HOW TO REFRACT AN EYE

(version 3-11-2017; written for EGRET; original version: 12-4-1996 by resident ophthalmology Nomdo Jansonius)

What you need:
- Box with trial frame, lenses, and occluder
- Cross cylinder of +/- 0.25 D
- Visual acuity chart
- This manual

General comments

1. This is not a ‘selling glasses’ tutorial. The aim is refracting a single eye, as needed for, for example, research. Prescribing glasses is more than just refracting two eyes (suggested reading: The Fine Art of Prescribing Glasses - Without Making a Spectacle of Yourself, by Milder and Rubin).
2. A fixed sequence of steps is crucial. All roads lead to Rome, but if you follow a specific route, follow its directions.
3. Always let the subject choose between two alternatives (with or without a newly added lens, or by flipping the cross cylinder): “Which one is better, Option 1 or Option 2?” (forced choice).
4. The size of an offered change should be related to the current visual acuity and/or refractive error.
5. Refracting an eye can be done at any distance, but in order to avoid stimulation of the accomodation reflex, a large distance (typically 6 m) should be used. If your experiment requires a large (3-6 m) testing distance, you could simply use the distance refraction. If you need a shorter testing distance, you should first refract the eye at 6 m and subsequently add an addition in

order to reach the ‘optimal correction for the viewing distance’. The table below gives the addition needed, that is, the amount of diopters to be added to the distance refraction.

Age (yr)	Testing distance (m)					
	∞	3-6	2	1	0.5	0.3-0.4
All ages	-0.25	-	+0.25			
< 40				-	-	-
40-55				-	+1.00	+1.50
> 55				+0.75	+1.75	+2.50

Example 1: If you refract a 61-year old subject and you find a distance refraction of S-0.50 C-1.00x30, this subject needs S-0.25 C-1.00x30 for performing a contrast sensitivity test at 2 m.

Example 2: For perimetry, we do not correct astigmatism but use the spherical equivalent (SE; sphere plus half of cylinder of distance refraction). For the subject above, the SE is -1.00 D. Hence, for performing perimetry at 0.50 m, a +0.75 D correction is needed. Note: for FDT you do not need any correction.

6. This manual has ‘no glasses’ as starting point. You may also start with an autorefractor value or an old prescription, or with the actual glasses of the subject using a lensometer.
7. Accurate refraction requires significant practising and experience. An approach that is easier, more safe in case of doubt, and reasonably accurate can be found in the appendix.

Refraction in the strictest sense

Step 1

Put on the trial frame. Take care of centration. Occlude one eye and measure visual acuity (VA) monocularly.

Step 2: global spherical refraction

Try with a positive spherical lens if improvement is possible. See table for lens power. If improvement occurs, ask the subject to read optotypes in order to judge how much improvement was obtained, and from this you estimate the power of the next lens. If no improvement occurs, try a negative spherical lens (following the same table).

VA after step 1	Power of lens to be tried (D)
0.8 or above	0.25
below 0.8 (0.4-0.63)	0.50
below 0.4 (0.2-0.32)	1
below 0.2	2

Continue with positive lenses until the image becomes blurred, with negative lenses until the image does not further improve (that is, add as much plus as possible or as little minus as possible). Note: For those who can accommodate, too much minus results in a smaller image, without obvious blur (inverted Dutch telescope).

If the visual acuity is now 1.25 or even better, you may stop here. Else, go to step 3.

Step 3: cylinder

No need to read optotypes during this step: ask the subject to look at an O or C that is one or two lines above the current VA.

Try with a cylinder of -0.50 D (never use a plus cylinder) with axis at subsequently 180, 90, 45, and 135° if improvement is possible. If yes, put the cylinder in the trial frame in the position that resulted in improvement. If no, you may stop here. Note: Use a cylinder of -1 D if VA < 0.6 after step 2.

Axis of cylinder

Determine the axis of the cylinder by flipping the cross cylinder with its stem parallel to the axis of the cylinder in the trial frame. If flipping matters, rotate the cylinder in the trial frame by 20° (10° for a cylinder of -1 D, 5° for -2 D or more) towards the negative axis of the cross cylinder if in its prefered position. Repeat until flipping doesn’t matter anymore. If you surpassed the optimal cylinder position (axis), you may go back in half steps.

Power of cylinder

Determine the power of the cylinder by flipping the cross cylinder with its stem at 45° angle with respect to the axis of the cylinder in the trial frame. If flipping matters, increase the cylinder in the trial frame in steps of -0.50 D. Add minus if the negative axis of the cross cylinder in its prefered position coincides with the axis of the cylinder in the trial frame. Repeat until flipping doesn’t matter anymore. If you surpassed the optimal cylinder power, select the last but one value. If the final cylinder power exceeds the initially chosen power, check/refine the axis (see above).

Step 4: optimising the sphere

Try to add positive lenses in steps of +0.25 D until the image becomes blurred. Theoretically, a cylinder of -1 D needs an additional spherical correction of +0.50 D (the ‘spherical equivalent’ of a cylinder equals its power divided by two). In reality, it is often less. If you had to add more than +0.50 D in this step (as is the case with high astigmatism), recheck cylinder axis and power (repeat step 3). If changes were needed, optimise the sphere again (repeat step 4). This ‘iterative’ approach may seem cumbersome, but in most subjects you will go through the steps only once (and if not, a single repeat of step 3 and 4 will do the job in the vast majority of the remaining cases).

Step 5

Measure visual acuity with optimal correction, that is, with the newly determined refraction. In young people, you expect 1.0, 1.25, or even 1.6 or 2.0; in elderly, 0.8 may be considered normal as well. If the visual acuity is < 0.8, call your supervisor... :)

That’s all folks!

Appendix: Quick and dirty - but yet acceptable - refraction

1. Use subject's own glasses as a starting point
2. Measure the power of the glasses with a lensometer and record the *distance* power (lensometer may also uncover a reading addition)
3. Measure visual acuity at distance (6 m):

<table>
<tr><td>VA ≥ 0.7</td><td colspan="2">Consider acceptable</td><td>Refraction = distance power</td></tr>
<tr><td rowspan="2">VA < 0.7</td><td rowspan="2">Put +0.50 D in front of own glasses;

if no improvement, try -0.50 D</td><td>VA ≥ 0.7</td><td>Refraction = distance power +/- 0.50 D</td></tr>
<tr><td>VA < 0.7</td><td>Refraction = distance power</td></tr>
</table>

4. Refraction as found (distance power as is, or +/- 0.50 D) can be used for testing at any distance of 2 m or more.
5. For testing at a shorter distance, you may have to add an addition to the refraction:

<table>
<tr><td rowspan="2">Age (years)</td><td colspan="2">Testing distance (m)</td><td rowspan="2">FDT</td><td rowspan="2">HFA (*)</td></tr>
<tr><td>1</td><td>0.5</td></tr>
<tr><td>< 40</td><td>-</td><td>-</td><td rowspan="3">No glasses at all</td><td>-</td></tr>
<tr><td>40-55</td><td>-</td><td>+1.00</td><td>+1.50</td></tr>
<tr><td>> 55</td><td>+0.75</td><td>+1.75</td><td>+2.50</td></tr>
<tr><td colspan="5">Example: Distance power of glasses of 65-year old subject is S-0.50 C-1.00x30; VA improved with -0.50 D. Hence, refraction is S-1.00 C-1.00x30. This subject needs S-0.25 C-1.00x30 for performing a test at 1 m.

(*) For HFA, we do not correct astigmatism but use the spherical equivalent (SE; sphere plus half of cylinder of refraction). For the subject above, SE is -1.50 D. Hence, for HFA a +1.00 D (-1.50 + 2.50) correction is needed.</td></tr>
</table>

You may use a trial lens clip attached to the subject's own glasses for the +/- 0.50 D or any addition needed. For HFA, the SE and any addition are summed up and put in the device trial lens holder.