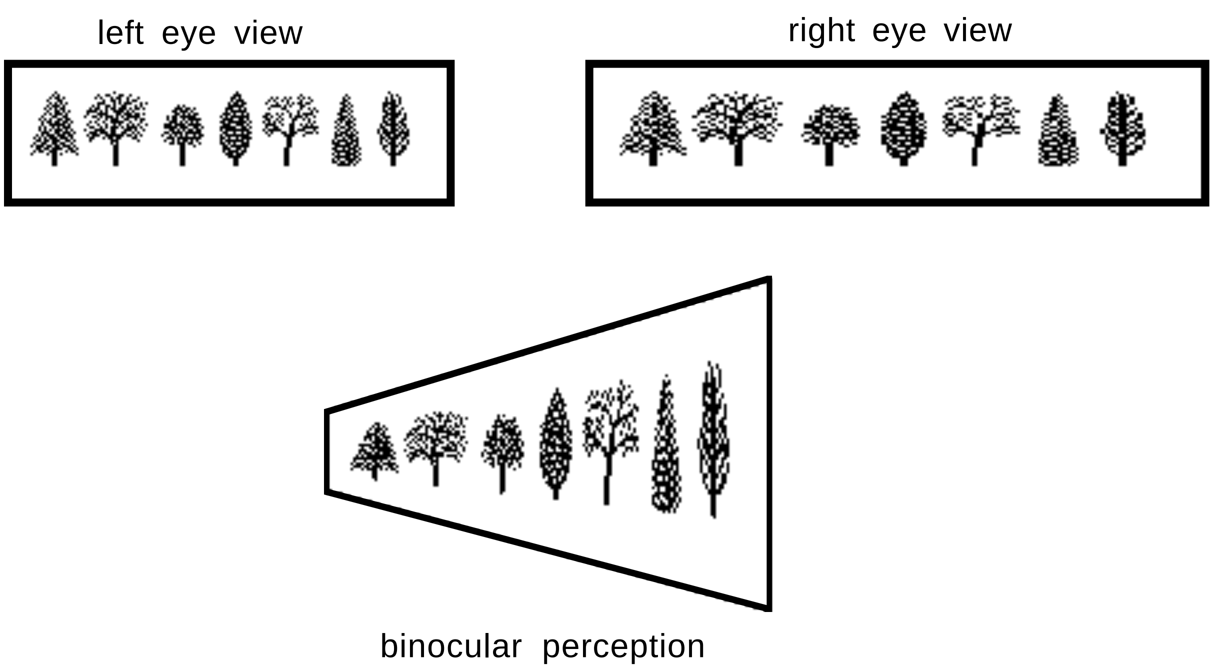
Magnification Problems

Aniseikonia

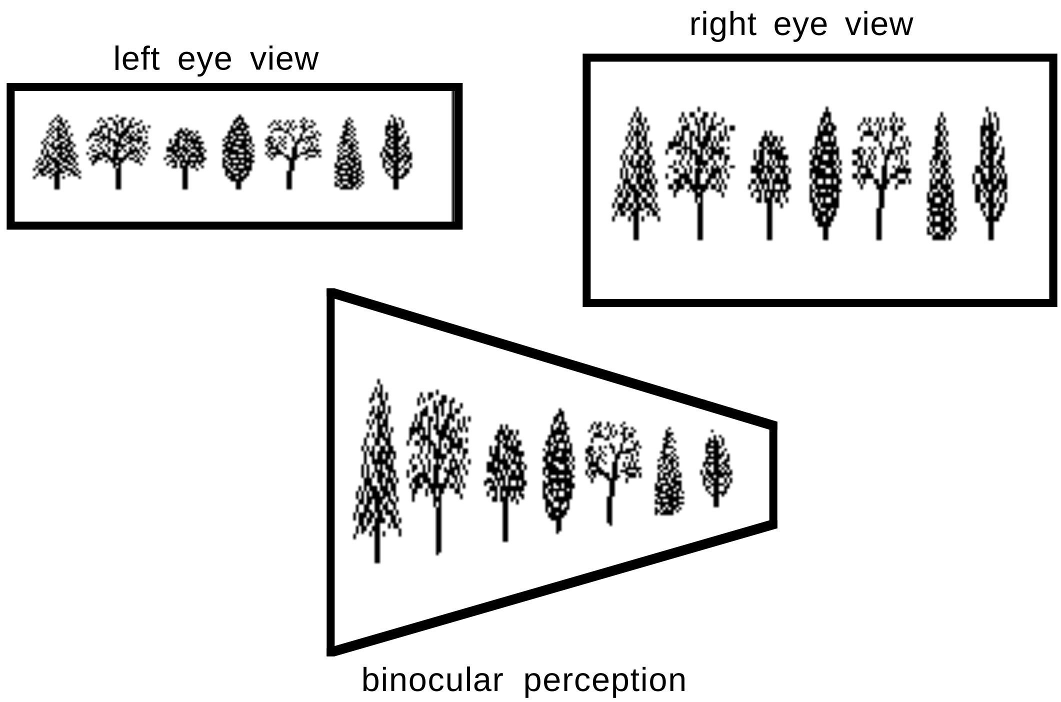
<u>Aniseikonia</u> is a condition in which the patient suffers from differences in size between the images in the two eyes. This will commonly be manifested as generalized asthenopic symptoms--headache, eyestrain, fatigue, reading difficulty, vertigo, space perception difficulties. The importance of aniseikonia and its attendant clinical manifestations is controversial except in the case of unilateral aphakia. There is, however, evidence for a population of patients which will benefit from treatment of aniseikonia.

Spatial distortions with aniseikonia depend on the meridian of magnification. With the geometric effect, magnification with a meridional magnifier axis 90° enlarges the horizontal dimension over the magnified eye resulting in an apparent tilting of the horizontal plane **toward** the eye with the magnifier. This is shown in the figure below.



Geometric effect when magnifier x90° is placed over right eye.

With the induced effect, magnification with a meridional magnifier axis 180° enlarges the vertical dimension over the magnified eye resulting in an apparent tilting of the horizontal plane **away from** the eye with the magnifier. This is shown in the figure below.

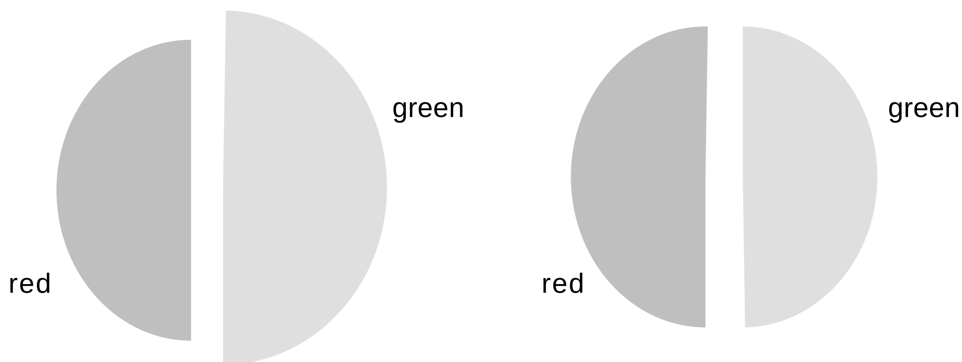


Induced effect when magnifier x180° is placed over right eye.

Magnification along oblique meridians causes the top of a horizontal plane to tilt toward or away from the observer. For example, magnification in the 45° meridian of the right eye tilts the top of the plane toward the observer while magnification in the 135° meridian of the right eye tilts the top of the plane away from the observer. Spatial distortions are usually observed by patients for a short time before they adapt. The wealth of binocular cues in the real world environment makes that possible.

Aniseikonia is detected clinically by measuring the relative size of retinal images directly or measuring it indirectly from the induced spatial distortions. The late, lamented, classic American Optical Space Eikonometer used this latter approach. The patient looked into the device at a pattern of lines against a black background. If the patient described the lines as tilted, adjustments were made until the tilt was eliminated. Relative image magnification could be read from the instrument knobs.

All tests available nowadays attempt to directly measure the relative dimensions of the images in the two eyes. The only commercial instrument for doing this is the Awaya New Aniseikonia Test.



The patient views paired red and green semi-circular targets like that above left through red-green anaglyph glasses. One pair of semi-circles should look like the target on the right above. The actual relative magnification of the two targets measures the patient's aniseikonia in the vertical dimension. The chart is rotated 90° and the test repeated to evaluate the horizontal dimension.

Other methods use existing clinic equipment and size lenses. Size lenses are afocal lenses which produce small amounts of magnification. They are, in effect, small magnification Galilean telescopes. One test has the patient view a line of letters while the examiner alternately covers one eye and then the other, as in the alternating cover test. Size lenses are used to eliminate any fluctuations in size noted by the patient. The magnification of the size lens is the amount of aniseikonia. Another test has the patient view a pair of parallel lines with the eyes blocked by a Turville septum. In aniseikonia, there will be small differences in the separation of the lines as seen by the left and right eyes. The difference is eliminated by a a size lens which, again, equals the amount of aniseikonia.

Aniseikonia is due to differences in the optics of the two eyes which produce different image sizes. Anisometropia may be refractive--due to the different optical powers of eyes of the same dimension, or axial--due to the difference in length of the two eyes. Axial anisometropia is much more common. In routine refraction, the two kinds of anisometropia may be differentiated on the basis of keratometry. If the difference in keratometry readings corresponds to the difference in refractive corrections, the anisometropia is refractive. Otherwise, it is probably axial. Nowadays axial anisometropia may be confirmed with A-scan ultrasonography.

In aniseikonia, the corrective lenses should be chosen so as to eliminate as much of the retinal size difference as possible. The first big question is whether to use spectacles or contact lenses. Knapp's Law states that spectacles keep retinal images the about same size in axial anisometropia while contact lenses keep retinal images about the same size in refractive anisometropia. This figures since contact lenses effectively replace the cornea, the most important refractive element of the eye. Since most anisometropia is axial, Knapp's Law says it is best corrected with glasses. But that produces a cosmetic problem since one spectacle lens will be thicker and heavier than the other and magnify one eye much more than the other making the eyes look notably assymetric. For this reason, many optometrists disregard Knapp's law in prescribing for anisometropes. They get away with it in part because so many anisometropes suffer from amblyopia and don't really use the two eyes together anyway.

Small amounts of magnification adjustment may, in principal, be made by adjusting the parameters of the spectacle lenses. The complete formula for magnification due to a thick spectacle lens can be written

$$SM=\omega'/\omega=\{1/[1-gF_V']\}\{1/[1-(t/n)F_1]\} \quad (1)$$

where

F_V' = back vertex power of the lens
F_1 = front surface power of the lens
t = thickness of the lens
n = index of the lens
g = distance from the back of the lens to the entrance pupil

The second term in curly brackets is called the power factor because it depends only on the back vertex power of the lens, not its shape. It is the factor we obtained for a thin lens. The first term in curly brackets is called the <u>shape factor</u> because it depends on the form of the lens through its front surface power F_1.

If $|gF_V'|$ and $|(t/n)F_1|<<1$, we can expand (1) using the binomial theorem in the form

$$(1-x)^{-1} \cong 1+x+ \ldots$$

so that

$$SM \cong 1+(t/n)F_1+gF_V'.$$

If we define percentage spectacle magnification as %SM=(SM-1)(100%) we may write

$$\%SM \cong (100\%)[(t/n)F_1+gF_V'].$$

The ways of changing spectacle magnification may be deduced from this latter equation. They are as follows:

To increase spectacle magnification:

- ☞ Increase F_1, the base curve power
- ☞ Increase t, the lens thickness
- ☞ Decrease n, the index of the lens material
- ☞ Increase g for hyperopes by moving the lens away from the face
- ☞ Decrease g for myopes by moving the lens toward the face

Realistic changes in lens design make only modest changes in magnification. Moverover, they may alter the peripheral performance of the lens and so should be undertaken only with caution.

