Vision and Driving
Outline

• Visual function and driving performance
• Visual standards for driving licenses in Europe
• Traffic lights
• Lighting design for motorized and pedestrian traffic
• Vehicle design
• Other complementary topics
  • Non-land vehicles, etc
• Discussion
  • Supplementary reading and learning
  • Mandatory activity no. 5
Lesson 9

Bibliography & Links

- **Basic:**
Bibliography & Links

• Complementary:


Lesson 9

Bibliography & Links

• Complementary:


Bibliography & Links

• Complementary:


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Bibliography & Links

• Complementary links:
  - Dirección General de Tráfico
  - Alain Afflelou Foundation + RACE
  - Vision In Vehicles Conference Series
  - INTRAS
  - European Transport Safety Council
  - Journals in Optometry, Ophthalmology, Work Risks, etc.
Introduction: vision & driving

• Driving a vehicle, land-type or not, is a complex visual task where many motor and visual functions are involved in, even coordinated with other senses, as touch in feet + hands + eye coordination

• Examples:
  • Cars, trucks, buses
  • Motorbikes, bikes
  • Trains, trams
  • Airplanes, helicopters
  • Ships, submarines
  • Spacecrafts, Future??
Introduction: vision & driving

• The on-road driving tasks:
  • Basic control (e.g., steering)
  • General driving (surveillance)
  • Traffic conditions (e.g., passing)
  • Roadway characteristics (e.g., intersections)
  • Environment (e.g., weather)
  • The vehicle (e.g., car emergencies)

• The off-road driving tasks
  • Pre-trip planning
  • Vehicle maintenance
  • Legal responsibilities

Perception & information processing
Lesson 9

Introduction: vision & driving

• Perception + information processing + decision/action:
  • Drivers and capable to adapting to driving situations in three main ways:
    • Strategic: decide to not drive in certain conditions (night, bad weather, etc) for avoiding accidents
    • Tactical: speed selection under particular conditions
    • Operational: increased attention at intersections, or using specific search patterns to look for traffic signs or radars

• Other breakdown for driving task itself:
  • Control: vehicle-driver interaction (braking, displays, etc)
  • Guidance: safe path and speed (roadway, signs, etc)
  • Navigation: planning and execution a trip (maps, guide signs)
Introduction: vision & driving

Level of Psychological Processing

- Decision making
- Attention control
- Perceptual-motor control

Functional Hierarchy

- Vehicle choice
- Trip decisions
- Navigation
- Guidance
- Vehicle control

Speed & Time Control

Handle,
Lane keeping,
Headway control,
Obstacle avoiding,
Crossing,
Management,
Handling,
e.

Filter model of risk behavior and road accident control
Summala (1996)
Vision & driving performance

• Visual perception: detection, recognition and discrimination:
  • Peripheral and central field of view (visual search)
  • Visual interpretation of environment (road, etc)
    • Perception of speed: motion sensitivity, speed adaptation, etc
    • Car following
    • Rear-end collisions
  • Decision making
    • Auditory and other sensory information
    • Information processing and accidents
    • Driver attention and workload
  • Right, comfortable and safe action (steering, guidance)
## Vision & driving performance

<table>
<thead>
<tr>
<th>VISUAL FACTOR</th>
<th>RELATED DRIVING TASK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accommodation</td>
<td>Changing focus from dashboard displays to the roadway</td>
</tr>
<tr>
<td>Static Visual Acuity</td>
<td>Reading distant traffic signs</td>
</tr>
<tr>
<td>Adaptation</td>
<td>Adjust to changes in light upon entering a tunnel in daylight</td>
</tr>
<tr>
<td>Angular Movement</td>
<td>Judging the speed of cars crossing our path of travel</td>
</tr>
<tr>
<td>Movement in Depth</td>
<td>Judging speed of an approaching vehicle</td>
</tr>
<tr>
<td>Color</td>
<td>Identification of colors of signals and cars</td>
</tr>
<tr>
<td>Contrast Sensitivity</td>
<td>Detection of dark-clothed pedestrians at night</td>
</tr>
<tr>
<td>Depth Perception</td>
<td>Passing on two-lane roads with oncoming traffic</td>
</tr>
<tr>
<td>Dynamic Visual Acuity</td>
<td>Reading traffic signs while moving</td>
</tr>
<tr>
<td>Eye Movement</td>
<td>Scanning the road for hazards</td>
</tr>
<tr>
<td>Glare Sensitivity</td>
<td>Reduction in visual performance due to headlight glare</td>
</tr>
</tbody>
</table>
### Vision & driving performance

#### TABLE 2.1

**Functional Characteristics and Response Properties of the Ambient and Focal Visual Systems**

<table>
<thead>
<tr>
<th>Primary functions</th>
<th>Ambient System</th>
<th>Focal System</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGN (lateral Geniculate Nucleus) source</td>
<td>Visual guidance; motor control</td>
<td>Form recognition; identification</td>
</tr>
<tr>
<td>Cortical stream</td>
<td>Magnocellular</td>
<td>Parvocellular</td>
</tr>
<tr>
<td>Field of view</td>
<td>Dorsal stream</td>
<td>Ventral stream</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>Peripheral (significant rod input)</td>
<td>Central</td>
</tr>
<tr>
<td>Contrast sensitivity</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Spatial frame of reference</td>
<td>Egocentric (absolute body coordinates)</td>
<td>Requires mid-to-high contrast</td>
</tr>
<tr>
<td>Temporal resolution</td>
<td>High</td>
<td>Allocentric (relative object space)</td>
</tr>
<tr>
<td>Primary control mode(^a)</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Memory requirements(^b)</td>
<td>Closed-loop</td>
<td>Open-loop</td>
</tr>
</tbody>
</table>

\(^a\) See Donges (1978).
\(^b\) See Norman (2002).
Vision & driving performance

• Models of driving information acquisition
  • Information theory
  • Gibson’s driving information acquisition model
  • Sign detection theory
  • Other models: ambient (dorsal) vs. focal (ventral vision)

• Methodology used to study driving information acquisition
  • Driving simulators
  • Research methods: observation and testing
  • Recording techniques:
    • Eye movements, drivers’ self-assessments, memory, sign recognition, traffic accidents, reaction time, etc.
Vision & driving performance

• Driver perception-response time
  • Detection
  • Identification
  • Decision: sight or safe distance
  • Response
  • **Night** vs. day
  • Chemicals and driver fatigue
  • Age and gender
  • Cognitive load

• Where do drivers look while driving (and for how long)?
  • In-vehicle displays, mirrors,
Vision & driving performance

Stop time = driver reaction time + system reaction time (0.3 – 2 sec) + braking time

Vehículo medio de 4.0 mt. de longitud

Energías Cinéticas

- Ec. Coche
- Ec. Camión

Ec. camión (90 km/h) = Ec. coche (464 Km/h)
Vision & driving performance

• Other interesting sub-topics:
  • Individual differences (stress, social factors, attitudes, genders, physical disabilities, age-related deficits, etc)
  • Fatigue and driving (long hours, time of day, inadequate sleep, countermeasures to sleepiness, etc)
  • Alcohol and drugs
  • Age differences (young vs. older drivers)
  • Neuropsychological, medical and psychiatric disorders
  • **Driver distraction**
    • Cell phones, navigation systems, etc
  • Driver education, training and licensing
Visual standards for driving licenses in Europe

• Historical context: professional vs. amateur drivers
  
  • **Before** EU harmonization (Gaceta Óptica, 450-451, 2010)
  
  • **Nowadays**: **RD 170/2010**
    
    • Annex I: material for minimal scanning
      
      – **Ophthalmological**
      
      – General medicine
      
      – Psychological
    
    • Annex II: template for psychophysical aptitude
    
    • Annex III: template for clinical record

• **Optometric recommendations** from **EU experts**

• Other interesting issues: organizational interventions, etc
Lesson 9

Traffic lights

• SIGNS
  - Instead visible
  - Clear and simple (conspicuity): CIE 137:2000
  - Avoid excessive signaling
  - Avoid confusion
Lesson 9

Lighting design

- Width and number of lanes, curvature radii, accesses, intersections, tunnels, etc.
# Lighting design: CIE 1995

<table>
<thead>
<tr>
<th>Category</th>
<th>( L_m ) (cd/m(^2))</th>
<th>Uniformity</th>
<th>Glare ( TI = 65 \cdot \frac{L_{VEILING}}{(L_m)^{0.5}} )</th>
<th>Surround SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>( \geq 2.00 )</td>
<td>( \geq 0.4 )</td>
<td>( \geq 0.7 )</td>
<td>( \leq 10 )</td>
</tr>
<tr>
<td>M2</td>
<td>( \geq 1.50 )</td>
<td>( \geq 0.4 )</td>
<td>( \geq 0.5 )</td>
<td>( \leq 10 )</td>
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<tr>
<td>M3</td>
<td>( \geq 1.00 )</td>
<td>( \geq 0.4 )</td>
<td>( \geq 0.5 )</td>
<td>( \leq 15 )</td>
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<tr>
<td>M4</td>
<td>( \geq 0.75 )</td>
<td>( - )</td>
<td>( \leq 15 )</td>
<td>( - )</td>
</tr>
<tr>
<td>M5</td>
<td>( \geq 0.50 )</td>
<td>( - )</td>
<td>( \leq 15 )</td>
<td>( - )</td>
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</tbody>
</table>
# Lighting design: CIE 1995

<table>
<thead>
<tr>
<th>Category</th>
<th>$E_m$ (lx)</th>
<th>Uniformity coefficient $U_0 = E_{\text{min}}/E_m$</th>
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<tbody>
<tr>
<td>C0</td>
<td>≥ 50</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>≥ 30</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>≥ 20</td>
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<tr>
<td>C3</td>
<td>≥ 15</td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>≥ 10</td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td>≥ 7.5</td>
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</tbody>
</table>
Vehicle design

• Interior

• Exterior
Other complementary topics
Supplementary reading and learning

• Download the next documents related with new optometric recommendations for driving licensing at worldwide:

  • Report on Driver Vision Screeing in Europe (June 2011)

• Why are they interesting?
• Which are the next steps at regulatory and harmonization level in Europe?
• And the future role for the optometrists?
Mandatory activity nº 5

• Relative Weight: 5 %
• Delivery process by Virtual Campus, section forum
• Individual Task:
  • Download the RACE-Alain Afflelou reports (in Spanish):
    • Older drivers and traffic security
    • Visual protection in driving
    • Distractions
    • Night vision in driving
    • Ocular protection in airbag accidents
    • Vision and traffic security
  • Which of them do you consider with well explained at technical/optometric level? Which do you like more? What is the role for the optometrists in these reports?