Studies on the Shrinkage of the Visual Field With Age

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The loss of visual sensitivity with age is accounted for by physical changes occurring at about age 35-45 years and consists in reduced power of accommodation of the lens and greater sensitivity to scotomatic glare. At age 60 a considerable decrease in the capacity to adapt to darkness and to perceive intermittent stimuli occurs. Also at this age a measurable shrinkage of the visual field is observed. It is thought that these later changes are associated with changes of retinal metabolism.

By means of perimetric and tachistoscopic field tests carried out on a large number of individuals ranging in age from 15 to 91 years, it was possible to measure changes in peripheral sensitivity and to recognize the nature of the changes. A shrinkage of several degrees in each decade above age 45 years was observed with a greater shrinkage above age 65.

The loss in the extent of peripheral vision appears similar to that produced by reduction of oxygen tension of the breathing air. It was possible to show that by reducing the percentage of oxygen for young observers, their sensitivity could be lowered to the same degree as that attained in the normal process of aging in the 66-75 year old. Such results support the assumption that the changes in peripheral visual sensitivity in the aged are due to reduced retinal metabolism. It is pointed out that for night vision and road safety of the aging population, reduced sensitivity should be taken into consideration by supplying adequate information within their range of visual perception.

•AFTER AGE 35-40 years the range of accommodation becomes gradually smaller and glasses become a necessity in order to see minute details (1). Recently, it has been shown that sensitivity to glare increases rapidly after age 40 and begins to affect the ability to make visual discrimination (2, 3). The ability to adapt to darkness (4, 5) and the perception of intermittent stimuli of light also increase with age (6, 7, 8), and an acceleration of functional loss is observed beyond 60 years.

All these changes in visual capacity are functions of the natural process of aging. The first two represent physical changes in the elasticity and clarity of the tissues of the lens, the latter occurring considerably later and coinciding with changes in metabolic activity of the human organism.

In clinical work and basic studies on vision it is a practice to determine the extent of the visual field by means of perimetry (9). Such tests indicate that under identical conditions of testing, younger individuals show a larger visual field than older people. In view of the functional losses mentioned above, it seemed of interest to study more extensively the shrinkage of the visual field in relation to age, and correlate these findings with the other changes in visual function mentioned previously.

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For peripheral field tests a Goldmann projection perimeter was used (10). Targets of various sizes and luminances were projected against the inner surface of a hemispherical shell and moved from the periphery toward the center of the visual field along radii 15 deg apart. The observer, while keeping fixation at the center of the hemisphere, signaled when he first saw the target appearing in his field of vision. By approaching successively the center from all directions, the limits of perceptibility were determined and yielded a graphic picture of the extent of the visual field.

The size of the visual field depends upon (a) size, (b) luminance, (c) color of target, and (d) the contrast between target and background. For this study the luminance of the light spot (3.3 millilamberts) and the luminance of the background (0.02 millilambert) were held constant while targets of 1 mm^2 and 2 mm^2 were presented.

The tests were carried out in the Retina Service Laboratory at the Massachusetts Eye and Ear Infirmary. The individuals tested were students, hospital employees, individuals escorting patients to the hospital, groups made available through the Veterans Administration and coming from state and federal offices, insurance companies, etc. Also, retired personnel from these offices served as observers. The field tests reported here represent only a small part of a more extensive study of various visual functions in these individuals.

The mean angular distance at which the targets became perceptible on 24 radii of the visual field 15 deg apart was plotted for 7 age ranges: 16-25, 26-35, 36-45, 46-55, 56-65, 66-75, and the range above 75 years. Despite individual variations in field size, the means of each age range show a gradual shrinkage of field size with age. The loss of peripheral vision up to age 55 is only slight, whereas in subsequent decades a more pronounced shrinkage occurs (Fig. 1).

For a more extensive study of field shrinkage with age a tachistoscopic test was developed which permitted study of sensitivity changes in the near periphery. An observer is positioned with the aid of a head and chin rest so that the eye tested is 1 m from and at the same level with the red fixation light at the center of a translucent tangent screen. The preferred eye is tested while the other is occluded (Fig. 2).

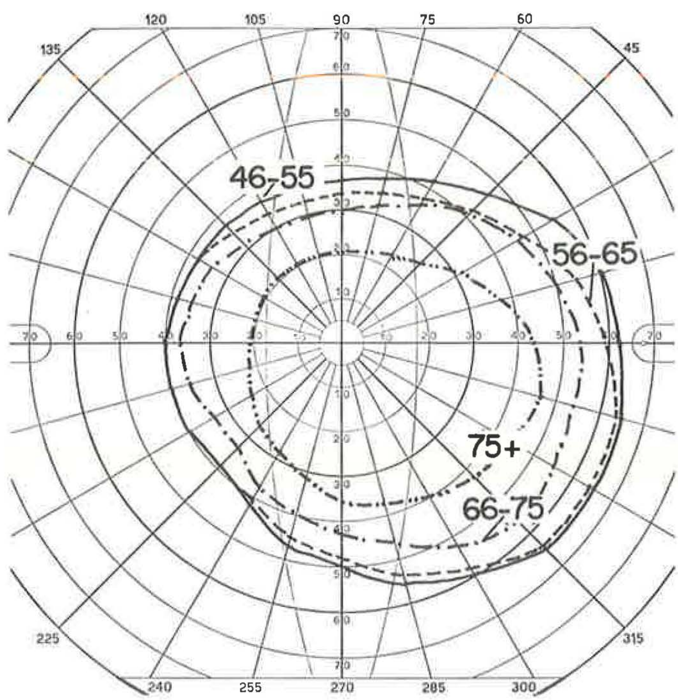

Figure 1. Perimetric fields of the right eye taken with a 1-mm target on individuals in age ranges of 46-55, 56-65, 66-75, and 75 years and over.

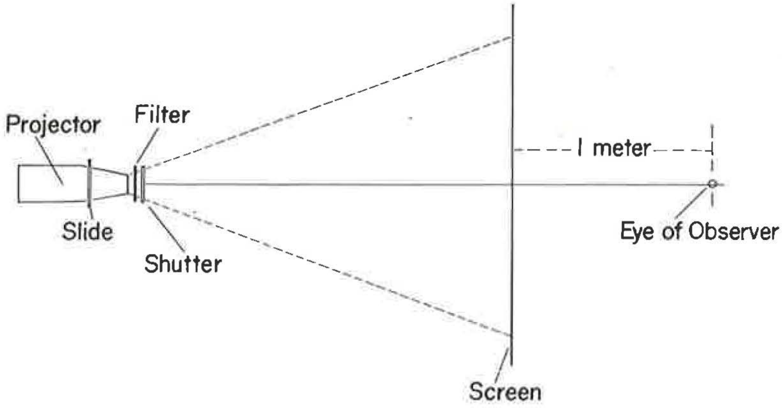

Figure 2. Diagram of apparatus for tachistoscopic field tests.

The test consists in recognition of a series of light spots situated on circles 10, 20, and 30 deg from the fixation point and projected on the screen by means of slides. The light spots subtend ½, 1, and 2 deg visual angle. They are arranged so that they form the configuration of squares or diamonds on the 10, 20, and 30-deg circles as shown in Figure 3. Each slide is presented by means of a compur shutter for 0.04 sec. Behind the shutter neutral density filters are inserted which permit variation of luminance of the light spots in half log unit steps. The luminances are presented in Table 1.

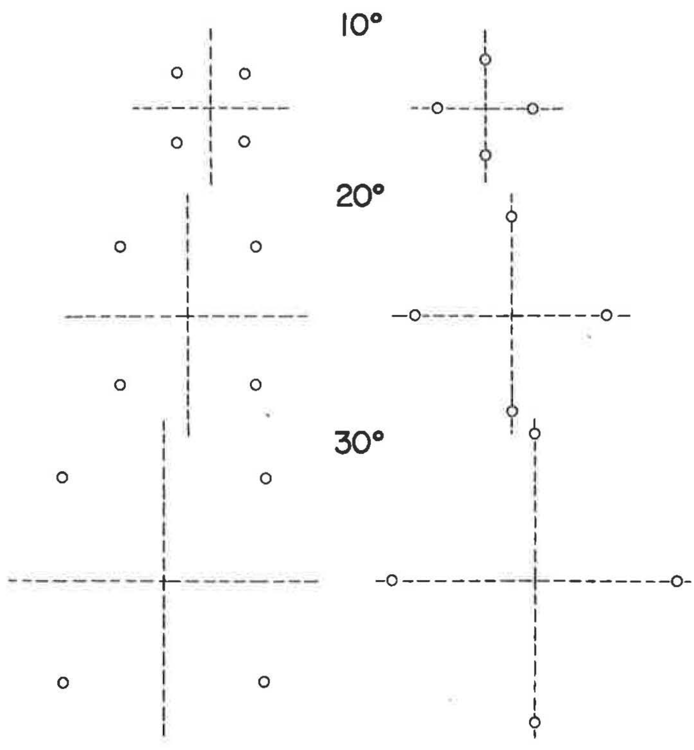

Figure 3. Arrangement of dots projected on screen 10, 20, and 30 deg from fixation.

TABLE 1

LUMINANCE OF LIGHT SPOTS

Luminance	Log Luminance
0.0023	$\bar{3}.36$
0.0091	$\bar{3}.95$
0.024	$\bar{2}.38$
0.08	$\bar{2}.90$
0.28	$\bar{1}.45$
0.9	$\bar{1}.95$
2.7	0.47
11.1	1.05
32.5	1.51

The observer is shown the 6 slides with the largest dots (arranged in alternating squares and diamonds 10, 20, and 30 deg around fixation) and is told he will be shown similar slides with smaller dots and at lower luminances. The projection screen is illuminated by ambient light of 0.1 millilambert. This presents a level of illumination to which all observers were able to adapt in 3 min for the visual discrimination to be made. Each slide was projected twice in succession and the observer was asked to report which spots he saw.

Altogether more than 250 individuals between 15 and 91 years of age were tested—30 in each decade. The results are presented in Figure 4, which shows the mean number of dots seen per individual in each age range, disregarding luminance and dot size, on the horizontal, vertical, and oblique meridians of the visual field. All curves have similar shapes. The number of dots seen in the upper visual field on the 45, 90, and 135-deg radii is considerably smaller than the number of dots seen in the lower visual field on the 225, 270, and 315-deg radii. It is interesting to note that lower sensitivity is found on the vertical meridian above fixation and highest sensitivity on the lower temporal oblique.

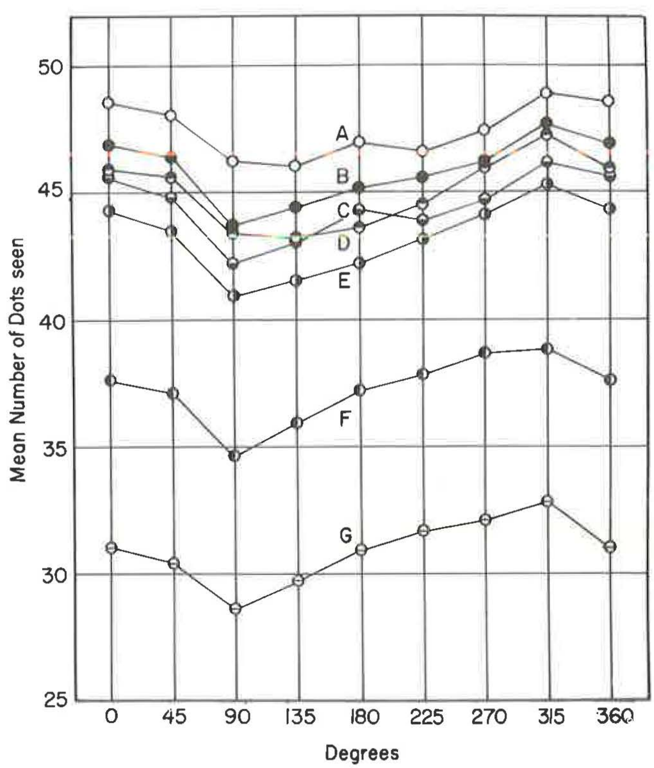

Figure 4. Mean number of dots seen on 8 radii of the visual field by individuals of seven age ranges. A: 16-25, B: 26-35, C: 36-45, D: 46-55, E: 56-65, F: 66-75, and G: 75 years and above.

The curves from the youngest to the oldest group have successively lower positions when plotted according to mean number of dots seen (Fig. 4). The highest position is held by the youngest individuals (A). The curves for the decades from 25-54 years take a lower position but lie closer together and cross each other, indicating only small changes in sensitivity (B, C, D). The curve for the 55-64 year range drops slightly, indicating the first decline in peripheral sensitivity (E). The 65-74 year old group shows a sharp decline in the number of dots seen and an equally great step downward is found for the group of individuals above 75 years of age.

Figure 5 shows the mean number of dots seen per individual in a 30-deg field where dot size was ½, 1, and 2 deg, but disregarding luminance and direction from center at mean ages of 20, 30, 40, 50, 60, 70, and 80+ years. The three curves are almost identical in shape. As dot size becomes larger proportionally, more dots are perceived at each age level. As age advances the number of dots seen decreases only slightly to mean age 60 years, after which much faster decrease is seen.

Pronounced changes in sensitivity observed in dark adaptation, flicker, and perimetric field tests occur after the age of 60 years. At this age, changes in the retina are noticed which are associated with changes in retinal metabolism. McFarland (11) recently suggested that there is a strong correlation between aging and oxygen deprivation and that the best correlations are shown for changes in visual sensitivity under reduced O_2 pressure and/or age. Dark adaptation thresholds were elevated 100 percent when O_2 tension was reduced from 20 to 12 percent. Further decrease to 9 percent O_2 tension yielded a threshold elevation of approximately 200 percent.

It was felt that the shrinkage of the visual field with age offered an opportunity to test the correlation between O_2 need and age by carrying out ordinary perimetric and

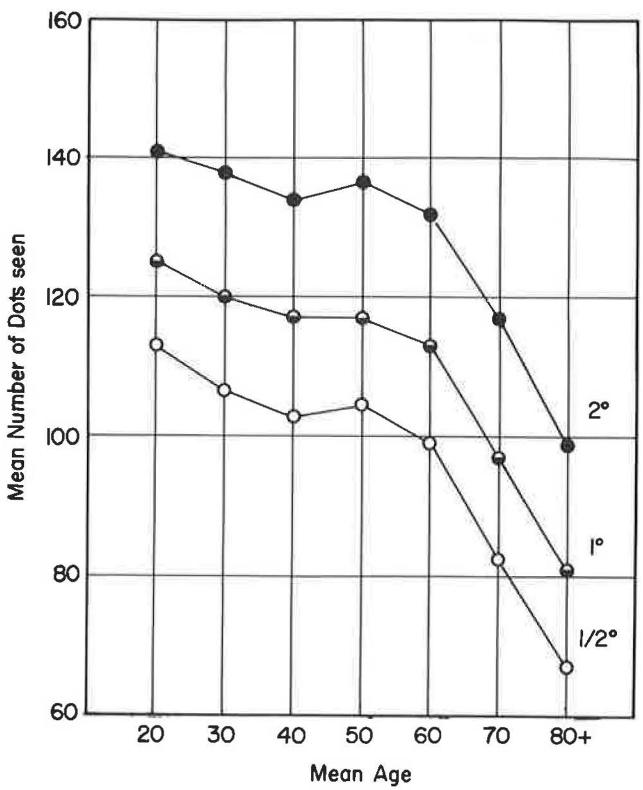

Figure 5. Mean number of dots of 0.5, 1, and 2-degree angular subtense seen at mean ages 20 to 80 years and above.

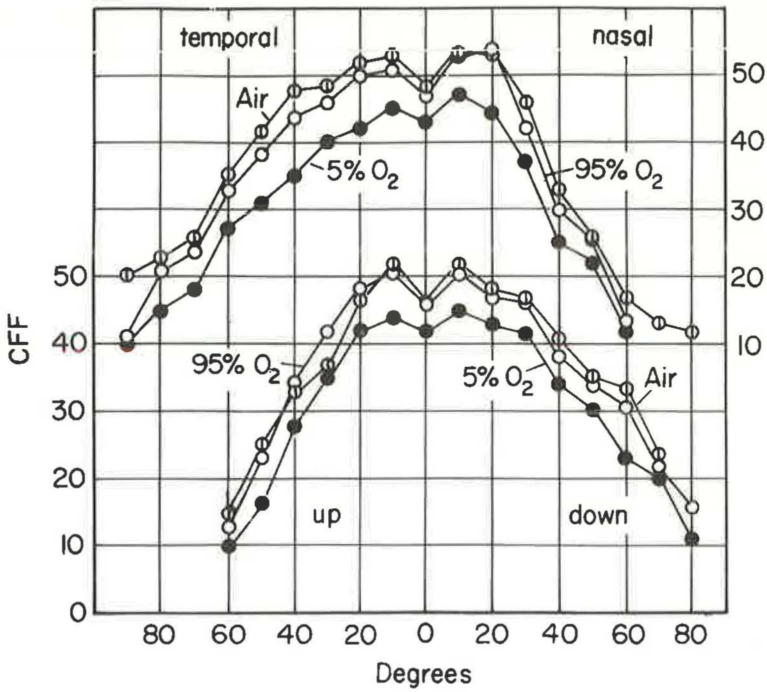

Figure 6. Critical flicker frequencies obtained on horizontal meridian of visual field when breathing air, 95 percent oxygen, and 5 percent oxygen.

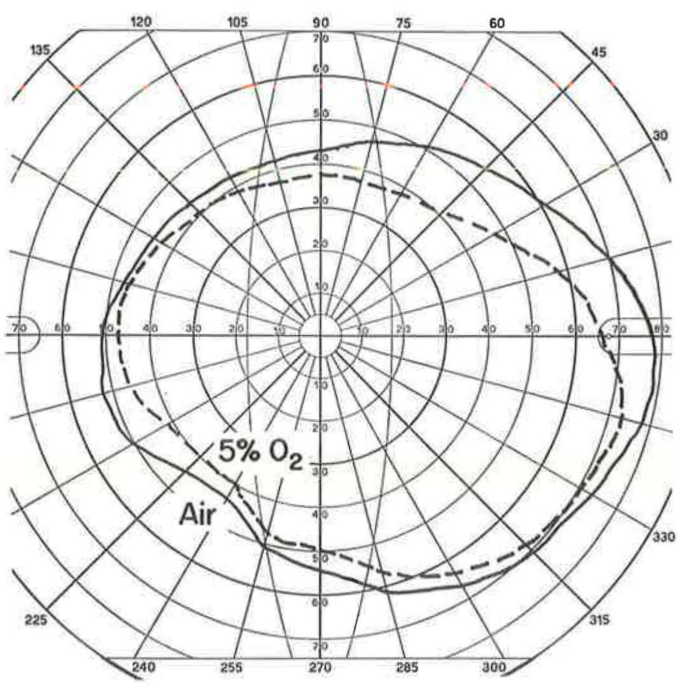

Figure 7. Perimetric field of right eye when breathing air and when breathing gas mixture containing only 5 percent oxygen.

tachistoscopic field tests in trained observers when the respiratory air contained only 5 percent O_2.

When studying flicker responses at various age levels, trained observers were tested along the horizontal and vertical meridians of the visual field. Critical flicker frequency (CFF) profiles are shown in Figure 6. When reducing the O_2 tension of the respiratory air to 5 percent, CFF drops about 3-4 cps for each point tested, and the CFF profiles lie consistently lower under O_2 deprivation. When, instead of air, pure oxygen is inhaled during the tests, a normal flicker profile is obtained, indicating that O_2 tension above 20 percent does not enhance CFF.

In standard perimetric tests individuals of all ages show a shrinkage of the visual field when the respiratory gas mixture contains only 5 percent O_2. The shrinkage of the field is general, but appears greater in the upper visual field than in other regions (Fig. 7). In the tachistoscopic tests the percentage recognition of target spots drops in young individuals about 10. 4 percent, whereas in individuals above 60 years of age the drop is approximately 15. 5 percent. These findings may be considered as additional evidence for the assumption that reduction in function of the peripheral retina is due to a reduction in metabolic rate.

The data presented here are concerned with near threshold levels of luminance. In night driving considerably higher luminance levels prevail, and since visibility is a function of luminance, a proportional field shrinkage may be assumed. The tachistoscopic tests concern a visual field extending only 30 deg from center, yet show clearly a shrinkage of a field this size. Older people may need 10 times more light than persons in the 26-35 year range in order to perceive a target at equal distance and direction from the central retina. Reduction in the O_2 tension of the respiratory air of a 25-year-old produces a vision loss equalling that of a 66-75 year old arrived at by the normal process of aging.

Visual performance under low levels of illumination and particularly in night driving depends to a large extent on the information gathered by the peripheral retina. To make this information readily available for the large contingent of motorists of advanced age, it would seem necessary and advantageous to take into consideration all pertinent factors, e.g., size, luminance, contrast, presentation time, etc., when visual information for safe vehicular travel is presented.

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