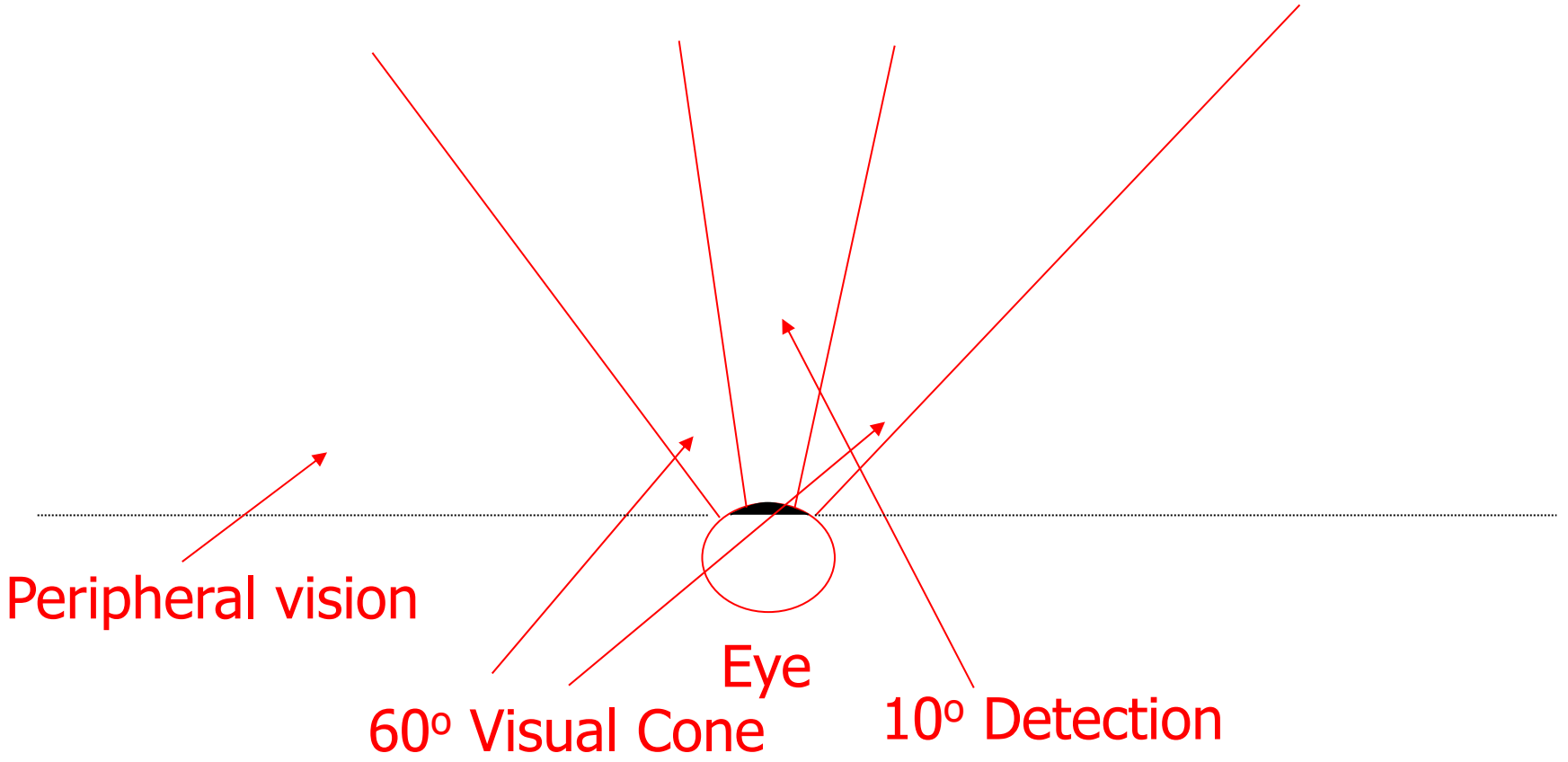


Perception

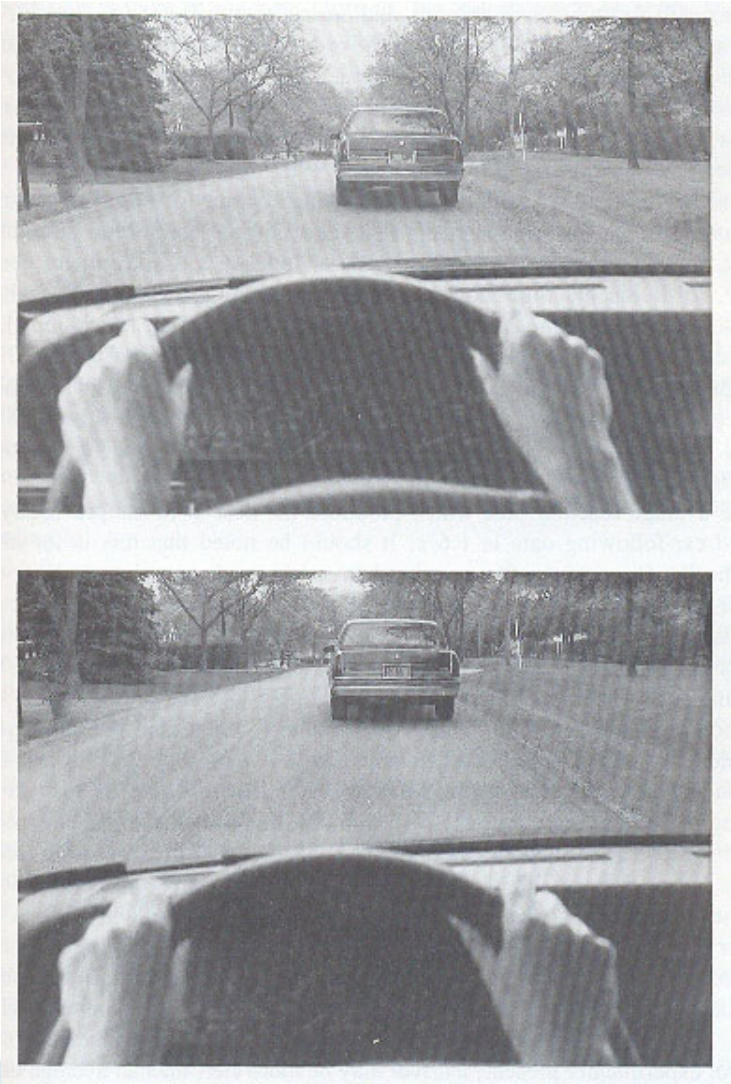
- Stimulus applied to any sense organs
- For motor vehicles: visual is the most important (also smell, auditory, tactile)
- Some important elements for driving task: color, contrast sensitivity, eye movement depth perception, static visual acuity, etc.



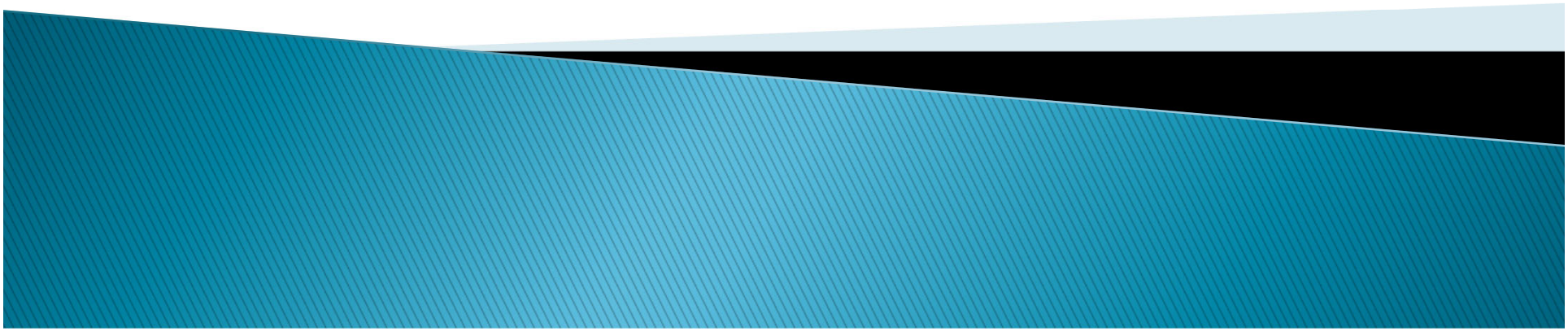
Fields of View



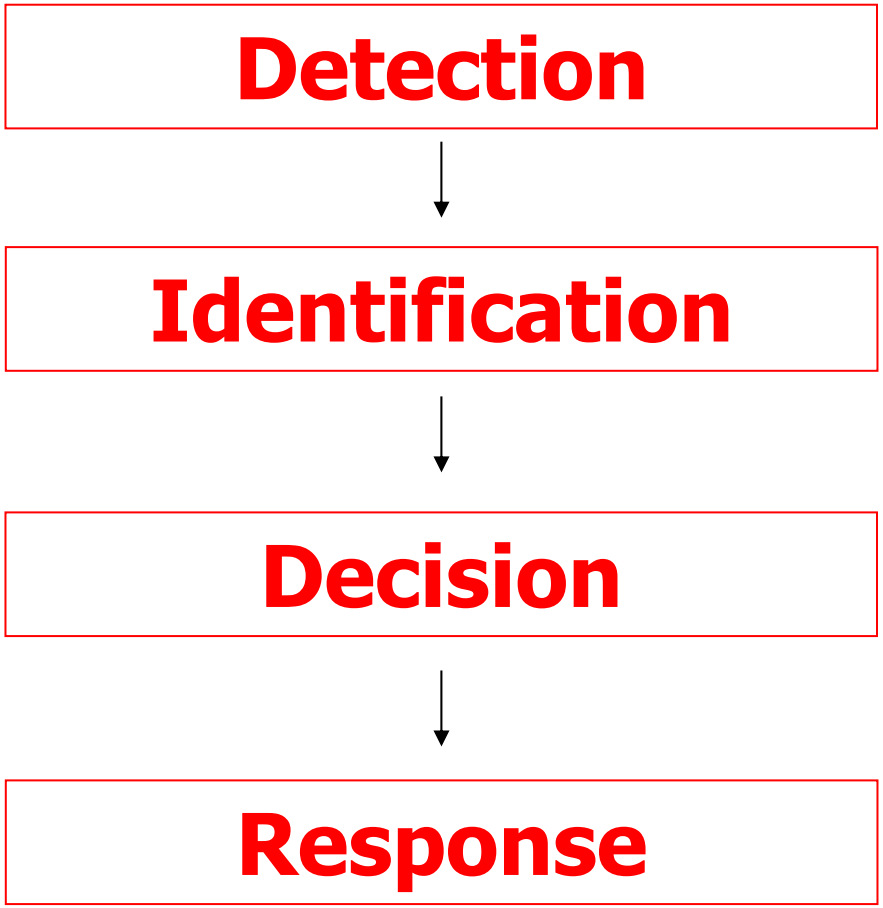
Judgment of Spacing



Driver Perception and Response Time



Stages of Perception-Response Time



Deduced Perception-Response Time

Table 3.2

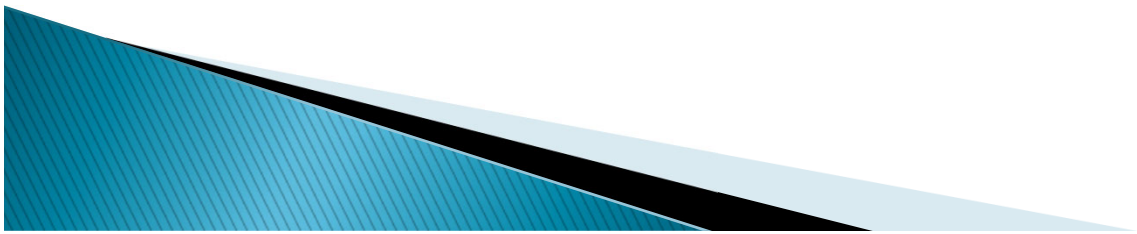
Results of an Effort to Deduce Driver Perception-Response Time, Based on Summation of Assumed Components Taken from the Research Literature

Element	Percentile of Drivers					
	50	75	85	90	95	99
1. Perception						
a. Latency	0.24	0.27	0.31	0.33	0.35	0.45
b. Eye Movement	0.09	0.09	0.09	0.09	0.09	0.09
c. Fixation	0.20	0.20	0.20	0.20	0.20	0.20
d. Recognition	0.40	0.45	0.50	0.55	0.60	0.65
2. Decision	0.50	0.75	0.85	0.90	0.95	1.00
3. Brake Reaction	0.85	1.11	1.24	1.42	1.63	2.16
Total A (1a–d+2+3)	2.3	2.9	3.2	3.5	3.8	4.6
Total B (1c–d+2+3)	2.0	2.5	2.8	3.1	3.4	4.1
Total C (1a–d+3)	1.8	2.1	2.3	2.6	2.9	3.6

[Source: McGee et al. (1983)]

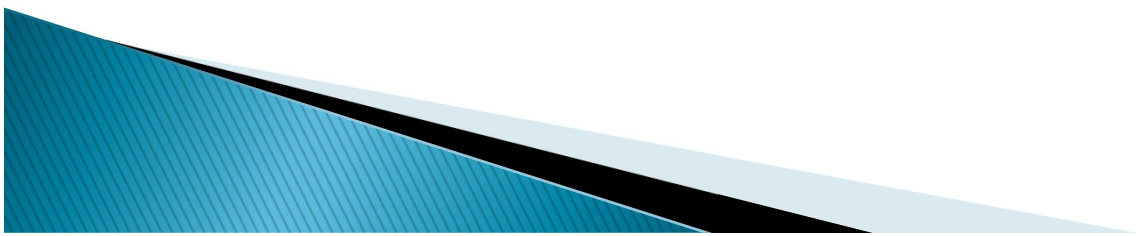
Factors Affecting PRT

- Detection
  - Object conspicuity
  - Amount of information being processed by the driver
- Identification
  - Poor visibility: nighttime and fog
  - Speed and trajectory of the potential hazard



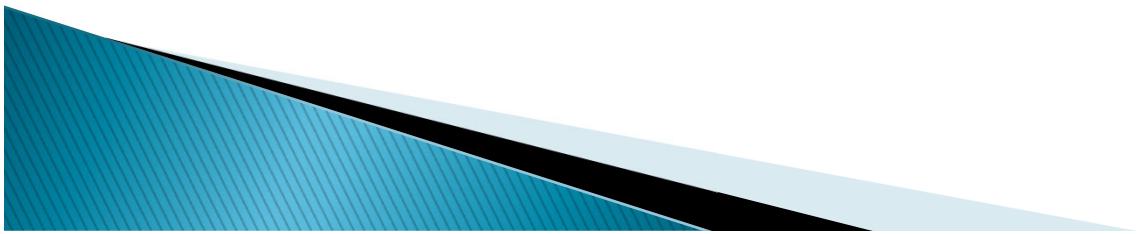
Factors Affecting PRT

- Decision
  - Choice: steering, braking (& accelerating?)
  - Choice may sometimes be more complex
- Response
  - Usually minor component of PRT
  - Time allocated for foot leaving the accelerator and hitting the brake pedal



Factors Affecting PRT

- Driver Expectancy
  - Predisposition on the part of drivers that something will happen or be configured in a certain way
  - Violation of expectancy will lead to longer PRT
- Night versus Day
  - Many situations have the same PRT (see next figure)
  - Detection may play a role in the difference



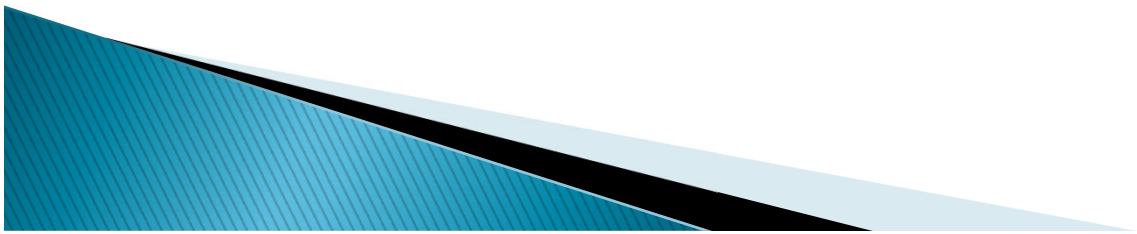
Night versus Day PRT

Table 3.5
Median and 85th Percentile Perception-Response Time by Age, Situation Type and Day/Night Condition

Age Group	Freeway PRT in Seconds Percentile				Arterial PRT in Seconds Percentile			
	50th		85th		50th		85th	
	Day	Night	Day	Night	Day	Night	Day	Night
20–40	2.9	3.8	7.8	7.1	2.0	2.8	4.2	5.2
65–69	3.9	3.8	7.6	6.7	2.8	2.4	7.6	4.9
70+	4.2	4.0	7.8	7.0	3.4	2.8	7.1	5.6

Factors Affecting PRT

- Driver Fatigue
  - Difficult to measure, but increase in driver fatigue will increase PRT
- Age and Gender
  - PRT increases with age (0.44 sec for 20 years to 0.52 for 70 years of age)
  - Female drivers have longer PRT than male drivers



Looking Behavior

Changing Lanes at Intersections

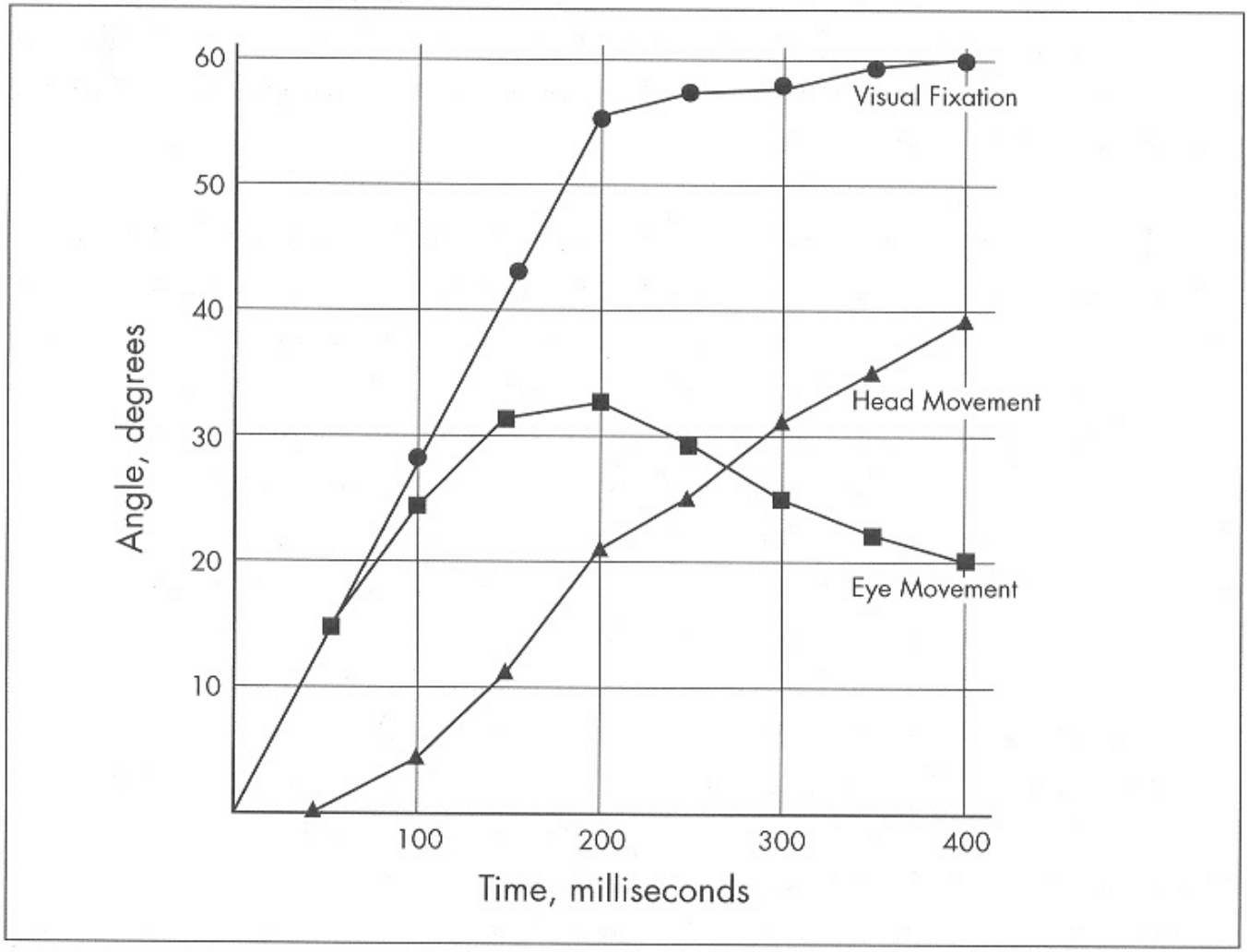


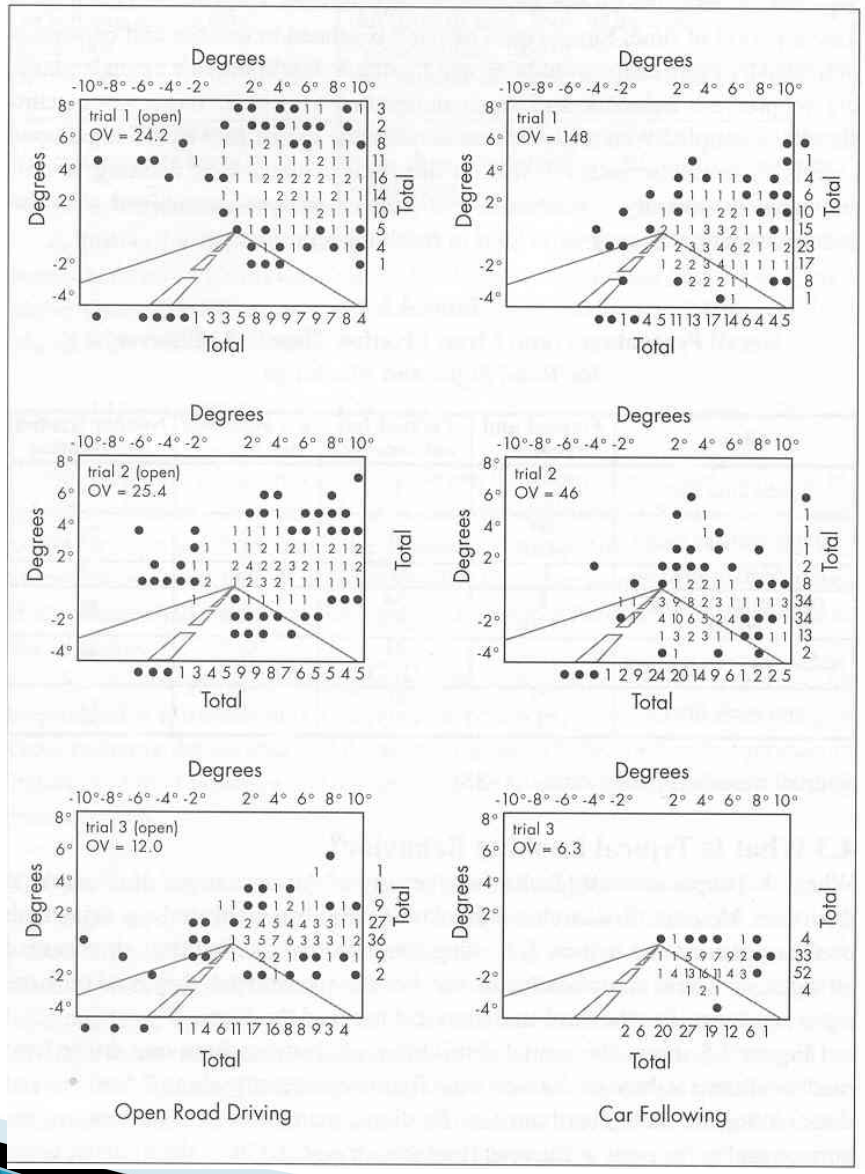
Figure 4.2

Location of Eye Fixations

Read all signs

Read only important signs

Did not read any signs



Eye Fixation for Car Radios

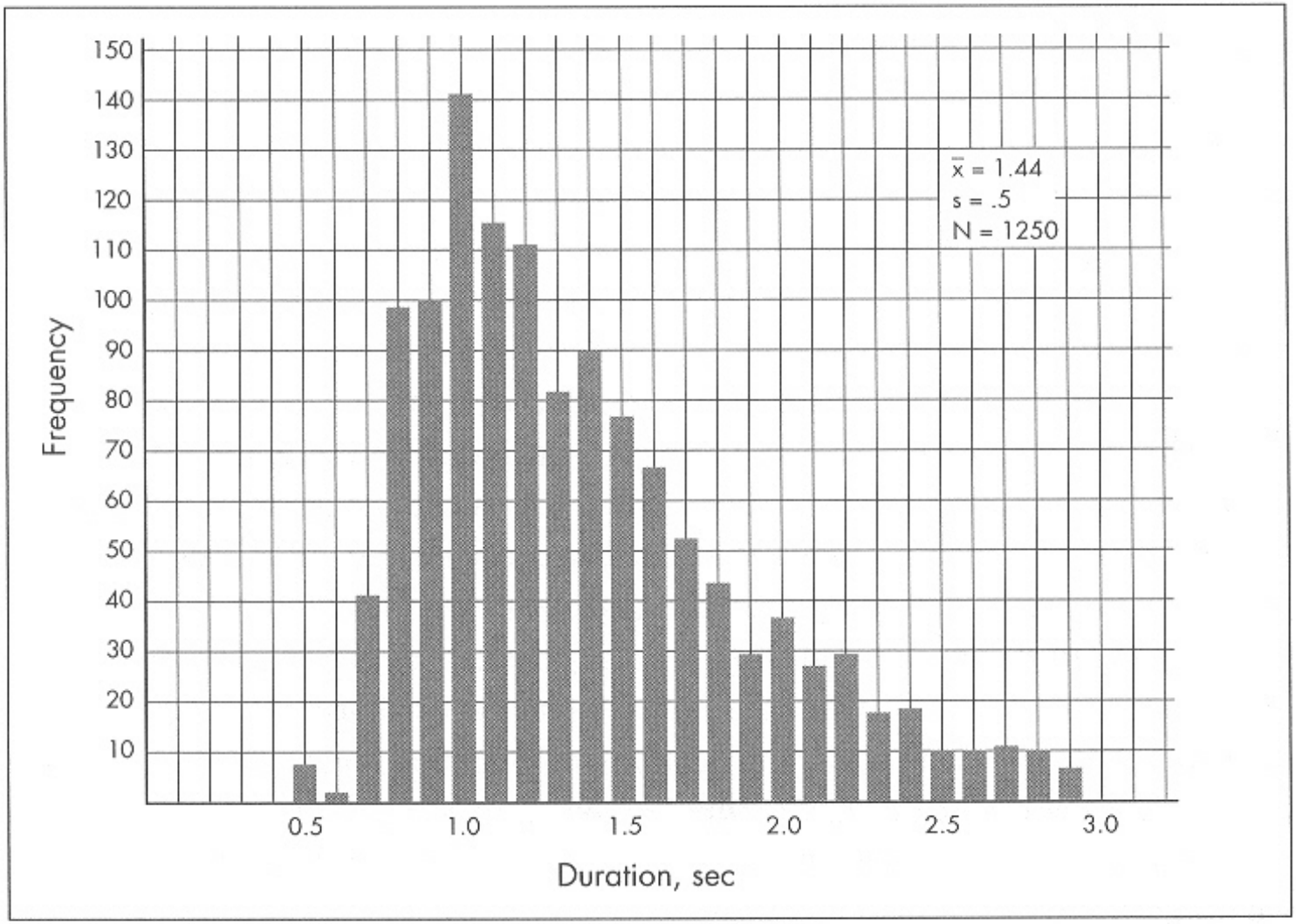


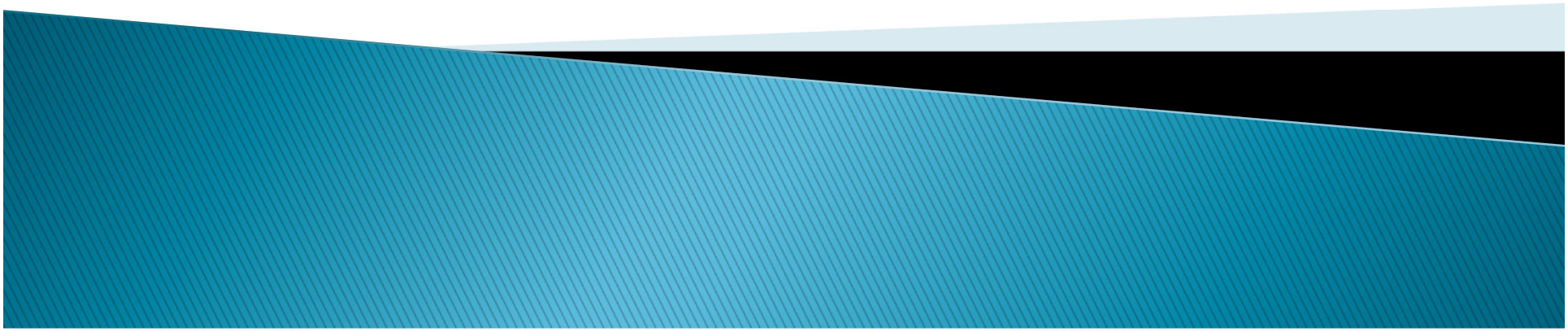
Figure 4.3

Eye Fixation by Daylight Conditions

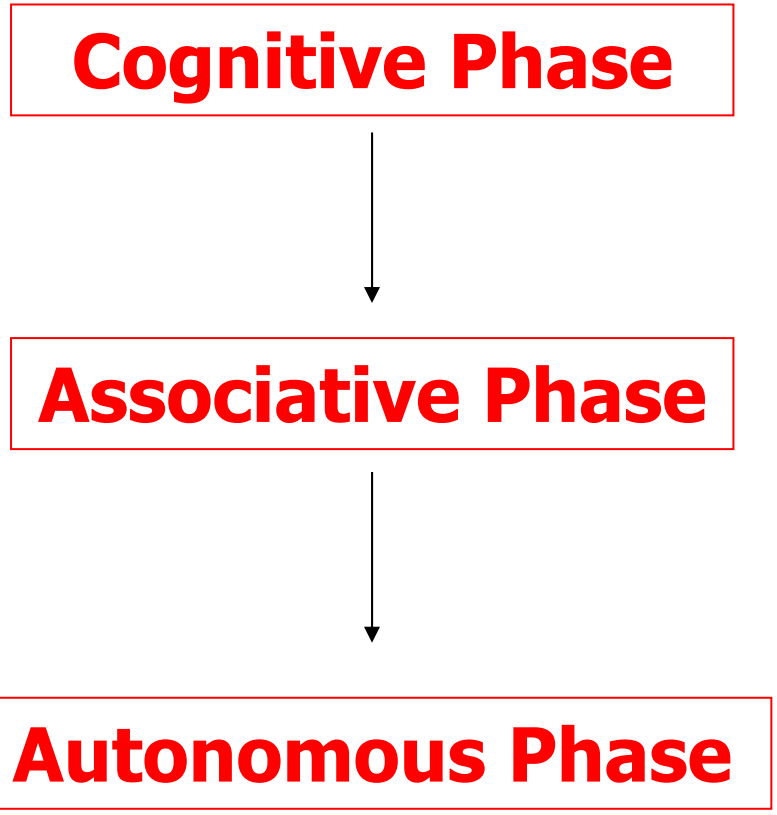
Mean Fixation Duration (seconds) as a Function of Light Level

Road geometry	Day	Night
left curve	0.43	1.05
straight	1.93	1.18
right curve	0.47	1.35

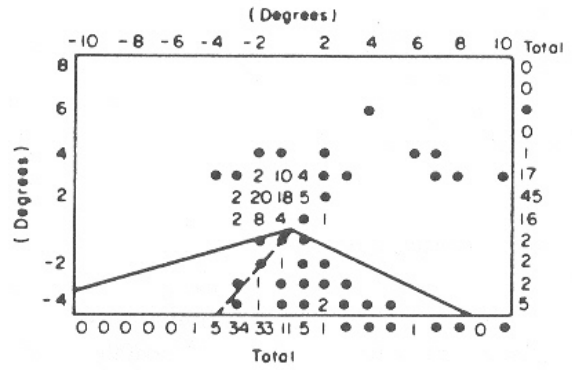
Driver Performance



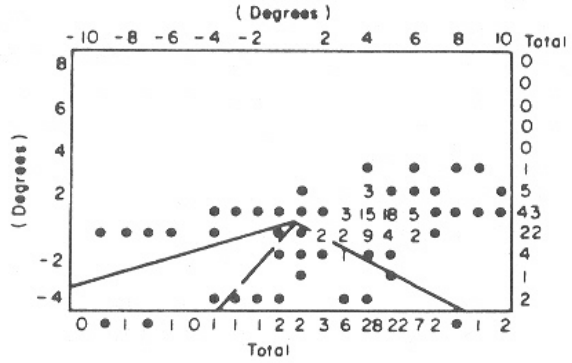
Acquisition of Driving Skills



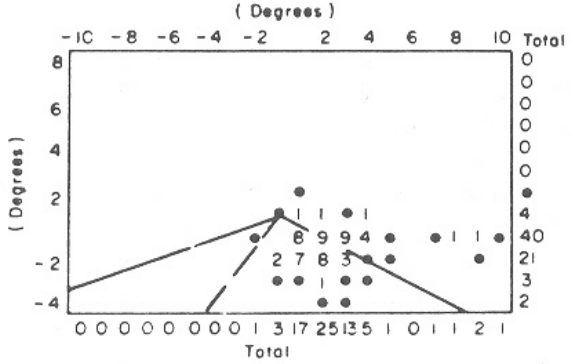
Eye Fixations of Novice Drivers



First few hours



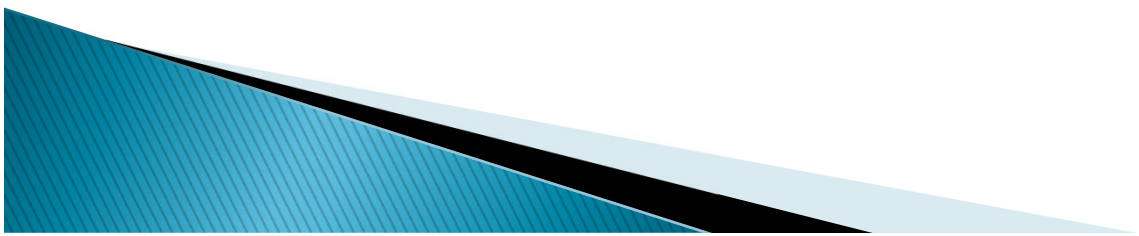
One month



Three months

Individual Differences

- Personality
  - Relationship between personality and crashes is weak (i.e., personality changes with time, confounding variables)
  - Some personality trait causing fatigue may lead to higher risk of crashes
- Emotions
  - Emotional disturbances affect all aspect of our life, including driving
  - Higher heart rate and blood pressure associated with increase traffic flow

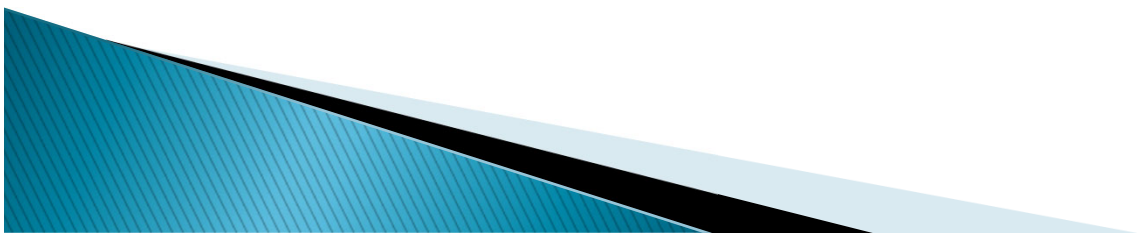


Individual Differences

- Stress
  - Stress can be caused by emotional (e.g., divorce), cognitive (e.g., cut-off), and physiological (e.g., sick).
  - Leads to aggression, confusion and risky behavior
- Motivation
  - Car ownership important to people
  - Motivational elements: travel for necessity, social status, freedom, self-expression
  - Faulty motivation may lead to higher risk behavior
  - Marketing of motor vehicles

Individual Differences

- Risk Taking Behavior
  - Objective versus subjective risk
  - Sensation seeking (SS) individuals: relationship not established SS and risky driving
  - Risk homeostasis theory
- Social Factors
  - Drivers are influenced by other drivers “culture of driving”
  - Drivers are also influenced by passengers (family members versus teenagers)



Male and Female Drivers

Table 5.1
Differences between Male and Female Drivers

Males more likely	Females more likely
alcohol used within 12 hours before the accident (3:1)	drugs/medication present (2:1)*
lack of attention/alertness	distraction
had 1 or more "impairment features" out of 5**	look but failed to see (2:1)
had a previous accident	failed to look
had a previous driving offence	lack skill
drove too fast	lack of care
more often impaired** (2:1)	inexperience
more perceptual errors if over age 65	more difficulty merging right into major road
more often at fault in right turn, overtaking and head-on accidents	more often at fault turning right and at T intersections
more accidents on curves	more accidents in daylight

* Where ratios are indicated, the differences were that much greater for that sex.
** Impairments include: alcohol, fatigue, drugs, illness, emotional distress.

Male and Female Drivers