MEASURING ULTRA LOW VISION:
NEW METHODS USED FOR BLIND SPORTS CLASSIFICATION AND PROSTHETIC VISION.

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All ophthalmic clinicians should be able to make quantitative assessments of their patients’ visual capabilities whenever vision is reduced to the extent that it cannot be measured properly with the standard tests of visual acuity, visual fields and contrast sensitivity. Tests for ultra low vision have become important for blind sports classification and also for testing changes in vision resulting from implantation of visual prostheses and from any other treatments directed at restoring vision. New tests and new procedures are being used for testing visual acuities in the 20/630-20/16000 range, for measuring central and peripheral fields when vision is too poor to be tested with Goldmann or automated perimetry and when contrast sensitivity test are inappropriate because of severe VA or VF limitations.

VISUAL ACUITIES

With increasing complexity of VA task

- Reading acuity
  - Typeset charts. Sets of Words or Text
- Optotype Chart Acuity
  - Rows of Letters, Tumbling E’s, Landolt rings, Numbers, Symbols
- Single Optotype Acuity
  - Letters, Tumbling E’s, Landolt rings, Numbers, Symbols
- Grating Acuity
  - Preferential looking, Orientation
- Vernier Acuity
  - Alignment or irregularities

BASIC PRINCIPLES – for any test of visual acuity

- The visual task should be the same at each size level
- The size progression should have a constant ratio (i.e., geometric or logarithmic progression)
- Spacing arrangements should be proportional to target size
- The range of size must allow the patient to pass at the largest size and fail at the smallest size.

THE SPECTRUM FOR THE CLINICAL MEASUREMENT OF VISUAL ACUITY

The letter chart is not suitable for measuring visual acuity when VA is very poor.

At lower levels of visual acuity, the task needs to be simplified systematically and, there systematic reductions in viewing distance when acuity is very poor.

**LETTER CHART ACUITY**

LogMAR Chart - ETDRS or similar. (Projector-chart display-screens limit size range)

- At 4.0 meters or longer Range: LogMAR = -0.3 to 1.0 (20/10 to 20/200, 6/3 to 6/60)
- At 1.0 meter Range to LogMAR = 0.3 to 1.6 (20/40 to 20/800, 6/12 to 6/240)

**SINGLE TUMBLING E ACUITY**

Single Tumbling E set with size range to 100M (14.5 cm)

- At 1.0 meter STE Range to LogMAR = 2.0 (to 20/2000, 6/600)
- At 25 cm STE Range to LogMAR = 2.6 (to 20/8000, 6/2400)

**GRATING ACUITY**

Grating Acuity set with size range to 60mm stripes, Cards 25 cm square

- At 25 cm GA Range to LogMAR = 2.9 (to 20/16000, 6/4800)

**BASIC VISION FUNCTION TESTS**

**WHITE FIELD PROJECTION**

- White hemi-field of quadrant fields on cards 25 cm square
- At 25 cm White field widths = 26 deg, LogMinArc = 3.2

**BLACK WHITE DISCRIMINATION**

- Black and white cards 25 cm square
- At 25 cm Field widths = 53 deg, LogMinArc = 3.5
**VISUAL ACUITY TESTS FOR ULTRA-LOW VISION**

FrACT test: Free download, Computerized test. Designed for research. Also good for clinic.


**BERKLEY RUDIMENTARY VISION TEST**

*Three card-pairs. Pairs of 25 cm square cards hinged*

1. Single Tumbling E card-pair  Sizes 100M, 63M, 40M and 25M
2. Grating Acuity card-pair Stripe widths 60mm, 38mm, 24mm and 15mm
3. WFP and BWD card pair  
   - WFP 2 panels, one has white hemi-field, one has a white quadrant
   - BWD 2 panels, one black, one white

*A computer version is available as a PowerPoint presentation. Viewing distances depend on screen sizes.*

**TEST SELECTION**

Use Single Tumbling E’s, sizes 100M and 25M at 1.0 meters

<table>
<thead>
<tr>
<th>At 1 meter</th>
<th>SINGLE TUMBLING E</th>
<th>size 25M</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 1.0 meter</td>
<td>STE 25M</td>
<td>SEEN</td>
</tr>
<tr>
<td>At 4.0 meters</td>
<td>STE 25M</td>
<td>SEEN</td>
</tr>
<tr>
<td>At 4.0 meters</td>
<td>STE 25M</td>
<td>NOT SEEN</td>
</tr>
<tr>
<td>At 1.0 meters</td>
<td>STE 25M</td>
<td>NOT SEEN</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>At 1 meter</th>
<th>SINGLE TUMBLING E</th>
<th>size 100M</th>
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</thead>
<tbody>
<tr>
<td>At 1.0 meter</td>
<td>STE 100M</td>
<td>SEEN</td>
</tr>
<tr>
<td>At 1.0 meter</td>
<td>STE 100M</td>
<td>NOT SEEN</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>At 25 cm</th>
<th>SINGLE TUMBLING E</th>
<th>size 100M</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 25 cm</td>
<td>STE 100M</td>
<td>SEEN</td>
</tr>
<tr>
<td>At 25 cm</td>
<td>STE 100M</td>
<td>NOT SEEN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>At 25 cm</th>
<th>GRATING</th>
<th>size 200M</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 25 cm</td>
<td>Grating 200M</td>
<td>SEEN</td>
</tr>
<tr>
<td>At 25 cm</td>
<td>Grating 200M</td>
<td>NOT SEEN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>At 25 cm</th>
<th>BASIC FORM VISION</th>
<th>Gratings to 60mm, White Field Projection, Black White Discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 25 cm</td>
<td>Test White Field Projection--WFP</td>
<td>(white quad field and hemifield)</td>
</tr>
<tr>
<td>At 25 cm</td>
<td>WFP NOT SEEN</td>
<td>Then test Black White Discrimination--BWD</td>
</tr>
</tbody>
</table>

**Testing Visual Acuity for Blind Sports Classification.**

1. B1: No light perception (NLP) to Single Tumbling E acuity is less than logMAR = 2.6 (20/8000)
2. B2: STE Acuity is logMAR = 2.6 to 1.50. (STE 20/8000 to 20/630)
3. B3: STE acuity is logMAR 1.4 to letter chart logMAR =1.0 (STE 20/500 to LC 20/200)

The critical distinctions are the dividing lines between

1. STE logMAR = 2.6 or better
2. STE logMAR = 1.5 or better
3. Letter chart logMAR = 1.0 or better
Ensuring consistency and identifying malingering.

Several alternative testing distances are used and the VA score is adjusted accordingly. Test distances are 400cm, 320cm, 250cm, 200cm, 160cm, 125cm, 100cm. Labels are placed on the floor at these distances. These give the adjustment to the logMAR score in steps of 0.1 log units from -0.6 for 400 cm, -0.3 for 200 cm and 0.0 for 100cm.

For the four STE cards (100M, 63M, 24M & 25M), the logMAR sizes at 100 cm are 2.0. 1.8, 1.6 & 1.4

For STE logMAR= 1.5, (20/630) 100M at 320cm, 63M at 200cm, 40M at 125cm.
STE logMAR= 1.4, (20/500) 100M at 400cm, 63M at 250cm, 40M at 160cm., 25M at 100cm
LC logMAR= 1.0, (20/200) 10M at 100cm, 12.5M at 125cm, 16M at 160cm, 20M at 200cm, etc.
LC logMAR= 1.4, (20/160) 8M at 100cm, 10M at 125cm, 12.5M at 160cm, 160M at 200cm, etc.

**VISUAL FIELDS**

Consider whether testing should be binocular (most useful for functional assessment) or monocular (useful for monitoring disease & understanding fixation behavior)

**Goldmann perimeter.**
- Excellent for detailed plotting of peripheral fields,
- Plots isopters at different visual sensitivities,
- Limited information from central field.

**Humphrey and similar**
- Excellent for monitoring progress.
- Determines threshold at selected points using tight controls and protocols.
- Limited for determining scotoma outlines. Limited information from central field.

**Amsler grid.**
- For central 10 degrees only. Qualitative responses.
- Often scotomas “filled in” and not detected.

**Tangent screen**
- For central fields. Traditionally white targets on black backgrounds.
- More helpful to use black backgrounds with white backgrounds of variable luminance.

**PERIPHERAL FIELDS IN ULTRA-LOW VISION.**

Confrontation. Switchable light sources as targets. But light should not be too bright. Introduce target from behind patient. Do not use the “shared midway tangent screen” technique. Always check extreme periphery, even if narrow tunnel vision.

**ADAPTING TANGENT SCREEN TESTING FOR PERIPHERAL FIELDS.**

Reduce the viewing distance from 100cm to 57 cm.
- To test right peripheral vision, patient fixates 30-degree circle on left side.
- To test left peripheral vision, patient fixates 30-degree circle on right side.
- Tangent screen markings remain useful.
- For testing right peripheral field along horizontal meridian
- Fixation=0° corresponds to 30°L mark on tangent screen,
- Then approximately 15°R ≈ 20°L, 30°R ≈ 10°L, 45°R ≈ 0°, 60°R ≈ 10°R, 75°R ≈ 20°R, 90°R ≈ 30°R.

**White Screens with Black Targets**
- White backgrounds might be more representative of real world.
- Large black targets can be used against white screen or background a wall.
- Can use laser pointer on white wall.
**BERKELEY CENTRAL FIELD TEST.**

A computerized test for the central 10 degrees. Available in a PowerPoint Presentation, and also as a dedicated program (BCVFT)

Two versions. Black target on white background, White target on black background.


Targets follow AMA recommendations for testing central visual field for the Evaluation of Disability.

Tangent screen methods for central visual field measurement.

Black targets on a 1-meter white tangent screen allow the measurement of central field out to 30 degrees.

A 7.5 mm target at 1 meter is equivalent to a Goldmann III.

**NEAR VISION TANGENT SCREEN FOR CENTRAL VISUAL FIELDS (±10°)**

Can use white card in sloping sign holder (22x28 cm) with black target on a clear plastic wand

Very low cost. At 50 cm, can test the central ±10 degrees.

A 7.5 mm target at 50 meter is equivalent to a Goldmann IV

**CONTRAST SENSITIVITY**

*Weber Ratio and Michelson Ratios*

Weber Contrast = (L\text{max} - L\text{min}) / L\text{max}

Michelson Contrast = (L\text{max} - L\text{min}) / (L\text{max} + L\text{min})

Unless CS is very poor, Weber contrast is approximately 2 times the value of Michelson Contrast and CS scores in log units of Weber Contrast will be about 0.3 log units lower than for Michelson.

**TESTS OF CS AT VARIOUS SPATIAL FREQUENCIES**

*Sine Wave Gratings*

**Vistech & FACT** 9 different contrasts at each of 5 spatial frequencies, Distance = 3m

CS range: to 2.1 log units Weber in various increments

**CVS 1000E** 8 different contrasts at 4 spatial frequencies  Distance = 1m

CS range to 1.95 log units Weber, irregular sequence of increments

*Square Wave Gratings*

**Cambridge Gratings** Gratings with 12.5mm stripes (4.2cpd at 6 meters)

CS range to 2.55 log units Weber, irregular sequence of increments

**TESTS OF CS WITH LARGE TARGETS WITH SHARP BORDERS**

**Pelli Robson Test** Letter chart, 3 letters each at 16 contrasts 33M letters at 1 meter

CS range: 0.0 to 2.25 log units Weber in 0.15 log unit increments

**MARS test** Letter Chart 48 letters each with different contrast, 12M letters at 50 cm

CS range: 0.04 to 1.96 log units Weber in 0.04 log unit increments

**Bailey Border Test** Locate border= on 15x2.5 cm rectangles. Distance =40 cm or closer

CS range to 2.2 log units Weber, 25 increments of 0.2 or 0.1 log units

**Melbourne Edge Test,** 25 discs, orientation of border bisecting discs  Distance – at near

CS range to 2.1 log units Weber, increments of 0.1 or 0.2 log units

**Berkeley Discs Test of Contrast Sensitivity**

Designed as a quick test, suitable for children and
6 cards, each with six 75cm square cells, some with 50mm test discs. At 40 cm

CS range 0.0 to 1.95 log units Weber in 0.15 log unit increments
**VISUAL ACUITY AT REDUCED CONTRASTS**

Comparing visual acuities at different contrast levels provides a measure of slopes within the Contrast Sensitivity Function

- Many **High and Low Contrast visual acuity charts** are available.
  - Bailey-Lovie, Regan, Lea symbols, others
- **SKILL test** - Smith Kettlewell Institute Low Luminance Test
  - Black on dark gray with black on white Bailey Lovie charts.
- **Small Letter Contrast Sensitivity Test** *(Rabin)*
  - 10M letters at 4 meters, 5 letters at each of 8 contrasts,
  - CS range to 2.0 log units Weber in 0.25 log unit increments

**CONTRAST SENSITIVITY TESTS WITH RESPONSE TIMES**

**BLINKING SQUARES TEST**
- Detection of 4 cm square targets in one of 4 quadrants on a display screen.
- Tests 24 contrasts, each twice. Maximum exposure time 6 seconds. Takes 2 minutes.
- CS range 0.0 to 2.3 log units Weber, in 0.1 log unit increments
- Records time for each response, by touch screen or computer keyboard. Displays graph.

**NUMBER SEARCH TEST**
- Search for 8 numbers 4 cm high in Arial bold. Each screen has randomly placed numbers 1 to 8.
- Six screens, each for 20 seconds. Two presentations each, at 24 contrasts.
- CS range 0.0 to 2.3 log units Weber in 0.1 log unit increments
- Records time for each response, by touch screen or computer keyboard. Displays graph.

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**ASSESSING THE EFFECTS OF ILLUMINATION**

We choose to use a standard filter to reduce task luminance from its standard level, by a constant ratio. We chose to use a NoIR U23 filter (neutral gray filter with 3% transmission) as our standard filter.

**Visual acuity and Illumination**

Effects of luminance on visual acuity are measured routinely using a NoIR U23 filter.
- The normally-sighted typically lose about 10 letters (0.2 logMAR units) on a LogMAR chart.
- Illumination levels have more effect on visual acuity in some disease conditions than in others.
- Within disease conditions there can be considerable variations in the effects of illumination.

**Contrast Sensitivity and Illumination**

Effects of luminance on binocular contrast sensitivity are measured routinely using a NoIR U23 filter.
- The normally-sighted, on average, lose about 0.12 log units of contrast sensitivity.
- Illumination levels have more effect on CS in some disease conditions than in others.
- Within disease conditions there can be considerable variations in the effects of illumination.