BIFOCALS

Reasons for Prescribing Bifocals

Presbyopia

Presbyopia is Latin for "old sight". It is the culmination of a loss of accommodation that starts about age 10 and gets to be a problem about age 40 for an emmetrope or corrected ametrope, sooner for an uncorrected hyperope. Therapy for this is a near prescription in the form of reading glasses or a bifocals. The difference between the distance and near prescription is called the add. A simple formula for the add power is

$$\text{add power(D)} = \text{age}/8 - 5.00 \pm 0.25.$$

where the add is the difference between near and distance prescriptions. Note that the formula above gives add=0 at age 40 and add=+2.50 at age 60. It assumes a 40cm working distance.

Example: What is the expected add at age 52?

Solution: add=52/8-5=+1.50D.

Accommodative Esophoria

Convergence accomponies accommodation and in some patients this causes the eyes to cross at near leading to discomfort or esotropia. The usual solution is to relieve accommodation with bifocals.

Types of Bifocals

A bifocal lens has two areas, one for reading at the bottom, one for distance at the top. There are several strategies for producing bifocal lenses.

Split Lenses

Honest to God, bifocals really **were** invented by Benjamin Franklin. The split lens is the Franklin type bifocal with a lens above and below cut along a straight line and joined in a frame. It survives today only in half eyes, inverted half eyes, and some low vision aids.

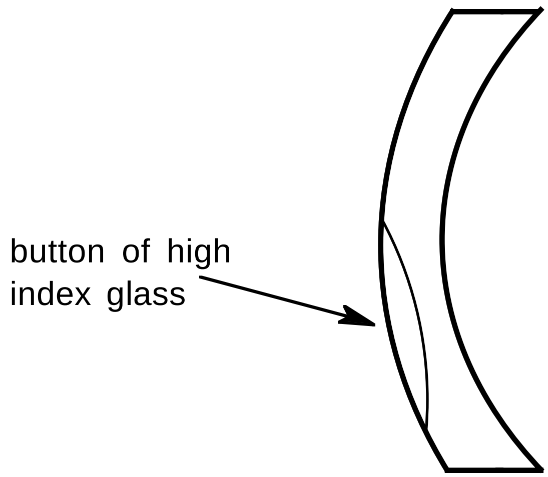
Cemented Bifocal

In a cemented bifocal a small plus lens is glued to the back of a distance Rx with a glue like Canada balsam. This is used today in some low vision prescriptions requiring very high adds.

The modern varient of the cemented bifocal is the Fresnel lens which sticks in place with water or alcohol. It is used sometimes as a temporary bifocal, but it is too unsightly, expensive, and optically poor for permanent use.

Fused Bifocal

A fused bifocal is a glass bifocal in which a small button of high index glass is inset into a concavity at the front of the lens. The add results from the additional power of the front of the button due to the high index and the interface at the back of the button.

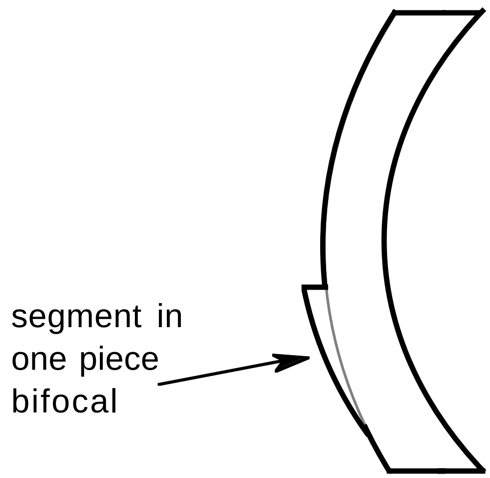


The curvature of the countersink curve can be calculated from paraxial optics knowing the add power, the front surface curve of the lens, and the indices of the two kinds of glass.

Fused bifocals were extremely popular up until 10 years ago when plastic lenses captured most of the spectacle lens market. No one has made a fused plastic lens.

One Piece Bifocal

This kind of bifocal is obtained by grinding a different curve on the front of back part of the lens or molding it with a little piece of protruberant material. This is the way all plastic bifocals, the most common bifocals, are made.

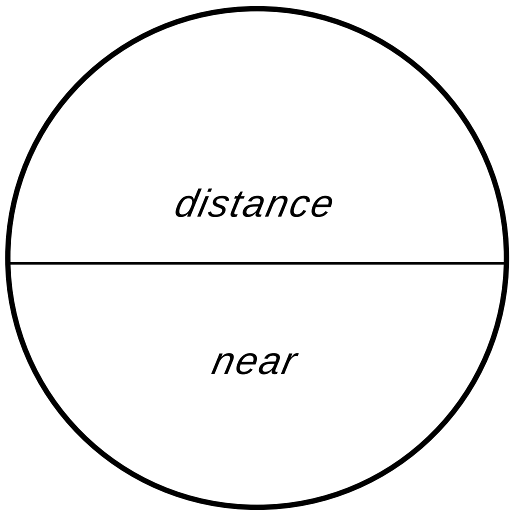


In one piece segments, cylinder is ground on the side of the lens opposite the add. Since minus cylinder lenses are standard today, this means the add is on the front of the lens.

Bifocal Shapes

Here is a survey of the common bifocal shapes and their relative advantages and disadvantages.

Executive Bifocals



The segment of the Executive bifocal covers the entire bottom half of the lens. The name suggests a captain of industry surveying the vital information laid out on his imposing desk.

Advantage:

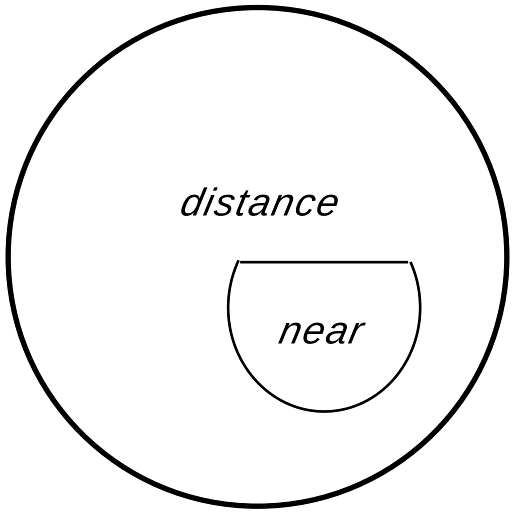
✔ It has a big field of view.

Disadvantages:

✘ It's heavy.
✘ It's ugly.
✘ It gets dirty in that long, deep crevice.
✘ The edge of the segment chips easily.

Few doctors prescribe the Executive bifocal any more if they can help it.

Straight Top Bifocal



The straight top bifocal comes in a variety of shapes and sizes. Those commonly available today are the ST25, ST28, and ST35 which are 25mm, 28mm, and 35mm indiameter, respectively.

Advantages:

✔ It's nearly invisible and attractive cosmetically.

✔ It's relatively light.

✔ It provides a good sized field of view.

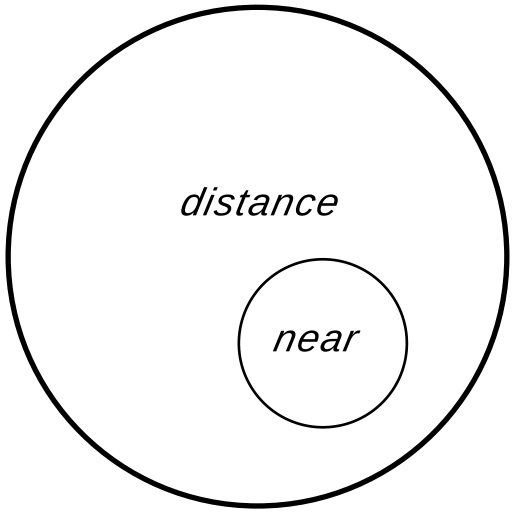
Disadvantages:

✘ Though **nearly** invisible, it's presence is obvious on inspection.

✘ The reading area is somewhat reduced.

The straight top bifocal is the most common bifocal style. The ST35 is a good alternative to the Executive bifocal.

Round Bifocal



The classic round bifocal was the Kryptok bifocal a fused glass bifocal. The manufacturing process left the Kryptok with somewhat inferior optical quality and it was rather less expensive than other bifocals. High quality glass and plastic round bifocals are available nowadays. The Kryptok was 22mm in diameter and even today most round bifocals have that same diameter.

Advantages:

✔ It's nearly invisible and attractive cosmetically, even more than the straight top bifocal.

✔ It's relatively light.

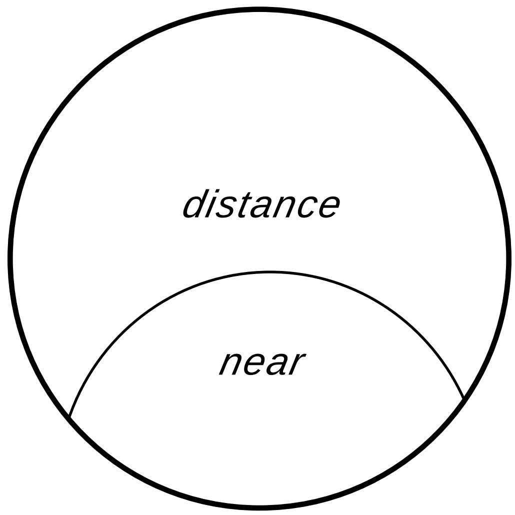
Disadvantages:

✘ Greater excursion of the eye is required to get into the widest part of the bifocal.

✘ There is a prismatic displacement or "jump" of the image when the eye enters the bifocal.

Round bifocal segments are not much prescribed nowadays. Most recipients are elderly patients who got used to them years ago and don't want to adapt to a new shape.

Ultex Bifocal



The Ultex bifocal is a round segment with a **very** big diameter. Unlike other bifocals, this one piece design is usually placed on the **back** of the spectacle lens.

Advantages:

✔ Spectacles may be ground in plus cylinder form for patients who can't adapt to minus cylinders.

✔ They can be used, in principal, in a dissimilar segment pair to compensate vertical imbalance (more on that later).

Disadvantages:

✘ There is a very significant prismatic displacement or "jump" of the image when the eye enters the bifocal.

✘ **It isn't available anymore!!!**

So why even discuss the lens if it isn't around? Because it sometimes appears on test questions, that's why.

General Optical Properties of Bifocals

Many important properties of bifocals can be calculated from minimal information about the add. For this section of the discussion all we need to know is:

☞ the distance Rx;

☞ The add power;

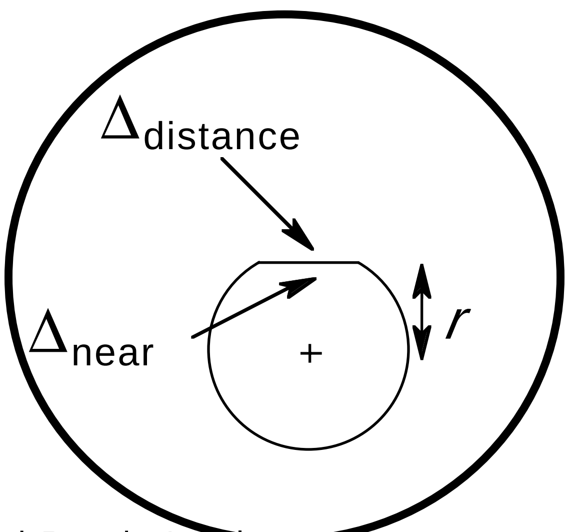
☞ the segment shape;

☞ the position of the optical center of the segment.

The way the add power is achieved--with a one piece lens, fused bifocal, etc.--is irrelevant for now.

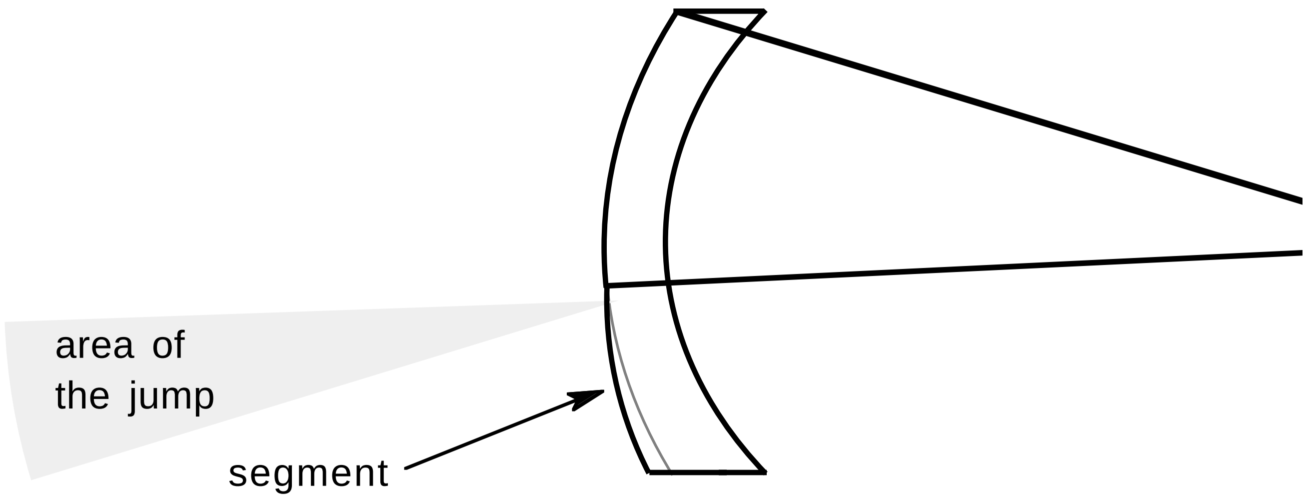
Jump

Finally, prism in ophthalmic lenses is responsible for the "jump" in bifocal lenses, a displacement of the image when fixation moves across the top edge of the bifocal segment. Jump is defined as the prism at the top edge of the segment, the product of the power of the add in diopters and distance from the optical centre of the segment to its upper edge in centimeters



In the diagram and Prentice's rule,

$$\text{jump(p.d.)} = |\Delta_{distance} - \Delta_{near}| = r\text{(cm)x(add power)}.$$



As the diagram above shows, the jump causes a blind spot around the segment line. The area of the jump is that area not seen due to the scotoma.

Example: What is the jump of a +2.00D Kryptok add?

Solution: a Kryptok add has 22mm diameter and 11m=1.1cm radius so the jump is

$$\text{jump}=(1.1\text{cm})(+2.00\text{D})=2.2\text{p.d.}$$

We can eliminate jump altogether by making r=0, that is, by placing the segment center at the top edge of the segment. This is the case with the Executive and (nearly) with the straight top segments.

Prismatic Imbalance at the Reading Center

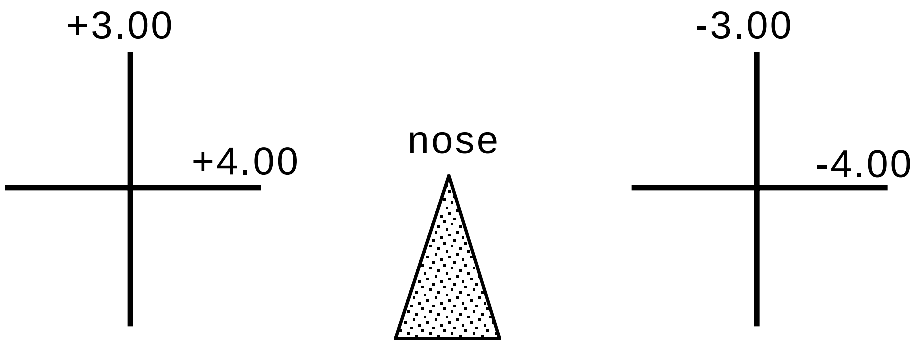
As noted previously, whenever a patient looks through any part of his lenses besides the optical center, he experiences prismatic imbalance if his Rx differs between right and left eyes. This is especially a problem with bifocals since the patient **must** turn his eyes down to look at near objects. With single vision lenses he has the option of turning his head.

Vertical imbalance, a difference in the vertical component of differential prism encountered in downward gaze, causes the biggest problem since even small amounts, 1p.d. or more, may produce eyestrain or even diplopia.

Example: Calculate the vertical imbalance for a patient with the following prescription if he reads 1cm below the optical center of his lenses:

O.D. +4.00-1.00x180, add +2.00
O.S. -3.00-1.00x090, add +2.00

Solution: Draw the power crosses of the two lenses:



In the calculation we may ignore the prism contributed by the segments since that will be the same in both eyes. From Prentice's rule, then, the prism encountered one centimeter below the optical center of the right eye is (+3.00D)(1cm)=3p.d. BU. For the left eye it is (-3.00D)(1cm)=3p.d. BD. The prismatic imbalance is |+3-(-3)|=6p.c., a serious problem.

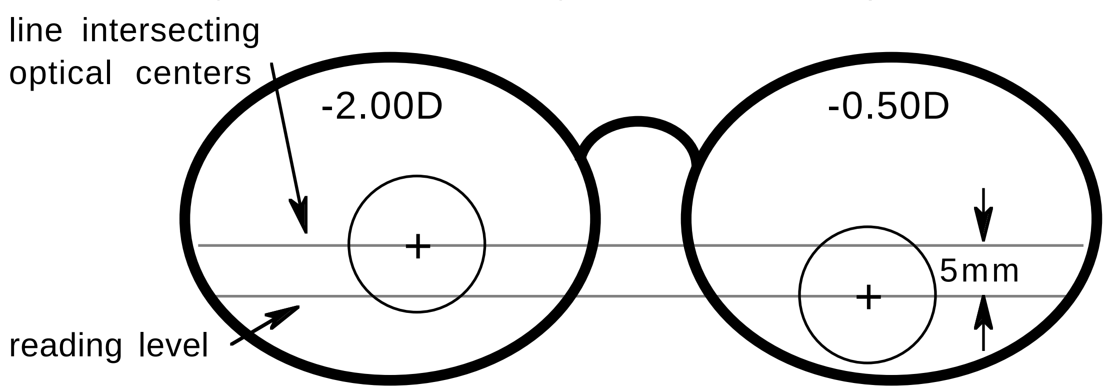
So how do we get around the problem of vertical imbalance? The trick is to have two segments with their optical centers at different heights.

Example: A patient's Rx is

O.D. -2.00DS, add +3.00
O.S. -0.50DS, add +3.00

Where should the segment centers be so that there will be no vertical imbalance if the patient reads through a point on the lens 10mm below the optical center of the distance portion of the lens?

Solution: Without the segment, the prism encountered 1cm below the optical center would be (-2.00D)(1cm)=2p.d. BD in the right eye and (-0.50D)(1cm)=0.5p.d. BD in the left eye. With a three diopter add, the segment centers would have to be separated by (2.0p.d.-0.5p.c.)/(+3.00D)=0.5cm=5mm. So the optical centers of the two segments would have to be separated by 5mm. Which segment would have to be higher? The right, to compensate the extra BD prism in the distance portion of the right lens at the reading distance with BU prism from the add.



The diagram shows schematically where the segment centers would be placed.

Of course in real life we wouldn't place two segments in the peculiar configuration above, but we **would** do the optical equivalent. Here are some practical ways of dealing with vertical imbalance.

☞ Dissimilar segments. Find two different segments which have centers sufficiently separated to produce adequate prism. About the biggest separation practical nowadays is 11mm obtained using a round segment over one eye and a ST in the other. This looks really weird.

☞ Compensated segments, a variation on the dissimilar segments theme. At one time Univis made the Univis R segments with centers that could be varied in position in 1mm steps up to 6mm.

☞ Prism segments. Segments with a given amount of prism have been available from time to time. They are unavailable now.

☞ Fresnel prisms. These are cosmetically and optically poor.

☞ Reading glasses. They're inconvenient, but they work!

☞ Contact lenses for all or most of the distance correction over which bifocals, or half-eyes are worn.

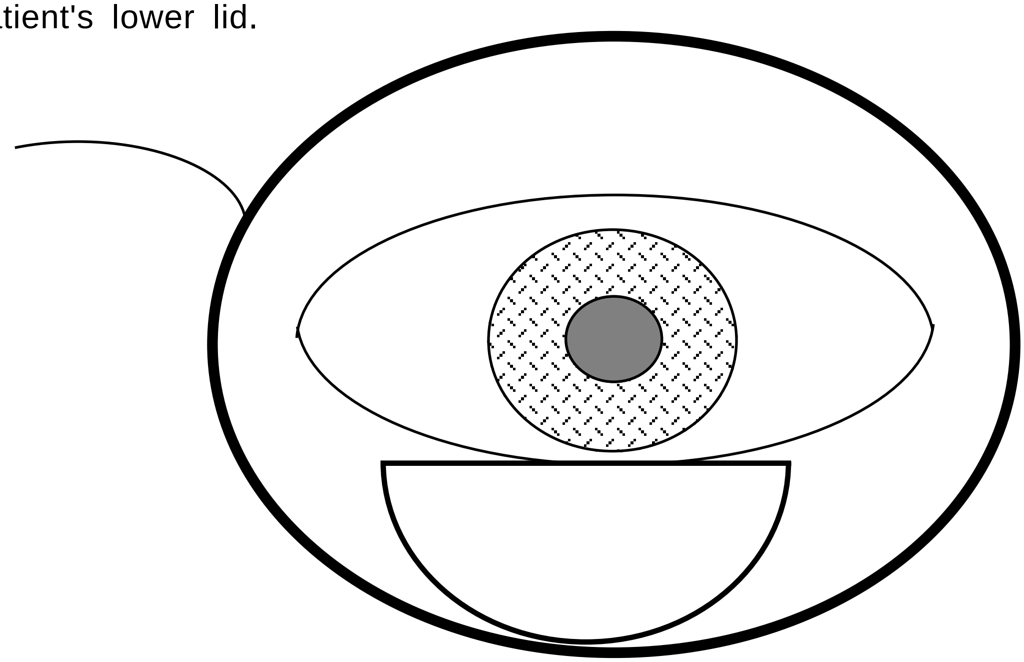
☞ Slab-off or bicentric grinding. This probably the most practical approach.

The subject of slab-off or bicentric grinding deserves a bit more discussion. In this procedure a dummy lens is glued, temporarily, onto the front of the bifocal lens. The dummy is then ground ad an angle with the optic axis of the distance portion of the bifocal. After that the sliver of the dummy lens remaining is removed, leaving a base up prism ground into the lens, along with a faint line. The patient will experience jump when he looks across the line. Bicentric grinding may be done on the front or back surface of a lens. It is helpful when more then 1p.d. of prism is required. The amount of slab-off prism may be verified by measuring the jump with a lensometer. Another way is to subtract the reading of a lens clock placed with the center pin on the slab line from the lens clock front surface reading.

Lateral imbalance is much less problem than vertical imbalance. It is routinely dealt with by insetting segments to the near PD, which also maximizes binocular field of view through the lenses. The inset leaves the patient with the imalance due to the distance Rx, but at least the segments don't add more.

Dispensing Bifocals

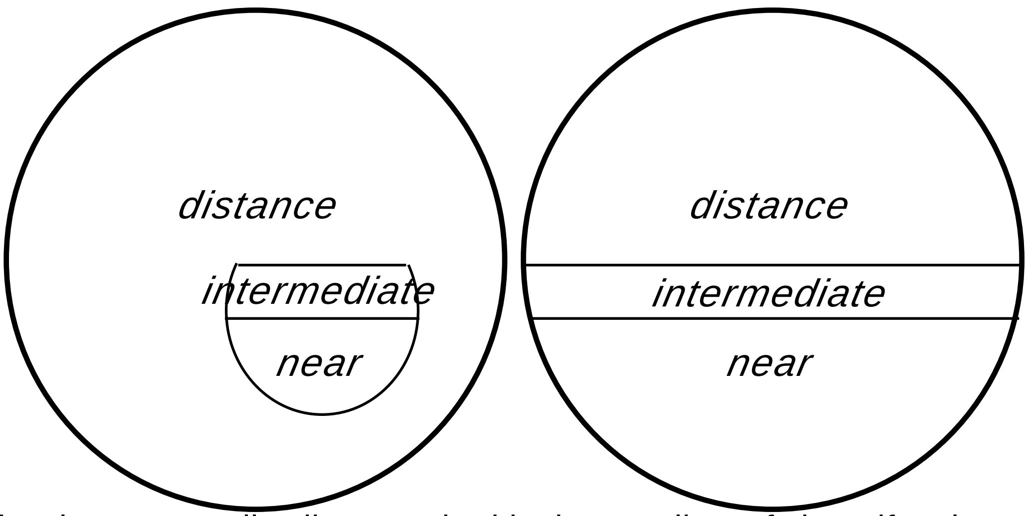
Bifocals are usually set so that the top of the segment lines up with the patient's lower lid.



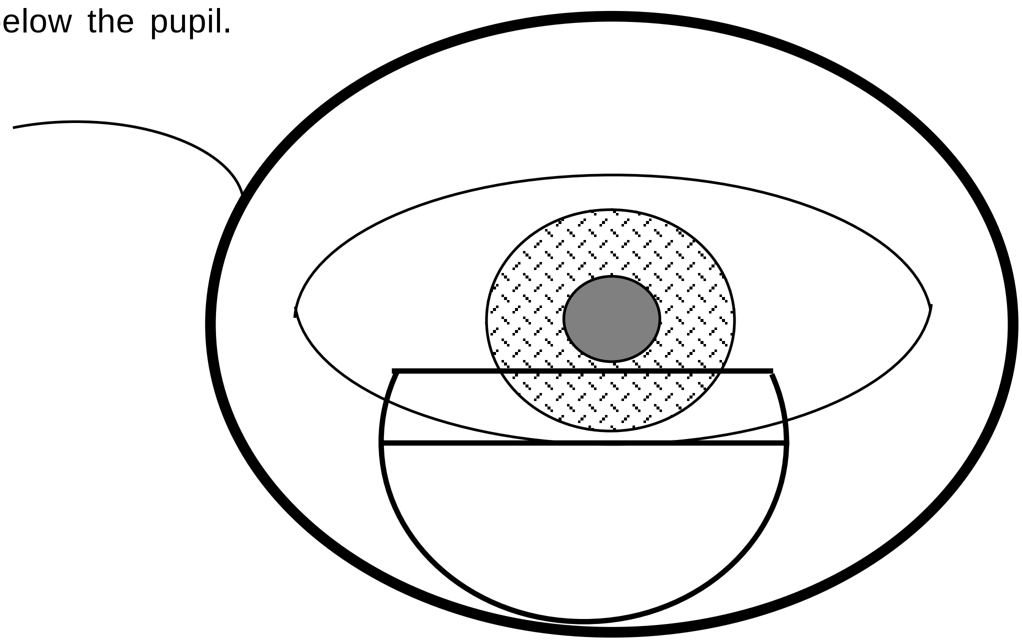
Multifocals

Multifocal lenses may be considered when the patient complains of a "lost" area between his distance and near prescriptions, e.g. things art arm's length aren't clear with the top **or** the bottom part of the bifocal.

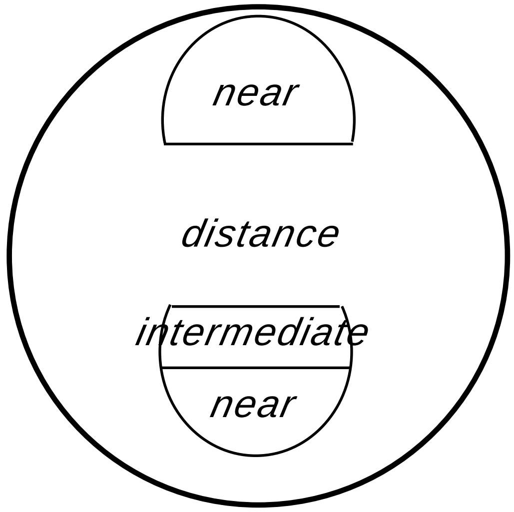
Trifocals sandwich another strip of optics between distance prescription and near prescription. The power of that strip is usually 50% of the add. Trifocals come in the same styles as bifocals, the most common being the straight top (left below) and the grotesquely ugly Executive trifocal (right below).



Trifocals are usually dispensed with the top line of the trifocal segment just below the pupil.



A double segment is has an additional add at the **top** of the lens. It is an occupational lens for painters, pilots, and the like.



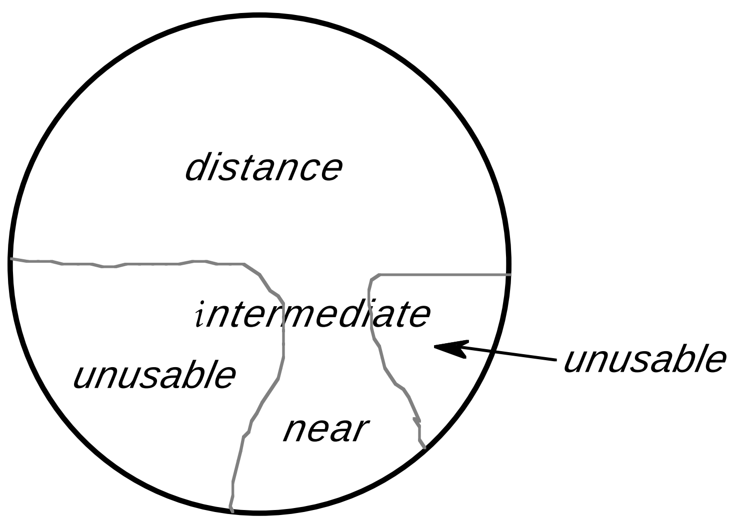
The top segment may be obtained in any power. The near correction can be had in a bifocal or trifocal.

Blended Bifocals

A blended bifocal is a round segment but with the periphery of the segment "smeared" over about a two millimeter width to make the segment less noticeable. The smearing is purely for cosmetic effect and has no optical function. Even cosmetically it is less than completely successful, the segment being apparent to a careful viewer. The archetype of the blended bifocal was the Younger lens.

Progressive Addition Lenses

For most presbyopic patients who need an intermediate viewing distance in ordinary activities, I recommend a progressive addition lens (PAL). These are sometimes called "no line bifocals". The best known brand name is Varilux, but there are around thirty other manufacturers in the market nowadays. Progressive addition lenses are marketed chiefly for their appearance ("Who needs more lines," coyly asks one Varilux ad), but they are optically useful because they provide an intermediate viewing distance. In fact they provide a continuously varying intermediate distance along a corridor connecting the distance part of the lens to the near part (shown schematically in the figure below), hence the name "progressive add". The price of this optical magic is a relatively small reading area on the lens compared to conventional bifocals, and a couple of optically unusable lens areas crammed at the bottom and outside of the lenses. Progressive addition lenses are expensive and take a bit of getting used to, but are the ideal solution for many presbyopes.



PAL designs may be considered "hard" or "soft". In hard designs, reading area is maximized but transitions to the unusable zones is abrupt. Soft designs have more gradual transitions at the expense of a narrower reading zone.

Dispensing is especially critical with progressive adds. The dispenser must carefully determine the position of the center of the patient's pupil with respect to the bottom bevel of the lens. This should exceed 24mm for most lenses. Monocular near PD's should be measured with a device accurate to 1/2mm. Lenses work best placed as close as possible to the face with an appropriate pantoscopic tilt.

The increasing ubiquity of the microcomputer in the last half dozen years has led to development of two new lenses especially designed for the presbyope who uses visual display terminals; the *Readable*™ lens made by Varilux® and the *Technica*™ lens produced by American Optical Company. Technically these are progressive addition lenses--but with a difference. These computer lenses have a large intermediate portion covering most of the center of the lens, with a small reading portion at the bottom and a small distance portion at the top.

