EFFECT OF ENVIRONMENTAL LUMINANCE ON CONTRAST SENSITIVITY IN VEHICLE DRIVERS

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BACKGROUND

Authors such as Owsleyin in 1994[1] or Arranz de la Fuente in 2003[2], have demonstrated the incapacity of conventional visual acuity tests to predict visual driving abilities. Owsley[3] reported that people with reduced contrast sensitivity are 8 times more likely to have a motor vehicle accident.

- Changes in illumination induce physiological changes in the eye that affect vision. The different levels of ambient luminance are: scotopic (lower than 10^{-3} cd/m^2); mesopic (10^{-3} to 10 cd/m^2) and photopic (above 10 cd/m^2).
- The different connections between the rods and cones and the remaining cells of the retina show varying patterns of convergence that affect sensitivity and resolution capacity.
- Driving in mesopic conditions carries more risks than driving in photopic conditions, and has more serious consequences[4]. The findings of Dickinson[5] indicate that drivers undergo a substantial loss in contrast sensitivity at all spatial frequencies during night driving.

JUSTIFICATION

- Varying luminance levels cause changes in the human visual system due to the functional and anatomical differences between the rod and cone systems of the retina.
- By determining the factor contrast sensitivity, we can evaluate visual function in situations closer to those of driving in reality.
- Driving carries a series of risks related to visual capacity. There is a need for improving this capacity.

OBJECTIVES

- To characterize the population sample by determining subject factors and factors related to their refractive state and night driving ability.
- To establish the effect of ambient luminance on contrast sensitivity.
- To evaluate photopic and mesopic contrast sensitivity and its relationship with age, type of driving licence, driving frequency, avoiding night driving, previous eye surgery and pupil diameter.

METHODS & MATERIALS

Figure 1: OPTEC 3500

We examined the right eyes of 103 vehicle drivers. The selection criteria for the study were:

- Use of habitual correction
- Current driving licence

Contrast sensitivity (CS) was determined by FACT tests using the OPTEC 3500 Vision Tester. The target includes sinusoidal gratings for 5 spatial frequencies (1.5, 3, 6, 12 and 18 cycles/º), each at 9 levels of contrast.

Contrast sensitivity was measured at luminances of 3 cd/m^2 and 85 cd/m^2 for mesopic and photopic conditions, respectively.

Tests were performed for distance vision with the test chart at 6 m (by optical simulation)

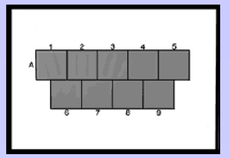

Figure 2: Target viewed by the subjects for each spatial frequency

Figure 3: Possible grating alignments

For each spatial frequency, the subjects were required to indicate the band alignments, starting from tests undertaken at maximum contrast until the contrast threshold was established.

RESULTS & DISCUSSION

FEATURES OF THE POPULATION SAMPLE

- **Age:** 20 to 84 years

  Age groups: 20 to 50 years, 51 to 70 years, 71 and older
- **Visual features**: 53% wore spectacles/contact lenses
- **Eye surgery:** 12% cataracts
- **Driving habits**:
  - 92% had licences for a motorcar
  - 56% avoided night driving
  - 45% drove less than 5 days a week

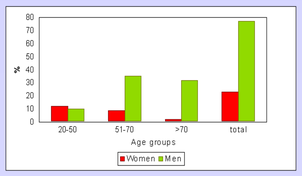

Figure 1: Proportions of men/women in the different age groups

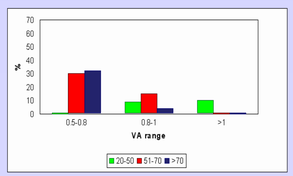

Figure 2: VA according to age

EFFECT OF AMBIENT LUMINANCE ON CONTRAST SENSITIVITY

The luminance level significantly affected CS measured at each spatial frequency except 3 cycles/°. Our results are consistent with those of Agustín[6], Arranz[2] and Dickinson[5] (FIG 3, TABLE 2)

	Spatial frequency (cycles/degree)				
	1.5	3	6	12	18
P-value	0.00	0.14	0.00	0.00	0.00

Table 2: Results of the statistical analysis of the effect of ambient luminance on CS

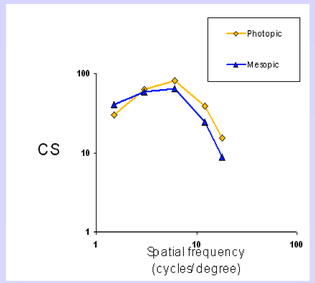

Figure 3: Contrast sensitivity in photopic and mesopic conditions

PHOTOPIC LUMINANCE LEVELS

Photopic contrast sensitivity values differed significantly for all spatial frequencies among the different age groups. These results are in line with those reported by Yager[7], Gilmore[8], Arranz de la Fuente[2], Haegerstrom- Portnoy[9] (FIG 4 ,TABLE 3)

- Photopic CS significantly differed depending on driving habits for spatial frequencies of 6 cycles/°. This finding was also reported by Owsley[10].
- Effects of cataract surgery on photopic CS indicate significant differences for 6 cycles/°, as described by Owsley[3].
- No differences in photopic CS were found related to:
  - Type of licence
  - Avoiding night driving
  - Pupil diameter

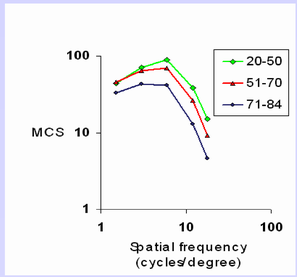

Figure 4: Mesopic contrast sensitivity according to age

	Spatial frequency (cycles/degree)				
	1.5	3	6	12	18
P-value	0.05*	0.00*	0.01*	0.00*	0.00*

Table 3: P-values for the statistical analysis of age and photopic contrast sensitivity

MESOPIC LUMINANCE LEVELS

- Age significantly affected mesopic CS measured at all spatial frequencies except 1.5 cycles/°. Our results are consistent with those of Yager[7], Crassini[11], Sloane[12] (FIG 5, TABLE 4).
- Effects of cataract surgery on mesopic CS: differences for 6 cycles/°, as reported by Agustín[6] and Owsley[10].
- Effects of pupil diameter on mesopic CS: differences noted for some pupil sizes.
- No differences in mesopic CS were found to be related to:
  - Type of driving licence
  - Driving frequency
  - Avoiding night driving

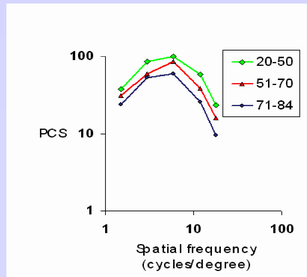

Figure 5: Photopic contrast sensitivity according to age

	Spatial frequency (cycles/degree)				
	1.5	3	6	12	18
P-value	0.13	0.00*	0.00*	0.00*	0.00*

Table 4: Results of the statistical analysis of the effects of age on CS

CONCLUSIONS

- Ambient luminance significantly affects contrast sensitivity.
- The level of photopic contrast sensitivity influences driving frequency.
- Contrast sensitivity shows no significant variation according to the type of driving licence despite different visual requirements for each licence type.
- Age negatively affects contrast sensitivity in vehicle drivers.
- Cataract surgery improved the contrast sensitivity of the drivers at intermediate spatial frequencies.

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