ASSESSMENT OF READING VISION IN LOW VISION PATIENTS
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Reading is a complex task involving vision and higher-order processing of information. Visual resolution is required to recognize letters, word-segments, and word strings. Systematic eye movements are required to integrate successive word-segments, words, word-strings, and sentences. Information processing is required to achieve comprehension, learning and memorization.

The optometrist’s responsibility is to help patients read effectively with comfort, and efficiency. Optimizing the visual stimulus according to the patient’s visual characteristics.

**Considering the Visual Stimulus**

- Ensure that vision is in good optical focus.
- Ensure that the print is of sufficient angular size.

**Visual Stimulus**

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<th>Visual Stimulus</th>
<th>Width of the field of view</th>
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**Measurement of Reading Acuity**

Reading typeset print is a more complex task than reading a letter chart. Patients with disturbed macula function have poorer VA for more congested visual tasks.

**Congested visual tasks**

1. **Contour interaction** - resolution of fine detail is more difficult with nearby high contrast contours.
2. **Crowding** – complex and crowded displays make it difficult to maintain fixation and attention on the immediate visual task.
3. **Serial integration**. Information from current fixation must be integrated with the preceding visual information, while also planning the next fixation shift.

**Distance and Near**

Reading acuity and letter chart acuity involve different tasks. The differences are important. Distance and near visual acuities should be the same, provided the visual task is the same and the image is in good focus.

There is rarely any point in making a distinction between distance and near.

It is usually very important to distinguish between reading acuity and letter chart acuity.
**Most Optometric Reading Charts are inadequate for low vision**

Most reading charts do not measure the visual acuity limit
- Range of print size is insufficient
- Size progression ratios are irregular
- Size designation is often inappropriate (Jaeger, reduced Snellen)

Most reading charts simply check visual adequacy. Useful for prescribing adds.

**Designating Print Size (height)**

**M-Units:** Distance in meters at which the height of the small letters subtends 5 minarc
5 minarc = 1.45 mm at 1 meter. Thus 1.0M print, letter height = 1.45 mm ≈ 1.5 mm

**Points:** Archaic units used by printers
- 1 point = 1/72 inch
- 10 point print = 10/72 inch = 3.53 mm, from top to bottom
- For “Times” or “Times New Roman” Block height = 8 points
  - x-height = 45% of block height, Thus 8 pts = 3.53 * 0.45 / 1.45 = 1.1 M
- To determine M units for Times lowercase font. M units = points / 9
- To determine M units for Times capitals and numbers. M units = points / 6

**N. Notation: (UK)**
- Times New Roman font Size in points
  - N10 = 10 point print in Times Roman font (lower case)

**Jaeger:** Not standardized
- J1 = pretty small, J10 = pretty big, Jaeger = pretty terrible
- Can be a 3-fold difference in size of print with the same J number

**Reduced Snellen:** Inappropriate to us a angular measure to specify height
- Assumes a constant near vision test distance (40 cm?)
- Uses distance acuity equivalents for the “standardized” distance
- Extremely confusing if any other distances are used (20/50 at 25 cm???)
- Suggests letter chart acuity and reading acuity will be the same

**Useful rules about print size**

- M-unit notation, N notation or points are all satisfactory
- Newsprint text approximately 1.0M in Times font (or similar)
- 1.0 M print = 1.45 mm high ≈ newsprint (Times)
- Newsprint at 40 cm - requires 0.40 / 1.00 M (=? 20/50 or 6/15)

  Millimeters to M-units
  Measure letter height in mm and multiply by 0.7 x, or divide by 1.45

**Requirements of charts to test reading vision**

For reading acuity measurement, some print must be smaller than the patient’s threshold size
- There must be a wide range of large print sizes, to allow systematic assessment of reading performance at supra threshold sizes.
READING TEST CHARTS

**Bailey-Lovie Word Reading Charts**
- Logarithmic size progression (ratio 0.1 log unit = 1.2589x or about 5/4)
- Size range 10M-0.25M, 17 sizes
- Times Roman font
- Unrelated words 4, 7 or 10 letter words used
- For 11 smaller sizes, 6 words (42 letters) per row
- Fewer words (3 or 2) at the 6 larger sizes

**Bailey-Lovie Text Charts and Words Charts**
- Logarithmic size progression (ratio 0.1 log unit = 1.2589x or about 5/4)
- Size range 5.0M to 0.25M, 14 sizes
- Times Roman font
- Each size level, two rows
- Ten 4, 5 or 6 letter words, or a sentence with 60 character spaces

**MNREAD charts**
- Logarithmic size progression (ratio 0.1 log unit = 1.2589x or about 5/4)
- Size range 8M-0.125M, 19 sizes
- Times Roman font
- Sentences with 60 character spaces, 3 rows for each size level

**Importance of logarithmic scaling for reading charts**
- Predicting improved resolution in response to change
  - # rows improvement for given change in distance (cm, inch)
  - # rows improvement for given change in power (D)
- Predicting change needed for improved resolution
  - EVD change to improve by certain # rows
  - Power change to improve by certain # rows

**Conversions using logarithmic scale**
- 5.0, 4.0, 3.2, 2.5, 2.0, 1.6, 1.25, 1.00, 0.80, 0.63, 0.50, 0.40, 0.32, 0.25.
- Other conversions in general:
  - 63 miles = 100 km, (2 steps)
  - 25 mm = 1 inch, (4 steps)
Assessment of Reading Efficiency
Patient reads print, going to progressively smaller sizes. Reading speed slows and reading becomes more difficult when print size approaches the limit of resolution. Print should be in good optical focus.
Be aware of addition, accommodation range and viewing distance.

Reading speed for reading aloud or reading silently
For silent reading, speed is best measured by monitoring eye-movements.
Look for return saccade to commence the next row. Observe eyes or monitor eyes.
For reading aloud, listen and judge ease of reading and notice slowing of print when print size is getting close to the threshold for resolution.
For timing, use stop watch or iPhone stopwatch function. Lap timer gives a list of times.
For 10-word sets, 6 seconds = 100 wpm, 3 seconds = 200 wpm, 12 seconds = 50 wpm.
Interpolate between these benchmarks to estimate wpm values.

DETERMINING VIEWING NEEDS FOR NEAR VISION

Viewing distance and/or magnification

Kestenbaum’s Rule  A simplistic approach
Sometimes called Reciprocal of Vision)
Estimates required add power based on distance VA
To resolve 1.0 M print  Required near addition = MAR
Thus, for VA = 20/200, MAR = 10. Required addition = +10.00D

RESOLUTION RESERVE (OR ACUITY RESERVE)
For efficiency and comfort, print size should be larger than threshold size
Resolution reserve = Print size/ Threshold size

Determining Resolution Reserve
Usually desirable to allow a cushion above the patient’s resolution limit
Identify the print size the patient will be reading.
The threshold size print (the acuity limit) should be smaller
But by how much?

DETERMINING RESOLUTION RESERVE
1 Arbitary  ( you decide or guess 2 rows or 3 rows or ?? rows)
2 Critical Angular Size
   Find smallest angular size that allows maximum speed
3 Preferred Angular Size
   Find angular size that the patient chooses when encountering small print
**Critical Angular Size**

Hard Copy
- Fixed viewing distance
- Patient reads from very large to smallest legible
- Clinician judges or measures reading speed
- Determines print size at which reading first slows
- Next largest print size is CAS

**CAS = Smallest print size allowing maximum reading speed**

**CAS determination affected by**
- Silent vs Aloud
- Text vs Words
- Easy vs Difficult

Often paradoxical results CAS smaller for reading aloud, words, or difficult material because reading is slow to begin with.

*CAS recorded as print size and viewing distance combination*

**Preferred Angular Size**

**Hard Copy**

First determine best close viewing distance (BCVD)
- Pre-presbyope: Find close distance used when attempting to read the smallest possible print
  - Best Close Viewing Distance = 1.5x closest viewing distance
  - At BCVD, accommodation demand = 2/3 maximum
- Presbyope (tested with reading addition)
  - Determine range of in-focus image. BCVD = in middle third of range

Then Test reading performance
- Patient reads aloud from very large to smallest legible
- Clinician observes changes in viewing distance made as the print becomes smaller.
- Record the size of the print being read when the distance is at or close to the BCVD

*PAS recorded as print size and viewing distance combination*

**Preferred Angular Size**

**Video magnifier**

Patient adjusts zoom on video magnifier to make the print size large enough to enable easy and comfortable reading
- At very large sizes, compromises are made as patient balances magnification against number of letters across the screen.

Then,
- Clinician gradually reduces magnification until patient first reduces viewing distance in order to read the print more easily
- Print size on screen measured in mm and converted to M units
- Record viewing distance and print size.

*PAS recorded as print size and viewing distance combination*
EXAMPLES

Example with Arbitrary Reserve

Patient wears a +2.50D add and the chart is at 40 cm. The threshold print size is 2.5 M
GOAL You want the patient to read 1.0M print but you arbitrarily decide to
give 2 rows of “reserve” (1.6x) to allow reasonably easy reading.
Enabling this patient to just read 0.63M would give 2 rows of “reserve”

Using proportions to determine EVD

Threshold = 0.40/2.5M To meet your goal of threshold = 0.63M threshold requires 0.10/0.63M
DECISION Choose a system that gives an EVD of 10 cm This will enable 0.63M to be read

Example with Critical Angular Size (CAS)

Patient reads 10M to 2.0M at top speed at 32 cm with an appropriate add.
 Begins to slow at 1.6M and reading acuity threshold is 0.32/0.50M
          CAS = 0.32/2.0M (one step above first slowing)
          GOAL You want the patient to read 1.0M newsprint at top speed.

Using proportions to determine EVD

Measured CAS = 0.32/2.0M   By proportions CAS = 0.16/1.0M
DECISION Choose a system with an EVD of 16 cm This will enable 1.0M print to be read at top speed

Problems with CAS

Maximum speed and point of slow-down vary with the task (words/text, aloud/silent, etc)
“Noise” in reading speed makes it difficult to decide slow-down point
Only one slow-down point for each read down the chart   Need to make several “sweeps”

Example with Preferred Angular Size (PAS) with hard copy

Young patient. Holds print at 14 cm when trying to read smallest possible
     Best Close Viewing Distance 21 cm
Patient chooses to hold the chart at 30 cm reading 10M, 8M, and 6.3M print with good speed.
     Then 0.27/5.0M; 0.25/4.0M; 0.21/3.2M; 0.18/2.5M; 0.15/2.0M 0.15/1.6M; 0.15/1.25M;
     0.14/1.0M
          PAS = 0.21/3.2M (at 21 cm)
          GOAL You want the patient to read 1.0M print so that it is at a “preferred” size

Using proportions to determine EVD

PAS = 0.21/3.2M = 0.20/3.2M = 0.063/ 1.0M
To meet your goal of having 1.0M print at PAS, a ~6.3 cm distance is require
DECISION Choose a system that gives an EVD of 6.3cm This will enable 1.0M to be at PAS

Example with Preferred Angular Size (PAS) with video-magnifier

Patient wears a +2.50D add and screen is at 32 cm.
Patient adjusts print size to be 20 mm high (but you do not bother to measure)
You reduce print size and patient moves in to 26 cm when print is 11mm high.
          11 mm = 7.7M ≈ 8.0M   PAS = 0.26/8.0M
          GOAL You want the patient to read so that 1.0M print is at PAS with an optical magnifier

Using proportions to determine EVD

PAS = 0.26/8M = 0.032/1.0M   To have 1.0M at the PAS, the indicated distance is 3.2 cm
DECISION Choose an optical system that gives an EVD of 3.2 cm This will enable 1.0M at the PAS
     A +32D lens is one option
**Problems with PAS**

You usually obtain a series of different values for PAS at different distances
Dilemma: Which one to choose?

Can use point of reading slow down as supplementary indicator of best size
Shoulder of reading speed curve is usually much sharper than in CAS method
Reading thresholds and chosen distances are not much affected by task
(words/text, aloud/silent, easy/difficult, etc.,)

**DETERMINING CONDITIONS TO OBTAIN OPTIMAL ANGULAR SIZE**

After the Optimal Print Size has been determined, (by CAS, PAS or arbitrary allowance methods)
Consider variations in print size, viewing distance, optical or electronic magnification.

Example: For a High School student, it was determined that the CAS = 3.2 M at 25 cm

*Alternative ways of achieving the same angular size.*

#1 For textbooks with 1 M print, an 8 cm viewing distance would achieve the same angular size
CAS Ratio of $3.2/25 = Ratio \ 1/8$  This is too close

#2 Using a paperweight dome magnifier, 1.0 M print becomes enlarged to become 1.5 M in size.
The eye should be 12 cm from the image.  CAS ratio = $2.3/25 = 1.5/ 12$

#3 If the textbook was available in 20 point print (2.5M), the required viewing distance = 20 cm
CAS ratio = $3.2/25 \ = 2.5/20$  Modest accommodation and convergence demand

#4 With a video magnifier, viewing from 40 cm, the 1 M print would need to be enlarged 5.0x
The CAS ratio $3.2/25 = 5.0/ \ 40$  5.0 M print on the screen = $5 \times 1.45 \text{ mm} = 7.25 \text{ mm}$

#5 With a hand held magnifier A +12.5D lens can provide an image at infinity with EVD = 8 cm
CAS ratio = $3.2/25 \ = 1.0/ 8$

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