Vision Assessment in Children

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Definition and framework

Vision

- The ability to see and distinguish between differences among shapes, patterns and colours
- The ability to recognize and use that information
- Develops in infancy and matures during early childhood

Ophthalmological evaluation

- An ophthalmologist is a medical doctor who specializes in the medical and surgical care of the eyes, the visual system and in the prevention of eye diseases and injury
- A multidisciplinary approach with paediatricians, optometrists, orthoptists and low vision specialists adds to an in depth understanding of the child and their vision

Ophthalmological evaluation

- **Overview** - How is vision evaluated?
  - Medical history is taken from the parents and the patient
  - The ophthalmologist's first general assessment: Evaluation and examination of the patient and his/her eyes
  - Assessing vision
    - Visual function testing(e.g. visual acuity, visual field, colour vision, contrast vision, binocular vision and visual function)
    - Additional testing (e.g. electrophysiological testing or imaging procedures) to help with diagnosing and evaluating the patient and his/her eye-sight
  - Children with a suspicion of CVI

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History

History

- Mother's health before and during pregnancy
- Pregnancy:
  - Duration
  - Birth weight
- Pregnancy and breast feeding:
  - Toxic or infectious agents
  - Use of medication
  - Fever or rash
- Family history
- The child's health and development

History

- Specific questions regarding the child's vision:
  - Eye contact
  - Fixation
  - Behaviour
  - The ability to follow an object
  - Interest in his/her surroundings
  - In play and the interaction with others
  - …

- The parents perception is important – intuition/insight (e.g. the parents perception of the child's eye-sight)
- It's important to also talk to the child, not just the parents and note the given response.

The ophthalmologist's first general assessment

The ophthalmologists first general assessment

- A general intuitive sense
- The first appearance of the child. Depending on the age of the child – what to expect.
- Observations during the examination:
  - Eye contact, eye control and eye movements (e.g. fixation, saccades, smooth pursuit movements and visually guided grasping)
  - Is the child interested in it's surroundings?
  - Do they notice small objects around them?
  - Demeanor, coordination, physical habitus and head posture
  - General appearance of the eyes: strabismus, nystagmus, eye motility, size, asymmetry and surface anatomy of the eyes and the surrounding tissue

The ophthalmologists first general assessment

- Observations during the examination:
  - General appearance of the eyes:
    - Strabismus (position of the eyes)
    - Nystagmus (involuntary eye movements)
    - Eye motility
    - Size
    - Asymmetry
    - Surface anatomy of the eyes and the surrounding tissue

Assessing vision

Assessing vision

- **Overview** – Specific testing: Methods depending age, health and development of the child:
  - Position of the eyes:
    - Observation of deviations
    - Evaluation of size and angle
    - Corneal light reflex
    - Cover/uncover test (for those who can maintain fixation)
    - Fixation behaviour
    - Observation of eye movements

Assessing vision

- **Overview** – Specific testing: Methods depending age, health and development of the child:
  - Pupillary responses:
    - Response to light
    - Accommodation-convergence reflex
  - Stereo vision
  - Visual acuity testing:
    - Preferential looking
    - Optotype testing
  - Measurement of refraction – sciascopy/retinoscopy

Assessing vision

- **Overview** – Specific testing: Methods depending age, health and development of the child:
  - Visual field testing:
    - Confrontational testing
    - Perimetry testing
      - Manual perimetry (e.g. Arc perimeter and Goldmann)
      - Automated perimetry (e.g. Humphrey and Octopus)
  - Colour vision assessment
  - Contrast vision assessment

Assessing vision

- **Overview** – Additional testing which aids in the evaluation of the child's eyes, optic nerves and higher visual system (brainstem and brain):
  - Electrophysiology testing:
    - Visual Evoked Potential (VEP)
    - Electroretinogram (ERG)
  - Neuroimaging (to be discussed with the neuro- or developmental paediatrician)

Assessing vision – Specific testing

- **Position of the eyes**
  - Hirschberg test – Light reflex of the cornea
  - Cover/uncover test – Alternating cover test, prism cover test for quantitative measurement of strabismus
  - Strabismus (squint, deviation of an eye) is caused by lack of coordination between the extraocular muscles, so both eyes do not have parallel lines of sight, thereby hampering proper binocular vision and possibly depth perception. Tropia/phoria. Can cause diminished vision and amblyopia

Assessing vision – Specific testing

- **Fixation behaviour**
  - The visual system at birth is functional but limited
  - Visual fixation is usually present in full-term alert new-borns, but the ability to follow targets is habitually not observed until later (often about 2 months of age)
  - The stability and duration of fixation is also low to begin with (often up until 5 months of age)
  - However, the lack of ability to fixate is usually an indicator of poor visual function as children get older

Assessing vision – Specific testing

- **Fixation behaviour**

Assessing vision – Specific testing

- **Eye movements**
  - The movements of the eyes are voluntary and involuntary
  - To track an object one uses three types of voluntary eye movements and these movements are thought to originate in the frontal lobe of the brain:
    - Smooth pursuit
    - Vergence shifts
    - Saccades
  - Six extra-ocular muscles facilitate the movements of the eyes and three cranial nerves carry signals from the brain to control these muscles

Assessing vision – Specific testing

- **Eye movements**
  - Movements are described as:
    - Elevations – Pupil directed upwards
    - Depression – Pupil directed downwards
    - Abduction – Pupil directed laterally
    - Adduction – Pupil directed medially
    - Extorsion – Top of eye rotating away from the nose
    - Intorsion – Top of eye rotating towards the nose
  - The child's ability to track/follow an object is tested at close range, for one eye and both eyes

Assessing vision – Specific testing

- **Eye movements**
  - Nystagmus:
    - Involuntary repetitive movement of the eyes
    - Can be horizontal, vertical or rotary, slow or fast and usually involves both eyes
    - Pathologic nystagmus can be congenital (3 – 6 months) or acquired, indicating an underlying visual or neurological problem
    - Can cause reduced vision

Assessing vision – Specific testing

- **Eye movements**
  - Nystagmus:
    - People with nystagmus from childhood may not be aware of there eye movements because what they see usually doesn't appear shaky to them
    - A tilt or turn of the head in order to see more clearly is common. This helps to dampen or slow the eye movements.

Physiological nystagmus: video (Wikipedia)

Assessing vision – Specific testing

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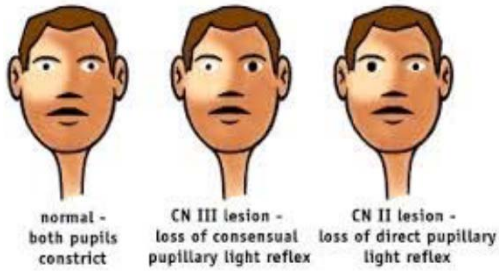
- **Pupillary responses**
  - Reflex that controls the diameter of the pupil in response to the intensity of light that falls on the retinal ganglion cells of the eyes, thereby assisting in adaptation to various levels of lightness/darkness regulating the intensity of light entering the eye
  - The optic nerve, or more precisely, the photosensitive ganglion cells through the retino-hypothalamic tract, is responsible for the afferent limb of the pupillary reflex. It senses the incoming light
  - The oculomotor nerve is responsible for the efferent limb of the pupillary reflex. It drives the muscles that constrict the pupil



Assessing vision – Specific testing

- **Pupillary responses**
  - Accommodation-convergence reflex
    - The young human eye can change focus from distance (infinity) to 6,7 cm from the eye in 350 milliseconds. A change in focal power of approximately 15 diopeters
    - With the accommodation reflex the eye adapts for near vision. The child focuses on a distant object (dilates the pupils), then shifts the gaze to a near object, whereby a normal response is a pupillary constriction and convergence of the axis of the eyes

Assessing vision – Specific testing

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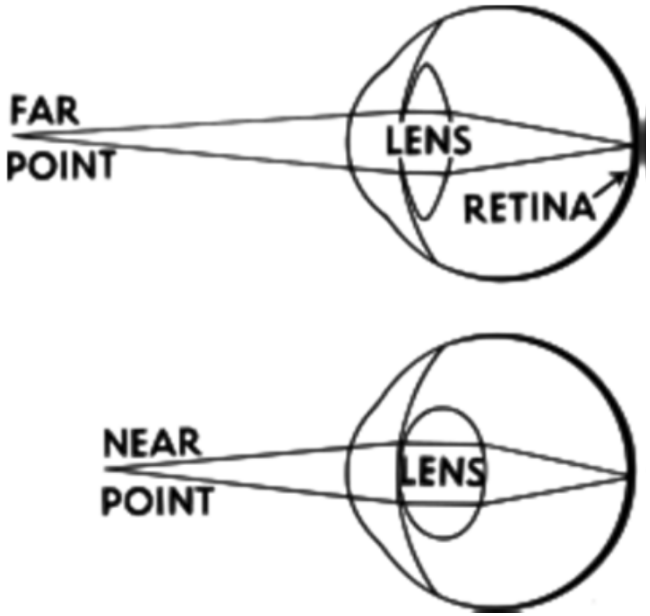
- **Pupillary responses**
  - Accommodation-convergence reflex
    - Vergence is the simultaneous movement of both eyes in opposite directions to obtain or maintain single binocular vision
    - Vergence is closely connected to accommodation. Under normal conditions, changing the focus of the eyes to look at an object at a different distance will automatically cause vergence as well as accommodation. *The accommodation-convergence reflex*



Assessing vision – Specific testing

- **Stereovision**
  - Stereovision is the perception of depth and 3-dimensional structure obtained on the basis of visual information deriving from two eyes. It's the highest degree of binocular vision
  - Binocular disparities are processed in the visual cortex of the brain to yield depth perception
  - Fine stereopsis is mainly based on static differences. It allows the individual to determine the depth of objects in the central visual area end is therefore also called quantitative stereopsis. It is typically measured in random-dot tests
  - Testing stereovision:
    - Random dot stereotests (e.g. Lang stereotest)
    - Contour stereotests (e.g. Titmus stereotest)

Assessing vision – Specific testing

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- **Stereovision**
  - Testing stereovision – Lang stereotest
    - Random dot stereotest
    - Consists of a random dot stereogram upon which a series of parallel strips of cylindrical lenses are imprinted in certain shapes, which separate the views seen by each eye in these areas, similarly to a hologram

Assessing vision – Specific testing

- **Stereovision**
  - Testing stereovision – Titmus stereotest
    - Contour stereotest
    - The most well-known example is the Titmus Fly Stereotest where a picture of a fly is displayed with disparities on the edges. The patient uses 3D glasses to look at the picture and determine whether a 3D figure can be seen

Assessing vision – Specific testing

- Visual acuity testing – **Preferential looking**
  - Infants demonstrate a greater tendency to look at a patterned stimulus than a homogeneous field
  - Normal values for development of “acuity” in the first year of life were estimated by identifying spatial stripe frequencies that were fixated longer than a homogeneous field by 75% of infants at a given age
  - Forced choice preferential looking tests:
    - Teller cards (masked observer looks through peeping whole in the boards)
    - Lea gratings

Assessing vision – Specific testing

- Visual acuity testing – **Preferential looking**
  - Forced choice preferential looking tests:

Teller cards

Lea gratings

Assessing vision – Specific testing

- Visual acuity testing – **Preferential looking**
  - Administration
    - The infant responds by turning the eyes or the head toward the striped target
    - Multiple trials are often needed
    - Detection of the finest grading gives the visual acuity
    - Measured in cycles/cm, taken into account the distance from the patient. The evaluation is in cycles/degree, which is converted (table) into Snellen measurements

Assessing vision – Specific testing

- Visual acuity testing – **Optotype testing**
  - An optotype is a symbol that, when correctly identified at a given distance, permits quantification of acuity
  - From 2-3 years old
  - Optotype tests:
    - E-test
    - Picture testing (e.g. Lea symbols or Kay pictures test)
    - Matching technique (e.g. HVOT chart or Sheridan-Gardner)

Assessing vision – Specific testing

- Visual acuity testing – **Optotype testing**
  - Administration:
    - Repeated tries at different times often necessary – learning curve
    - First tested binocularly, with and without refractive correction, then each eye
    - School age children tested with Snellen/LogMAR

Assessing vision – Specific testing

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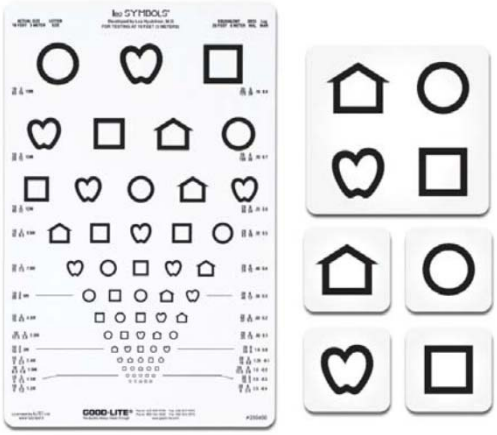
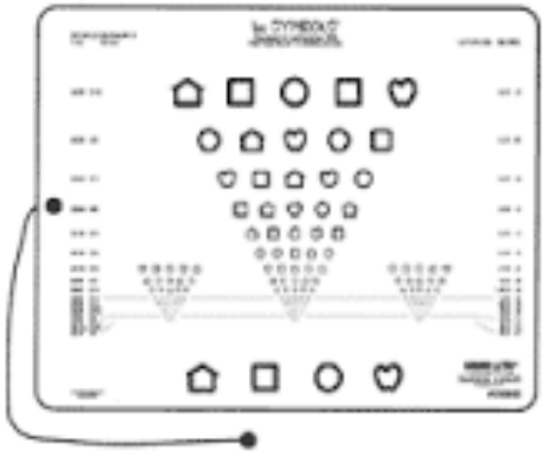
- Visual acuity testing – **Optotype testing**





Lea symbols

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- Visual acuity testing – **Optotype testing**

Kay pictures Test

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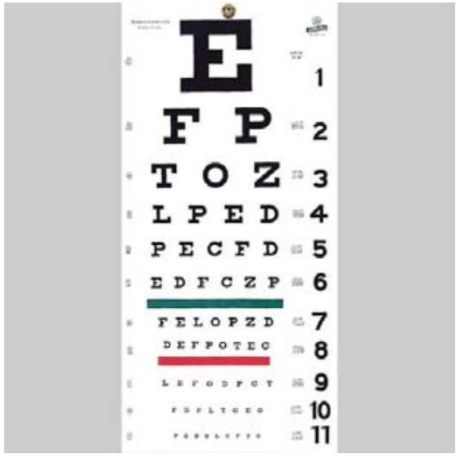
- Visual acuity testing – **Optotype testing**



HVOT chart or Sheridan-Gardner

Assessing vision – Specific testing

- Visual acuity testing – **Conversion table**

LogMAR	Snellen	Decimal
0,00	6/6	1,00
0,18	6/9	0,67
0,30	6/12	0,50
0,48	6/18	0,33
0,60	6/24	0,25
0,78	6/36	0,17
1,00	6/60	0,10

Assessing vision – Specific testing

- **Measurement of refraction**
  - The exam:
    - Participation depends on the age of the child as well as its health and development
    - Exam to accurately measure refractive error, slit-lamp examination for evaluation of the anatomy of the eye, for diagnosis of abnormalities of the anterior segment and by indirect ophthalmoscopy (fundoscopy) with a lens to look for subtle abnormalities of the retina or optic nerve/nerve fiber layer
    - Dilation of the pupil for a better view/sciascopy
    - Uncooperative child – Examination under sedation or under anaesthesia

Assessing vision – Specific testing

- **Measurement of refraction**
  - The exam:
    - After dilation of the pupils
    - Subjective measurement in older children
    - Prescription of glasses if needed
    - Prescription of occlusion treatment in younger children with suspected amblyopia
    - Amblyopia (lazy eye) is due to abnormal vision development in one or both eyes in childhood and is the most common cause of monocular blindness

Assessing vision – Specific testing

- **Visual field**
  - Young children with severely restricted visual fields can be identified by the confrontation technique
  - Visual field testing:
    - Confrontational testing – A figure is brought in from the periphery by one person while another watches the fixation/eye movements
    - Perimetry testing – Perimetry is a more suitable method to identify relative visual field defects in older children (from 6-7 years):
      - Manual perimetry
      - Automated perimetry

Assessing vision – Specific testing

- **Visual field**
  - Visual field testing – Perimetry testing
    - Manual perimetry (e.g. Arc perimeter and Goldmann):
      - Is a technique in which changes in size and intensity of a stimulus are used to detect relative visual field defects
      - A continuously monitoring of the fixation and cooperation of the child is important
      - The children are told to say 'yes' when the see the stimulus. Some children have problems saying when they see the stimulus. In these cases, the field can be measured by means of eye movements
    - Automated perimetry (e.g. Humphrey and Octopus)

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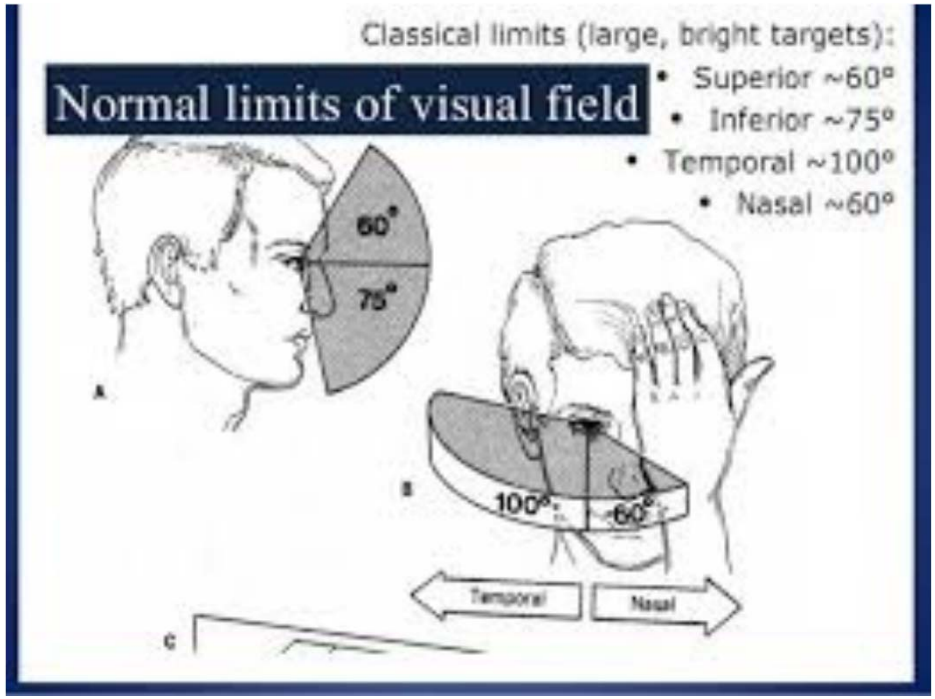
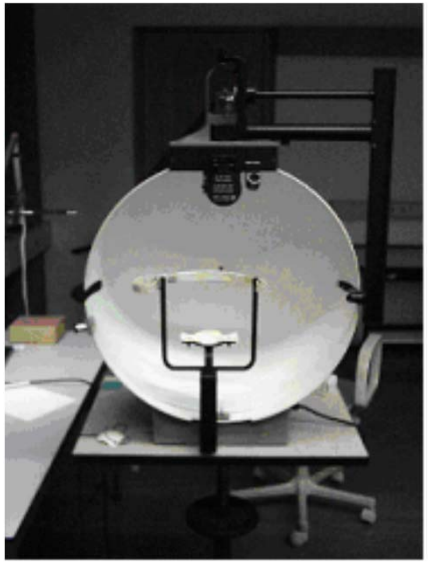
- **Visual field**
  - Visual field testing



Assessing vision – Specific testing

- **Visual field**
  - Visual field testing



Goldmann

Confrontation testing

Assessing vision – Specific testing

- **Colour and contrast vision**
  - Colour discrimination and contrast sensitivity are present but poorly developed in new-borns
  - During the first six months of life – Rapid anatomic development in the eye and central visual pathway parallels a rapid improvement in visual acuity, contrast sensitivity and colour discrimination:
    - Maturation of the retina and retinal photoreceptor (rod and cone cells)
    - Myelination of the optic nerves and tracts
    - Increased synaptic density of the visual cortex

Assessing vision – Specific testing

- **Colour and contrast vision**
  - After six months of life – The visual system develops at a slower rate:
    - Myelination continues to increase in the central visual pathways until about four years of age
    - The development of the visual cortex continues throughout the first decade of life

Assessing vision – Specific testing

- **Contrast sensitivity**
  - Is the ability to detect gradations in brightness
  - Is the ability to distinguish between object and background. A test of visual function.
  - Visual acuity drops in situations of low contrast and the quality of vision suffers
  - Contrast testing provides information about the visual performance (visual acuity is tested in high contrast), face recognition, stairs and different lightning conditions
  - Contrast sensitivity tests:
    - Pelli Robson – Contrast Sensitivity Chart
    - Lea Hyvarinen – Heiding Heidi Low Contrast Test
    - Preferential looking

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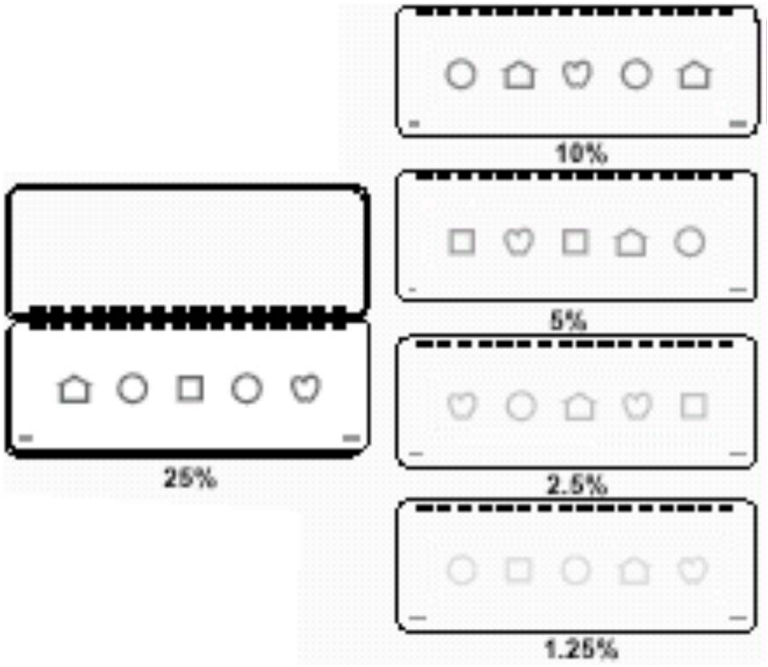
- **Contrast sensitivity**



Assessing vision – Specific testing

- **Contrast sensitivity**

Pelli Robson – Contrast Sensitivity Chart

Lea Hyvarinen – Heiding Heidi Low Contrast Test

Assessing vision – Specific testing

- **Colour vision**
  - Is the ability to distinguish objects based on the wavelengths (or frequencies) of the light they reflect, emit or transmit
  - Colours can be measured an quantified in various ways
  - A person's perception of colours is a subjective process whereby the brain responds to the stimuli that are produced when incoming light reacts with the several types of cone cells in the eye
  - In essence, different people see the same illuminated object or light source in different ways
  - Parallel channels lead from the retina to the thalamus carrying information into the visual cortex, where colour is ultimately determined

Assessing vision – Specific testing

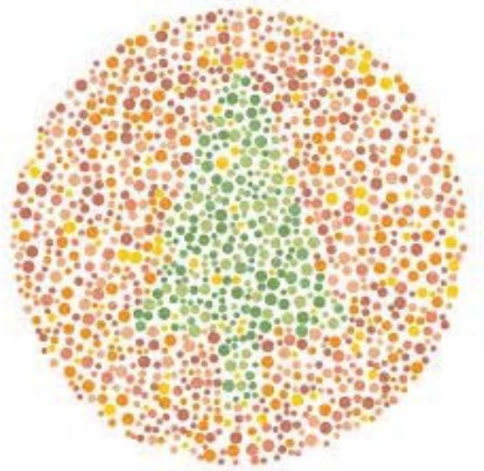
- **Colour vision**
  - In very low light levels, vision is scotopic – Light is detected by rod cells of the retina. Rods are maximally sensitive to wavelengths near 500nm and play little, if any, role in colour vision
  - In brighter light, such as daylight, vision is photopic – Light is detected by cone cells, which are responsible for colour vision
  - Colour blindness can be:
    - Total or partial (more common)
    - Blue/yellow or red/green (more common, 8% of males)

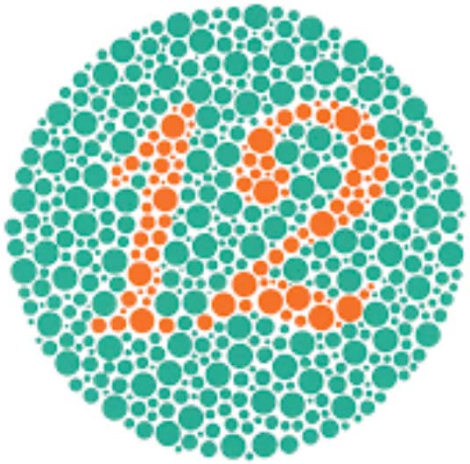
Assessing vision – Specific testing

- **Colour vision**
  - Colour vision testing:
    - Ishihara Color Test – red/green
    - Farnsworth Color Vision Test – red/green and blue/yellow
    - Waggoner computerized color test
    - Functional implications

Assessing vision – Specific testing

- **Colour vision**
  - Colour vision testing:





Ishihara Color Test

Assessing vision – Specific testing

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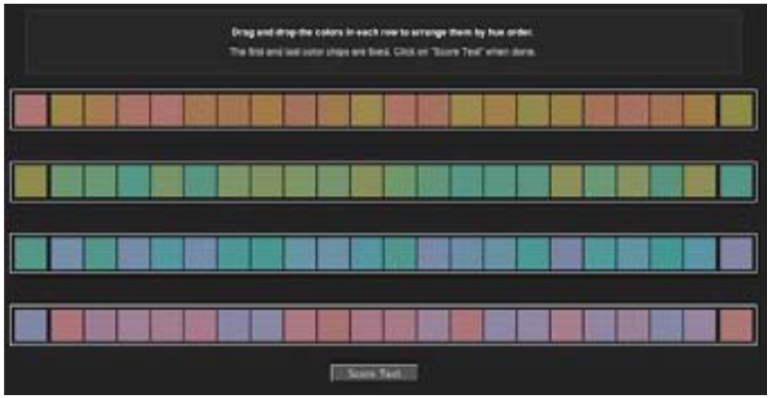
- **Colour vision**
  - Colour vision testing:



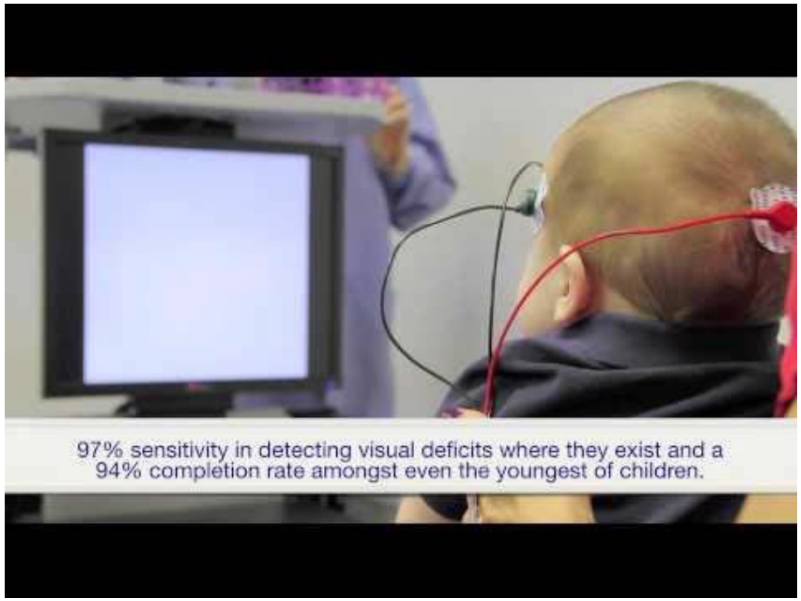
Farnsworth Color Vision Test

Assessing vision – Additional testing

- **Visually Evoked Potential (VEP)**
  - Can be useful for assessing visual function in children with developmental disabilities, ocular motor apraxia and cortical visual impairment
  - The occipital lobe's electrical response to retinal stimulation is measured
  - It takes about 100ms from light stimulation of the retina until the response of the cortex. In case of damage somewhere between the retina and the cortex, the response is altered (longer duration or reduced amplitude)
  - The interpretation takes experience

Assessing vision – Additional testing

- **Visually Evoked Potential (VEP)**

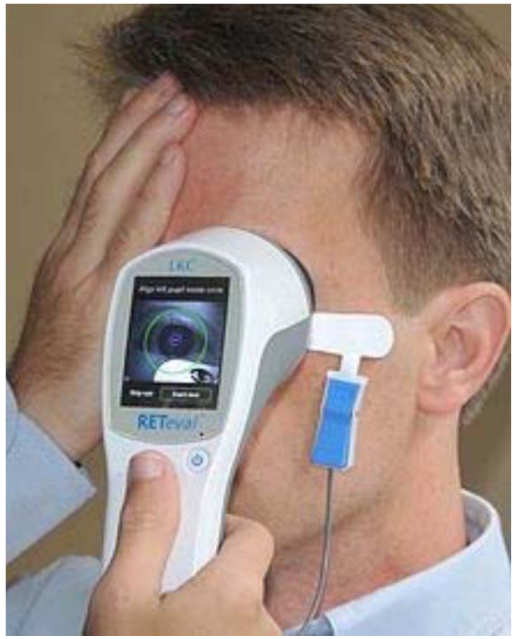


Assessing vision – Additional testing

- **Electroretinogram (ERG)**
  - Measures the electrical responses of various cell types in the retina, including the photoreceptors (rods and cones), inner retinal cells (bipolar and amacrine cells) and the ganglion cells
  - Electrodes are usually placed on the cornea (contact lens) and the skin near the eye, although it is possible to record the ERG from skin electrodes
  - During a recording the patients eyes are exposed to standardised stimuli and the resulting signal is displayed showing the time course of the signals amplitude (voltage)

Assessing vision – Additional testing

- **Electroretinogram (ERG)**
  - ERG is used for the diagnosis of various retinal diseases
  - Used under anaesthesia in children with suspected retinal problems/visual impairment



Children with a suspicion of CVI

Children with a suspicion of CVI

- **Evaluation of each child**
  - The evaluation of each child is different
  - Which methods are chosen for vision assessment depends on the problems at hand as well on the child itself

Children with a suspicion of CVI

- **Children with suspected CVI**
  - Are evaluated the same as all other children
  - Other pathology, if present, must be accounted for and attended to
  - Refraction and amblyogenic factors must be evaluated and corrected if needed
  - The history and examination is very indicative and important in the evaluation and diagnosis of children with suspected CVI
  - Evidence provided by imaging procedures, such as MRI, is important

Children with a suspicion of CVI

- **Children with suspected CVI**
  - The diagnosis and follow-up is a multidisciplinary approach with pediatricians and ophthalmologists. Also genetics and imaging specialists (radiologists) work together
  - Early intervention with detailed assessment and visual training is paramount, with special pedagogues, low vision specialists and opticians working closely with the parents and caregivers of the child

Final thoughts

Final thoughts

- Please note that provided information are not exhaustive
- This publication was supported by the Erasmus+ Programme of the European Commission
- This publication reflects the views of the authors, partners of the TeachCVI projects. Therefore, the Commission cannot be held responsible for any use of the information contained herein
- Find more information about the TeachCVI project on the website: http://www.teachcvi.net
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