VISUAL ACUITY ASSESSMENT IN CHILDREN

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Visual acuity testing represents an extremely important part in the practice of pediatric ophthalmology. Pediatric glaucoma is not an exception. Visual acuity can be assessed in children as young as few weeks old. Visual acuity can be measured objectively when the child is too young or too uncooperative to be tested subjectively. Objective tests may be qualitative or quantitative.

Evolution of Vision in Children

The development of vision is interrelated with the total development of the body. So, it is essential to compare the child's visual performance with a series of normal milestones before traditional quantitative tests are appropriate (table). Fixation, turning to light and pursuit can be produced in many normal full term babies. During the following days, the newborn can show brightening and reduced motor activity with fixation. Optokinetic nystagmus (OKN) can be induced in this period. Fixation reaches a peak at 4-5 weeks. After 2-3 months, the child begins to reach out to touch or grasp a visually interesting object and accommodation reaches its adult accuracy. After three months, the child is able to show blinking to threat, mimic facial postures and examine interesting objects. Stereopsis is fully established before the fifth year of life[1].

Age	Expected visual milestone
0-2 weeks	Fixation Turning to light Pursuit Brightening Reduced motor activity with fixation Optokinetic responses
4 weeks	Refixation
2-3 months	Visually directed reaching Developing accommodative accuracy
3-5 months	Blinking to threat Mimicking facial postures Detailed examination of objects
5 years	Developing stereoacuity

Willshow,1985[1].

Guidelines for Visual Acuity Assessment in Children

- Cooperation is better if one examiner gets to know the child and examines him at each visit.
- The test should first be explained to the child at near distance. The mother can teach him at home if necessary.
- Start the test with both eyes open, then with the better eye uncovered.

- The occluder should be comfortable and away from the eye but in the line of sight to avoid peeping round. A + 5.00 lens can be used[2].
- Young children may respond better if tested at three meters instead of six[3].
- Encourage the child to see small symbols by changing the chart to present them singly or within smaller ones but allow him to say "I can't see" insisting that it is not his fault.
- Visual acuity results depend on the test used which should be reliable and reproducible. In children, testing should also be easy and not too long.

Clinical Testing of Visual Acuity in Children

I. Subjective tests

A. Finding objects:

- Silently placing interesting objects around the room and then asking the child to locate and retrieve them is a useful test.
- *Worth"s Ivory Ball test*[4] uses balls of varying sizes and an estimate of the visual acuity is made from the smallest ball size that attracts the child's attention.

B. Illiterate visual acuity tests:

1. Matching Tests
   - ***Miniature toys***; small toys are shown to the child and asked to name them or match with similar ones he selects from a tray[5].
   - **Ffooks symbols***;* [6] the basic shapes of a square, circle, and triangle are presented singly in different sizes on each face of a cube. The child picks up a plastic replica of the shape he sees (fig. 1).

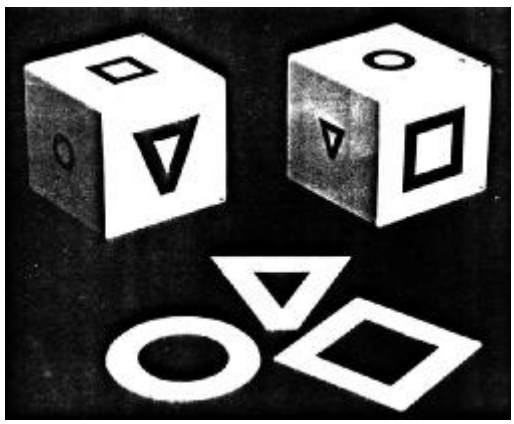

Figure 1. Ffooks symbols.

   - ***Sheridan-Gardiner test;*** [7] a single test letter surrounded by four other letters is showed to the child who is asked to point to the matching letter on his own card. This is a suitable test for pre-school children (fig. 2).

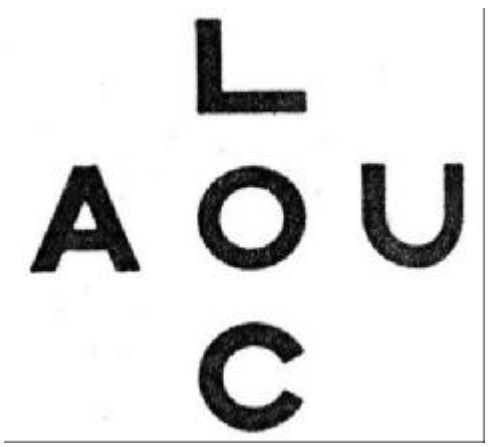

Figure 2. Sheridan-Gardiner Card.

2. Directional Tests
   - ***Landolt's Broken Rings***; [8] although the validity of this test is the highest of all visual acuity tests due to minimal

false clues, it is difficult to be sure that the child is indicating correctly as he sees.

- ***E-test***; the child is given a replica E to copy the position of the limbs of the letter indicated on the linear E testing (fig.3)[9].

Figure 3. Directional E-test.

- ***Sjogren's hand test***; the picture of a hand is printed in varying sizes on cards; the fingers correspond to Snellen's notation. The child is encouraged to orientate his own hand in the direction of the card hold by the examiner (fig.4)[10].

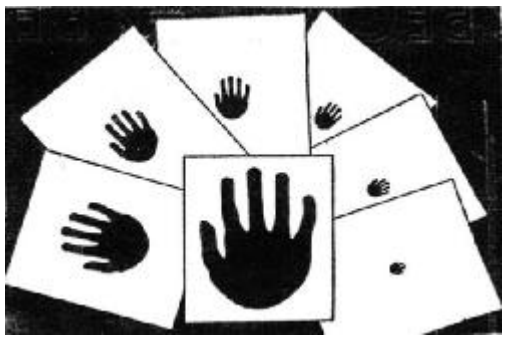

Figure 4. Sjogren's hand test

3. **Picture Tests**

For a picture chart to be valid, each pat of each picture must subtend a visual angle of one minute of arc at the stated distance. Each picture must also depict a familiar object or animal in a form which the child can recognize. These criteria are very difficult to apply in practice and the main value of picture charts is in providing a comparison between the vision of the two eyes and in successive visits.

- ***Allen cards;*** schematic drawings of common objects are presented singly at three meters using a 6/9 optotype. Therefore, the acuity level is recorded as 3/9 if it can be recognized. If it cannot the cards are moved closer and the acuity is recorded as 2/9 or 1/9 (fig. 5). This test is recommended for two to five years old children[11].

Figure 5. Allen cards.

- ***Beale Collins and Clement Clarke picture tests;*** these are optotype charts composed of pictures of varying sizes. The optotypes of Beale Collins (fig. 6) chart are twice the size of Snellen's optotypes, while those of Clement Clarke (fig. 7) are the same size as Snellen's.

However, the details of the pictures are often smaller than the limbs of the Snellen letters[12].

Figure 6. Beale Collins picture test

Figure 7. Clement Clarke picture test

C. Literate visual acuity tests:

Literate vision tests in the form of rows of broken rings, letters, or numbers are easier to use if only one, two, or three lines are presented at one time.

II. Objective tests

A. Affect:

Affect is observation of the individual in his environment. The crudest level of visual acuity may be based on whether the infant recognizes his mother's face, is aware of objects in his crib, or looks at and follows any objects[2].

B. Fixation and Following:

Visual acuity is estimated objectively by assessing the fixation of each eye. Poor visual acuity is present in one eye if on cover testing:

1. there is unsteady, wandering, or obviously eccentric fixation,
2. the eye is slow to fixate, returning to a squinting position immediately when the other eye is uncovered,

3. the child consistently resists occlusion of one eye but tolerates occlusion of the other eye.

If the uncovered eye deviates immediately upon removal of the cover, two or more lines of difference in acuity between both eyes; or a visual acuity of 6/60-6/30 is suspected. If the uncovered eye holds briefly but switches before a blink, one line of difference or a visual acuity of 6/15-6/9 is suspected. If the uncovered eye holds through a blink, equal vision or a visual acuity of 6/9-6/6 is suspected. Poor visual acuity in both eyes can be expected when observing photophobia and nystagmus or roving eye movements[13].

C. Pendular eye movements:

- Visual acuity can be estimated by the maximal distance at which eye movements can be induced by a swinging checkerboard pattern passing behind a cut-out window[14].
- Catford-Oliver drum (fig. 8) contains circular targets of equivalent Snellen type. The drum is rotated and the target oscillates across an aperture . By turning the drum, the various targets may be presented individually in decreasing size until rotating eye movement no longer exists[15].

Figure 8. Catford-Oliver drum

D. Optokinetic Nystagmus (OKN):

Induction of OKN indicates that the child has perceived the stimulus. An OKN response occurs only when separate images can be resolved by the eye. The test is mainly useful in determining the presence or absence of vision and in comparing the behavior of one eye with that of the other. Used for quantitative assessment, it has been shown to overestimate visual acuity by a wide margin[13]. Progressively smaller images can be used to estimate the visual acuity of young children by detecting the smallest stimulus that can either evoke or arrest an OKN.

Figure 9. OKN drum

1. Evoking OKN
   - ***OKN drum;*** it may be used to test vision in babies to answer the question "can this baby see?" The stripes are about the width of the 6/120 letter (fig. 9)[16].

Figure 10. OKN induced by light bar

   - ***Light bar;*** multiple moving light spots, that can be varied in size, are displayed within a light bar (fig.10). The OKN is recorded by electrodes

placed at the outer canthi. The light spots are increased in size, i.e. the gaps in between are decreased, in steps. The smallest gap inducing OKN is a measure of the visual acuity[17].

2. Arresting OKN

- ***Gear-toothed pattern;*** horizontally moving pattern consisting of two parallel gear-toothed patterns on a gray background is used to induce OKN. Inhibition of the nystagmus is produced by a stationary grating of horizontal light and dark lines superimposed on the moving pattern (fig. 11). The highest spatial frequency of the grating capable of arresting the nystagmus is a measure of the visual acuity[18].

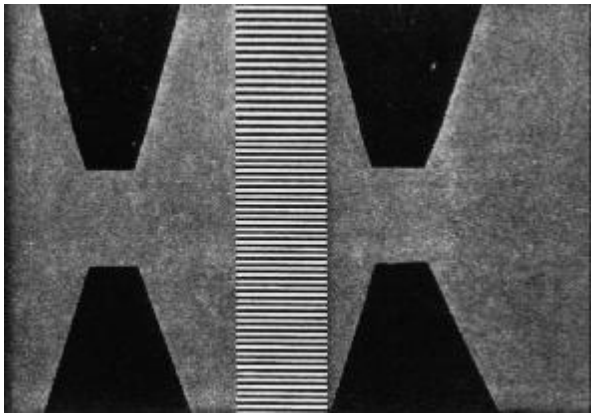

Figure 11. Gear-toothed pattern with horizontal grating.

- ***Optokinetic drum with fixation image;*** the size of the fixation spot that can arrest the OKN induced by rotating the drum is a measure of the visual acuity (fig. 12)[19].

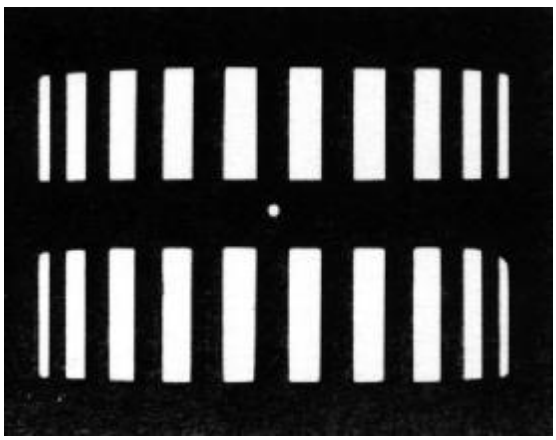

Figure 12. Optokinetic drum with fixastion image

E. Visual Evoked Potential (VEP):

Pattern reversal stimulus in the form of grating or checkerboard can be used to elicit visual evoked potential from children as young as few months old. Visual acuity can be estimated by observing the behavior of the p_{100} (the second positive wave) in response to the stimulus size (fig. 13) by various methods:

1. The smallest stimulus pattern (i.e. with highest spatial frequency) that can elicit a VEP is a measure of the visual acuity[13].

Figure 13. The visual evoked response

2. By comparing the VEP with previously collected data from optically blurred adults, the pattern size producing the highest wave amplitude provides an estimate of the visual acuity e.g. when the largest amplitude is obtained from checks subtending a visual angle of < 20 min of arc a visual acuity of 6/6 is expected[20].

3. The p_{100} becomes larger in amplitude as the pattern complexity increases i.e. the pattern size decreases. As the pattern becomes too small, the amplitude decreases rapidly. So, extrapolating the response to zero amplitude versus the spatial frequency of the grating size is a measure of the visual acuity (fig. 14)[21].

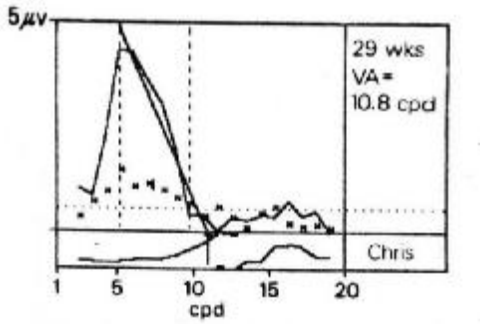

Figure 14. Extrapolation of the p_{100} amplitude against the spatial frequency

F. Preferential Looking(PL):

The observation that an infant prefers to look at an object with form rather than a homogeneous unpatterned background of equal luminance is the basis of the preferential looking test[22]. Gratings of different spatial frequency fixed on one side of special cards as ***Teller acuity cards*** (fig. 15) are displayed through a central opening in a gray screen in front of the child (fig. 16). Any consistent clue from the child as fixation, pointing, or verbalization is used to decide whether or not he could see the grating. Each card is presented with the grating on one side, then turned 180 degrees so that the grating is in the opposite side. This is repeated in a random manner. Nine positive responses out of 12 presentations are necessary to consider that the child can see the grating. The finest grating the child can see indicates the child's acuity. Preferential looking is one of the most reliable tests in estimating the visual acuity in preverbal infants and young children[17].

Figure 15. Teller acuity cards.

Figure 16. Preferential looking test.

Conclusion:

Using OKN, VEP, and PL visual acuity can be measured in children as young as a few weeks' old. A visual acuity of 6/240 could be estimated in newborns. By one month, the visual acuity is 6/180-6/90. By six months, a visual acuity of 6/18-6/6 could be detected and 6/6 vision can be reached by the age of three years[13]. The lack of concordance of results with the various techniques is explained by the different pathways used in them. Although the term objective is used to describe these tests, still they need at least some cooperation on the part of the tested subject. In addition, the threshold depends on the decision of the examiner.

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