

Table of Contents

Preface.....	xv
Chapter 1: Introduction	1
1.1 Human Factors.....	1
1.2 The Driving Task.....	2
1.3 System Elements.....	3
A. The road user.....	4
B. The vehicle.....	5
C. The road	6
1.4 The Investigation of Motor Vehicle Accidents	6
References.....	7

Part I: The Driver

Chapter 2: Perception and Information Processing	11
2.1 Introduction.....	11
2.2 Perception	12
A. Background.....	12
B. The eye.....	14
C. Photometric terms	15
D. Contrast.....	15
2.3 Perception of the Road.....	15
A. Drivers' appreciation of the roadway environment	15
B. Hazard detection and recognition	16
C. The impact of adverse weather	17
D. Nighttime conditions.....	17
2.4 Visual Search.....	18
A. Drivers' field of view	18
B. Useful field of view.....	18
2.5 The Perception of Speed	18
A. The role of speed in driving.....	18
B. How speed information is used.....	19
C. Speed perception and road characteristics	20
D. Speed perception and vehicle size	20
E. Speed adaptation	20
F. Motion sensitivity	20
2.6 Car Following	20
2.7 Rear-end Collisions.....	21
2.8 Auditory and Other Sensory Information	21
2.9 Information Processing and Accidents.....	22
2.10 Driver Attention and Workload	22
2.11 Steering	25
2.12 Positive Guidance	25
A. The basic concept.....	25
B. Task complexity	26

C. Principles of information placement	26
D. Expectancy	26
2.13 Summary	27
References	28
Chapter 3: Driver Perception-Response Time	33
3.1 Introduction	33
3.2 Background	34
A. Definition	34
B. Stages of perception-response time	35
3.3 Human Perception-Response Time	36
A. Background	36
B. Driver perception-response time	36
3.4 Decision Sight Distance	42
3.5 Overview of Research	44
3.6 Factors Affecting Perception-Response Time	44
A. Detection	45
B. Identification	45
C. Decision	46
D. Response	46
E. Night versus day	46
F. Chemicals and driver fatigue	47
G. Age and gender	47
H. Cognitive load	48
3.7 Special Situations	49
A. No clearly defined entry	50
B. Erroneous assumption or identification	50
3.8 Summary and Conclusions	52
References	53
Chapter 4: Where Do Drivers Look While Driving (and for How Long)?	57
4.1 How Is Glance Behavior Described?	57
A. What are the terms used to describe glance behavior?	57
B. What are some general characteristics of driver glance behavior?	59
C. How is glance behavior measured?	62
4.2 Why Are Eye Fixations of Interest?	62
A. Does visual demand actually relate to crashes?	62
B. Does looking at an object guarantee the object is noticed?	63
4.3 What Is Typical Looking Behavior?	63
4.4 How Is Glance Behavior Affected by the Road Environment?	65
A. Where do drivers look when driving curves?	65
B. How do traffic and other external demands affect where drivers look?	68
C. How have eye fixation data been used to assess the merits of road and vehicle markings, and signs?	69
4.5 How Does Glance Behavior Change with Driver Characteristics?	72
A. How does glance behavior change with driving experience?	72
B. What is the effect of fatigue on glance behavior?	72
C. How do alcohol and other drugs affect eye movements?	72
4.6 What Is the Impact of Vehicle Characteristics on Glance Behavior?	73
A. How do eye glance patterns vary as a function of the vehicle driven?	73
B. How does scene illumination alter glance characteristics?	75
4.7 How Might In-Vehicle Devices Impact Driving?	75
A. What is typical looking behavior for in-vehicle devices?	75
B. How long can drivers look at the vehicle interior?	77
4.8 Conclusions	78

4.9 A Final Thought	79
References.....	79
Chapter 5: Individual Differences	83
5.1 Introduction.....	83
5.2 Personality.....	83
5.3 Emotions	85
5.4 Impact on Victims and Families.....	85
5.5 Stress	86
5.6 Aggressive Driving and “Road Rage”	86
5.7 Motivation.....	89
5.8 Risk Taking	90
5.9 Self-Assessment of Driving Skills	91
5.10 Behavioral Compensation.....	92
5.11 Social Factors.....	93
5.12 Driver Attitudes	93
5.13 Gender Differences	94
5.14 Driving Experience	97
5.15 Physical Factors and Motor Skills	97
A. The role of motor control in driving.....	97
B. Physical disabilities.....	97
C. Age-related deficits	98
5.16 Conclusions	98
References.....	99
Chapter 6: Fatigue and Driving	103
6.1 Introduction.....	103
A. Definitions of fatigue	103
B. Measurement of fatigue	103
C. Causes of fatigue.....	104
D. The extent of the fatigue problem.....	104
E. Fatigue and crashes	105
6.2 Long Hours	105
A. Arousal and performance	105
B. Crash risk	106
C. Summary	107
6.3 Time of day	108
A. Sleepiness.....	108
B. Performance	109
C. Crash risk	110
D. Summary.....	113
6.4 Inadequate Sleep.....	113
A. Performance.....	114
B. Crash risk	114
C. Summary	115
6.5 Countermeasures to Sleepiness.....	116
A. Rest breaks.....	116
B. Food	116
C. Caffeine	116
D. Naps	117
E. Education.....	117
F. ITS countermeasures.....	117
G. Rumble strips	118
H. Summary	118

6.6 Conclusion	118
Additional Reading	118
References.....	119
Chapter 7: Alcohol and Drugs	123
7.1 Introduction.....	123
7.2 Alcohol Use While Driving.....	123
7.3 Alcohol and Accidents	124
7.4 Single Vehicle Collisions	126
7.5 Measures of Intoxication.....	126
7.6 Driving Abilities Impaired by Alcohol	127
7.7 Rate of Alcohol Consumption.....	132
7.8 Alcohol and Fatigue	133
7.9 Alcohol and Aggression	133
7.10 Alcohol and Degree of Injury	134
7.11 Drug Effects	134
Endnotes.....	139
References.....	139
Chapter 8: Age Differences—Drivers Young and Old	143
8.1 Older Drivers	143
A. Introduction.....	143
B. Demographics of older drivers.....	143
C. Older driver crashes	144
D. Difficulties experienced by older drivers.....	145
E. Increased vulnerability of the elderly.....	145
F. Sensory and perceptual changes	146
G. Attention.....	148
H. Memory	149
I. Psychomotor performance.....	149
J. Stress	149
K. Improvement with training	149
8.2 Young Drivers	149
A. Introduction.....	149
B. Dangerous driving behaviors	150
C. Influence of young passengers	151
D. Alcohol	151
E. Perception of dangerous situations.....	152
F. Self perception	152
G. Motivation and emotion.....	153
H. Gender differences.....	154
I. Potential countermeasures.....	154
8.3 Conclusion	154
References.....	155
Chapter 9: Neuropsychological, Medical and Psychiatric Disorders and Motor Vehicle Operations	159
9.1 Our Right to Drive and Our Right to be Safe: Two Competing Interests.....	159
9.2 Regulatory and Legal Factors Relating to Disability and Automobile Driving.....	160
9.3 The Americans with Disability Act and Constitutional Analysis.....	160
9.4 Failure to Warn and the Special Relationship of Healthcare Providers.....	161
9.5 Risk Assessment, Risk Communication, and Risk Management	162
9.6 Accident Risk Associated With Neuropsychological and General Medical Disorders.....	162
A. Aging and “Full-Timing”	162
B. Traumatic brain injury.....	164

C. Psychiatric disorders and cultural trends	167
D. Psychotropic medications	168
E. Attention deficit disorder	170
F. Road rage	171
G. Cellphones	171
H. Huntington's disease	172
I. Epilepsy	172
J. Visual disorders	173
K. Spina bifida	175
L. Cardiac disorders	175
M. Diabetes	176
N. Conclusions on diabetes	178
O. Dyssomnias	178
P. Aphasia and stroke/cerebral vascular accidents	179
9.7 Adaptive Driving Programs And Medical Decisions	180
A. Adaptive programs	180
B. Simulator training	181
9.8 Assessment Issues	181
A. The cognitive behavioral driver's test	181
B. The Neurocognitive Driving Test	181
C. The Drivers' Neuropsychological Rating Scale	182
D. Working with the family unit	183
E. Multi-stage decision models	183
F. The "Four E's"	184
9.9 Conclusions	186
9.10 Agencies of Interest	187
References	187
 Chapter 10: Driver Distraction	195
10.1 Introduction	195
10.2 Definitions of Driver Distraction	196
10.3 What is the Scope of the Driver Distraction Problem?	197
A. The 100-Car Study of Inattention	202
B. Distraction, Crash Configurations and Environmental Conditions	203
10.4 Cell Phones and Driving	203
A. Epidemiological Studies of Cell Phone Crash Risk	204
B. Observation and Self-Report of Cell Phone Use While Driving	205
C. Driver Performance While Using Cellular Phones	207
D. Response Time	207
E. Dialing and Answering	207
F. Handheld versus Hands-free Cell Phones	208
G. Conversation	208
H. Age Differences	209
I. Passengers versus Cell Phone Conversation	210
J. Cell Phone Case Studies	210
K. Summary of Cell Phone Research	211
10.5 Other In-Vehicle Distractions	211
A. New Technologies	211
B. Radio, CD, MP3 Players	211
C. Navigation and Route Guidance Systems	213
D. DVD Players, Text Messaging and Email	213
E. Multiple Functions, Systems and Willingness to Engage	214
10.6 External Distractions	215
A. Roadside advertising	215

B. Visual clutter	216
10.7 Countermeasures for Driver Distraction	217
A. Legislation and Regulation	217
B. Corporate/Private Sector	217
C. Education and Licensing	218
D. Social Norms	218
E. Cell Phone and Telematic Design	219
10.8 Conclusions	220
Acknowledgments	221
References	222

Chapter 11: Driver Education, Training, and Licensing	231
11.1 Introduction	231
11.2 Background	231
11.3 Traditional Driver Education	233
A. Instructors and trainers	234
B. Trainer qualifications	235
11.4 What We Know	236
A. Early licensure	236
B. Good driver?	237
C. Skid control and advanced skill development	237
D. Simulation and computer-based training	238
E. Motivation and insight	238
F. Reasons to take driver education	239
G. Formal and informal rules	240
11.5 Perception and Cognition	242
A. Perception	243
B. Cognition	244
11.6 Language	245
11.7 Graduated Driver Licensing (GDL)	246
A. Introduction	246
B. Incentives	248
C. Embedding Driver Education in a GDL	249
11.8 Parental Involvement	253
11.9 New Directions	255
11.10 The Paradigmatic Shift	256
11.11 Conclusion	257
References	260

Part II: The Vehicle

Chapter 12: Vehicle Design	269
12.1 Introduction	269
12.2 Requirements of the Driving Task	269
12.3 Anthropometry	270
12.4 Controls	271
12.5 Displays	272
12.6 Visibility from Within the Vehicle	273
12.7 Visibility of Other Vehicles	274
A. Daytime-running lights	275
B. Emergency vehicles	275
12.8 Trucks	276
12.9 Traffic Control Devices Relevant to Truck Operators	277
12.10 Motorcycles	278

12.11 Agricultural Vehicles	280
12.12 All-Terrain Vehicles	280
12.13 Vehicle Size and Safety	281
12.14 Safety Belts	282
12.15 Antilock Brake Systems	283
12.16 In-Vehicle Information Systems (IVIS)	283
12.17 Noise	286
12.18 Vibration.....	286
12.19 Older Drivers	287
12.20 Driving Vehicles of the Future.....	287
12.21 Conclusion	289
References.....	289

Chapter 13: Visibility with Motor Vehicle Headlamps	295
13.1 Introduction.....	295
13.2 The Importance of Target Contrast	296
A. Definition	296
B. Calculating contrast.....	298
13.3 The Reflectivity of Objects in the Real World	298
13.4 Driver Vision at Night.....	301
A. Vehicle lighting systems	302
B. The visibility provided by automotive headlamps	309
C. Correction for expectancy	316
13.5 Nighttime Driving Speeds.....	318
13.6 Overdriving of Headlamps.....	318
13.7 Overview	319
Endnotes.....	319
References.....	319

Part III: The Roadway Environment

Chapter 14: Roadway Design	323
14.1 Introduction.....	323
14.2 Perception of the Road.....	325
14.3 Highway Hypnosis.....	326
14.4 Driver Workload and Roadway Design	326
14.5 Sight Distance	327
14.6 Roadway Width.....	329
14.7 Grades	331
14.8 Intersections	331
14.9 Bridges	334
14.10 Roundabouts	334
14.11 Curves	336
14.12 Rural Roads.....	339
14.13 Safety Countermeasures.....	339
A. Traffic calming.....	339
B. One-way streets.....	339
C. Other engineering solutions	340
14.14 Road Design and Accident Litigation	341
14.15 Conclusion	341
References.....	341

Chapter 15: Traffic Control Devices	345
15.1 Introduction.....	345

15.2 Criteria for Effective TCDs.....	345
A. Conspicuity	345
B. Legibility distance.....	347
C. Glance legibility	348
D. Comprehension	348
E. Response time	349
F. Other criteria.....	349
15.3 Problems with TCDs.....	349
15.4 Signs.....	350
A. The importance of signs.....	350
B. Classification of signs	350
C. Symbol signs.....	351
D. Word signs.....	351
E. Changeable message signs	353
F. Bilingual signs	353
15.5 Signals.....	354
15.6 Pavement Markings	355
15.7 Rumble Strips and Speed Bumps.....	356
15.8 Post Delineators	358
15.9 Supplemental Warning Information.....	358
15.10 Environmental Factors	358
15.11 Aging and TCD Effectiveness.....	359
15.12 Cross-Cultural Comprehension of TCDs.....	360
15.13 Compliance with Traffic Control Devices	360
15.14 Methods for the Evaluation of TCDs.....	361
15.15 Conclusion	362
References.....	363
 Chapter 16: Visibility Under Roadway Lighting	367
16.1 Introduction.....	367
A. The purpose of roadway lighting	367
B. Sources of lighting	368
16.2 Definitions and Concepts	368
A. Basic lighting definitions	368
B. Lighting concepts	368
C. Visibility measures.....	370
16.3 Performance of Roadway Lighting.....	370
A. Background.....	370
B. Effects of roadway lighting on nighttime visibility	371
C. Effects of roadway lighting on nighttime safety	372
D. Effects of roadway lighting on nighttime traffic operations	373
E. Effects of roadway lighting on nighttime security and crime	373
F. Other effects of roadway lighting	374
16.4 History of Criteria and Standards for Roadway Lighting.....	374
A. History of roadway lighting standards.....	374
B. Other roadway lighting standards	376
C. Legal issues	376
16.5 Types of Roadway Lighting.....	376
A. Sources of roadway lighting	376
B. Roadway lighting geometry	377
C. Distribution of light.....	377
D. Other factors	378
16.6 Methods for Assessing Roadway Lighting	380
A. Introduction.....	380
B. Calculations and computer predictions	380

C. Measurement of roadway lighting	381
D. Field evaluations of roadway lighting	382
16.7 Summary	382
References	384
Chapter 17: Environmental Factors	385
17.1 Introduction	385
17.2 The Hours of Darkness	385
17.3 Twilight	386
17.4 Adverse Weather	388
17.5 Effects of Restricted Visibility	389
17.6 Driver Behavior in Fog	390
17.7 Conclusion	391
References	391
Chapter 18: Railroad Grade Crossing Accidents	393
18.1 Introduction	393
18.2 The Accident Picture	393
18.3 Driver Behavior at Grade Crossings	394
18.4 Driver Perception of Railroad Crossing Hazards	396
18.5 Decision Errors	397
18.6 Attempting to "Beat the Train" Across the Tracks	398
18.7 Traffic Control Devices	398
18.8 Pedestrian Safety	400
18.9 Countermeasures	400
18.10 Conclusion	401
References	401
Chapter 19: Highway Work Zones	403
19.1 Human Factors and Work Zones	403
19.2 Accidents in Work Zones	404
A. Problems with accident data	404
B. The accident picture	404
19.3 Driver Information in Work Zones	405
19.4 Speed Selection and Control	405
19.5 Nighttime Conditions	408
19.6 Driver Behavior and Opinions	410
19.7 Older Drivers	411
19.8 Pedestrians in Work Zones	411
A. Background	411
B. Pedestrian and worker accident problem	411
C. The pedestrian in a work zone environment	412
D. Conspicuous work zone attire	413
E. Traffic control treatments	413
F. Pedestrian safety treatments	414
19.9 Trucks in Work Zones	415
19.10 Lane and Shoulder Width	416
19.11 Traffic Control Devices	416
19.12 ITS Applications in Work Zones	418
A. National ITS Architecture	418
B. Objectives and benefits of ITS work zone applications	419
C. Case studies and evaluations of ITS work zone applications	419
D. Summary of ITS work zone applications	420
19.13 Safety Countermeasures	421
19.14 Conclusions	421
References	421

Part IV: Accident Causation and Remediation

Chapter 20: Pedestrians and Bicyclists	427
20.1 Pedestrian Safety.....	427
20.2 The Pedestrian's Task.....	427
20.3 Pedestrian Accidents	428
20.4 Driver and Pedestrian Behavior.....	430
20.5 Distracted Pedestrians	431
20.6 Alcohol Use.....	431
20.7 Left-turning Accidents	431
20.8 Walking Speed	432
20.9 Disabled Pedestrians	434
20.10 Older Pedestrians	435
20.11 Child Pedestrians.....	437
20.12 Nighttime Conditions.....	440
20.13 Winter Conditions	442
20.14 Social Factors.....	442
20.15 Roadway Design	443
20.16 Pedestrian Signs, Signals, and Markings	444
20.17 Intelligent Transportation Systems and Pedestrian Safety.....	447
20.18 Safety Countermeasures.....	448
20.19 Bicycle Safety	448
20.20 Cyclists' Perception of Risk.....	450
20.21 Cyclists' Behavior.....	450
20.22 Older Cyclists.....	451
20.23 Road and Environment Factors.....	452
20.24 ITS and Bicycle Safety	453
20.25 Other Non-motorized Transportation Modes.....	453
A. In-line skates	453
B. Heelys.....	454
C. Skateboards	455
D. Scooters.....	455
E. Segways.....	455
20.26 Conclusion	455
References.....	456
 Chapter 21: Left-Turn and Gap Acceptance Crashes	463
21.1 Introduction.....	463
21.2 Definitions and Task Analysis	463
21.3 Left-turn Crash Patterns.....	464
21.4 Gap Acceptance Crash Patterns	466
21.5 Motorcycles, Small Vehicles, Bicycles, and Pedestrians	467
21.6 Age Differences in Left-turn and Gap Acceptance Crashes	469
21.7 Driver Citations and Error	472
21.8 Left Turn Driving Simulation and Field Studies.....	473
21.9 Gap Acceptance Studies.....	474
21.10 Perception of Oncoming and Cross Traffic.....	475
21.11 Signals and Intersection Design	477
21.12 Conclusions.....	478
Acknowledgments.....	480
Endnotes.....	480
References.....	480

Chapter 22: Single-Vehicle Accidents	487
22.1 Introduction.....	487
22.2 Characteristics.....	488
22.3 Suicide?.....	490
22.4 Remedial Measures.....	491
22.5 Summary.....	492
References.....	493
 Chapter 23: Eyewitnesses to Accidents: The Factors that Determine Accuracy	495
23.1 Introduction.....	495
23.2 Observing and Encoding Events into Memory.....	497
A. Observational point of view and perceptual adequacy	497
B. Allocation of attention	497
C. Involuntary focus of attention	498
D. Knowledge, familiarity and expertise with the content of the event	498
E. Witness expectations and interpretation of the event.....	499
F. Alcohol and encoding	500
23.3 Retaining the Memory for Observed Events	500
A. The inevitably wrong focus of autobiographical memory.....	501
B. Systematic changes in the content of memory with each repetition	501
C. Post-event information can create new (and potentially false) memories	502
23.4 Forgetting of Memory.....	503
A. Without the proper retrieval cues, recall may fail	504
B. Memory failures can result from psychogenic memory blocks	504
C. Memory failures can result from physical trauma	505
23.5 How to Improve Recall.....	505
A. Additional retrieval cues improve recall.....	505
B. Psychotherapy, relaxation and hypnosis improve recall	505
C. Healing with time normally reduces amnesia following head injury	506
23.6 Memory for Everyday and Unusual Events Differs in Accuracy	507
23.7 Do Some People Have Better Memories than Others?.....	507
A. Mnemonic systems and training to improve memory	507
B. Individual differences in suggestibility.....	508
C. The memory of children.....	508
D. Aging and memory.....	508
23.8 The Surprising Lack of a Relationship between Confidence and Accuracy.....	509
23.9 When Are Two Witnesses Better than One?	509
23.10 Summary.....	510
References.....	510
Endnotes.....	514
 Chapter 24: Human Factors in Traffic Accident Litigation	515
24.1 Introduction.....	515
24.2 The Profession.....	515
24.3 Hazards in Vehicle Operation	515
24.4 Designing for Whom?.....	516
24.5 Admissibility of Evidence from a Human Factors Expert.....	517
24.6 What the Human Factors Expert has to Offer the Lawyer.....	517
24.7 Locating Suitably Qualified Human Factors Experts	518
Reference	518
Suggested Readings	518
 About the Authors	521
Index	525