Asian Journal of Research and Reports in Ophthalmology

3(2): 6-12, 2020; Article no.AJRROP.56011

Technique for Measuring Strabismus with Synoptophore – Review

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Seydi Okumus, Gaziantep University, Turkey.
Reviewers:
(1) Marcello Colombo Barboza, Brazil.
(2) Shubha Ghonsikar Jhavar, Government Medical College, Aurangabad, India.
(3) Asaad Ahmed Ghanem, Mansoura University, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/56011

Mini-review Article

Received 17 February 2020
Accepted 23 April 2020
Published 30 April 2020

ABSTRACT

Binocular vision is a brain process in which the integration of two retinal images into a single visual perception is achieved. Binocular vision provides a greater field of vision as well as the main benefit, stereoscopic vision. For many years, the Synoptophore has been the standard choice instrument for Orthoptic management. It is used for assessing and treating of ocular motility disorders very reliably. Mechanical or electrical irritation of a retina leads to the projection of the sensation to the same point in the space where it would be projected if the same retinal point was irritated by light. This is the instrument that performs a comprehensive assessment of binocular vision. It provides standard measurements and easy treatments. To measure the range of fusion, it is preferable to start with convergence, gradually turning the arm of the Synoptophore inward and asking the patient if he or she sees a cat with a tail and ears. In conclusion its important for ophthalmologist and optometrists to have a good knowledge of handling the instrument and to get used of its worthiness in orthoptic practice.

Keywords: Strabismus; binocular vision; synoptophore; orthoptic management.

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1. INTRODUCTION

1.1 Binocular Vision

Binocular vision is a brain process in which the integration of two retinal images into a single visual perception is achieved. Binocular vision provides a greater field of vision as well as the main benefit, stereoscopic vision. It is acquired, and its development is achieved under certain conditions:

a) The retinal images from both eyes must be similar in size, shape, and purity;
b) These images must be projected in both sides and directions;
c) Both of the above conditions must exist at least at the end of 2 years.

Therefore, when these conditions are not met, binocular vision is not developed in patients with congenital strabismus. These projective properties are endogenous and specific to each point of the retina. Mechanical or electrical irritation of a retina leads to the projection of the sensation to the same point in the space where it would be projected if the same retinal point was irritated by light. When the nasal points of the retina are irritated, the impression is that the stimulus comes from the temporal part of the field of vision, that is, the nasal points are temporally projecting. In the same way the temporal points project upward and upward project downward and downward upward.

1.2 Historical Review

In 1832 Sir Charles Wheatstone invented the first stereoscope, and his patent was published in 1838. The stereoscope was the precursor to the present-day Synoptophore [1-3]. The first Synoptophore was used in the 19th century by E. Hering [1-3]. The basic principle of the instrument is the mechanical separation of vision into the right and left eye [1-3]. At the beginning of the 20th century, Claud Worth produced the Amblyoscope, to assess and restore binocular vision from horizontal and vertical deviations due to strabismus. In 1929, Clement Clarke patented the first patent on a Synoptophore (Major Amblyoscope). In 1931, M.C Maddox, daughter of E. Maddox, developed transparencies (slides) for the first three devices, and for all grades of Binocular Single Vision, as Claud Worth first put it, so that the extent of simultaneous perception and area of suppression can be determined [1-3].

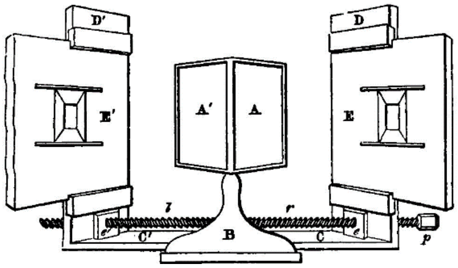

Fig. 1. The first stereoscope (Charles Wheatstone) [1]

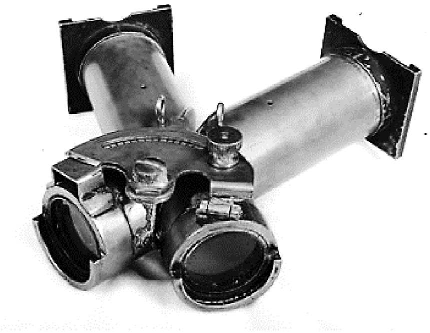

Fig. 2. Worth's Amblyoscope [1]

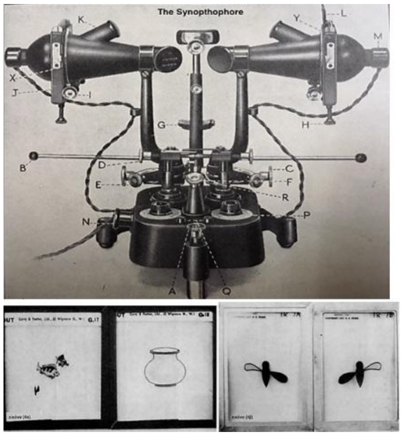

Fig. 3. The first Synoptophore and the pictures which were used [1]

2. WHAT IS SYNOPTOPHORE

For many years, the Synoptophore has been the standard choice instrument for Orthoptic management. It is used for assessing and treating of ocular motility disorders very reliably This is the instrument that performs a comprehensive assessment of binocular vision. It provides standard measurements and easy treatments.

It is a useful Orthoptics tool specifically for detecting the objective and subjective angle of deviation, abnormal retinal correspondence, cyclophoria, hyperphoria and horizontal and vertical vergences in patients with strabismus and contributes to the treatment of binocular abnormalities by training the ocular muscles, [4,5], allowing the visual stimuli to be projected on each eye separately.

Fig. 4. A modern Synoptophore

2.1 The Important Parts of Synoptophore

The Synoptophore consists initially of its base, a patient chin rest, a metope, the volume and frequency control buttons of the light sources, as well as two tubes each with a + 6.5 D ophthalmic lens at each end and a socket for the other end transparencies [4-7].

The +6.50 D eye-pieces consist of collimating lenses, which helps the patient to relax their eye-accommodation, as if the patient looks at infinite distance. A plane mirror reflects 90° along the two optical tubes. These tubes can move at horizontal, vertical and rotary direction in relation to their holding so that the two projected images can be moved in relation to each other. The tubes are 15.5 cm in length, so the transparencies are positioned on the focal point of the eyepieces so that the outgoing rays are parallel and do not require adjustment by the patient so the condition that is created is that the images are positioned in the infinite range. A light source is placed at the end of the tubes, which evenly illuminates the transparencies.

The patient sees each slide separately according to the corresponding eye. The two tubes are welded to allow movements, horizontal, vertical and circular. Their position is checked precisely by markers moving on corresponding scales (prism Δ, arc/sec). There is also the possibility of locking so that they can be moved simultaneously or separately. The scales on the Synoptophore, measure the displacement, degrees and Prism Dioptres (Δ) [3-7].

2.2 Objective Measurement of Strabismus Angle

The cover test principle is used for the objective measurement of the Strabismus angle (H.H.Emsley, 1957) This is achieved by placing two different slides (e.g. lion and cage) in the slots of the instrument and adjust the tubes in parallel (mark should be 0 degrees on the horizontal scale) then the patient focuses through the tubes while the operator illuminates alternately. every transparency[7].

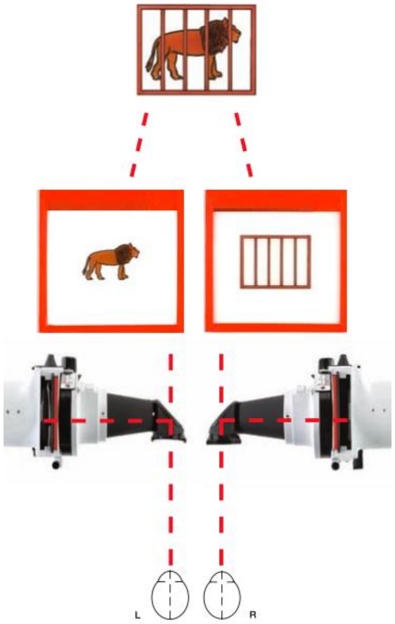

Fig. 5. A modern synoptophore with the slides it uses

The tubes are adjusted objectively (by the examiner) and subjectively (by the patient) so that both the lion is perceived to be inside the cage or one image is suppressed

When the visual axes of both eyes remain parallel, there is no distortion, the eyes remain motionless as the focus is transferred from one eye to another by alternating the illumination of the images. In the event of a deviation (in or out), the eye that deviates will make an outward or inward movement respectively, in order to focus whenever the projection transparency is illuminated [8-12].

Then the tube of the corresponding deviation eye is tilted horizontally so that no movement is observed. At this point the angle of strabismus is neutralized and its magnitude is measured on the horizontal scale in degrees, in case of convergence it is denoted by (+) and in case of divergence it is denoted by (-). In the same way we can measure simultaneously and any co-existing vertical deviation [9-13].

If the divergent eye fails to focus to the image of transparency, for example due to amblyopia, corneal reflections can give us the angle of Strabismus. The reflections come from the light sources at the ends of the tubes, we can adjust them in the center of the pupil field, and then read the scale of the angle.

2.3 Diagnostic Uses of Synoptophore

1. Measurement of Simultaneous Perception (The first grade of BSV)
2. Measurement of the objective and subjective angle of deviation.
3. Measurement of the amount of deviation at near eye accommodation, simulating near viewing (Accommodative convergence to accommodation ratio (AC/A ratio)).
4. Measurement of Sensory (SF) and Motor Fusion (MF) (The second grade of BSV)
5. Measurement of Stereopsis (The third grade of BSV)
6. Measurement of the primary and secondary deviations
7. Measurement of deviation in 9 gaze positions
8. Measurement of Torsion
9. Clinical evaluation of binocular vision: (a) retinal correspondence: normal or abnormal; (b) presence and type of suppression; (c) stereoscopy.

2.4 Therapeutic Uses of Synoptophore in

1. Suppression
2. Retinal correspondence
3. Correction of Eccentric Fixation (Foveal, Outer foveal, Peripheral)
4. Accommodative tropia
5. Correction of eterophoria

3. CLINICAL EVALUATION OF BINOCULAR VISION

The examination starts by finding the strabismus angle by placing two different slides. When neither of the two eyes rotate during the light switch, both images are left illuminated and the examiner asks the patient to tell what he or she sees. When the patient responds by saying that he sees the lion in the cage based on our original example, we conclude that there is a simultaneous perception and the retinal match is normal [14-18].

If the subject is unable to see the lion and the cage at the same time, then there is a central repulsive defect in the eye corresponding to the image that is not seen. In this case, we use larger images to move away from the area of repulsive scotoma. If then the larger images are perceived then we have a peripheral simultaneous perception. If even with the larger images we have repulsive scotoma then there is no central or peripheral simultaneous perception.

Then we ask the subject to put the lion in the cage and it will give us a different angle from the objective (subjective angle). When the subjective angle is 0 degrees, there is complete sensory contraction of the strabismus and the abnormal retinal match is called harmonic. When the subjective is less than the objective angle but not 0 degrees, there is a partial sensory counterbalance to Strabismus and the abnormal retinal match is called nonharmonic. The difference between an objective and subjective angle is called anomaly angle. For example, if the objective angle is 20 degrees and the subjective 15 degrees, then there is an abnormal retinal match and the anomaly angle is 5 degrees.

4. SENSORY FUSION

Sensory fusion is examined with images that are flawed but complement each other on the two slides; for example, in one slide there is the outline of a cat with a tail without ears, whereas in the other slide the same cat has a tail and no ears.

The imperfections are useful in checking whether the cat seeing the patient is a product of sensory fusion and not a suppression of one of them. If there is a match, the patient sees the cat with all its features (tail, ears). If there is no matching, the patient looks at the cat's contour without looking at its tail or ears, depending on the repulsive eye.

Central fusion (central fovea) is controlled with 2 degrees surface images, while peripheral fusion is controlled with larger images. Fusion control is done with the Synoptophore set at the subjective angle of strabismus [15-19].

5. MOTOR FUSION

The Motor fusion and the measurement of its amplitude is done by moving the arms of the Synoptophore inward and outward. If there is a Motor fusion, the eyes will converge or diverge to maintain Sensory fusion. It is necessary to disclose the existence of minimal Moto fusion otherwise the complete picture that the patient sees may be due to simultaneous perception.

To measure the range of fusion, it is preferable to start with convergence, gradually turning the arm of the Synoptophore inward and asking the patient if he or she sees a cat with a tail and ears. Continue converging until the patient sees two cats. It is possible for the patient to keep the images unified because of adaptive convergence, which occurs when the range of fusion is exhausted. The images then appear smaller.

Likewise, we turn the arms outward and determine the fusion deviation. To conclude kinetic matching, a minimum of 5 degrees of positive fusion (convergence) and 3 degrees of negative fusion range are required (deviation). In clinical practice the values are higher (most commonly in the positive range of fusion) with no particular value as they are performed *in vitro*. [15-19].

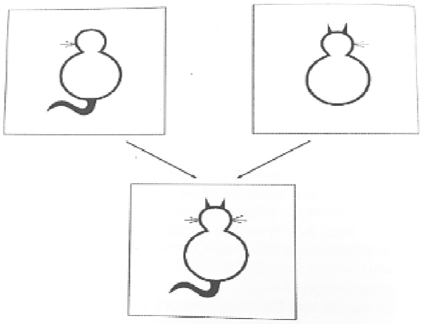

Fig. 6. Contemporary Synoptophore and slides used

a) one slide has the outline of a cat with no tail ears, while the other b) the slide itself has a tail and no ears

6. CLINICAL INVESTIGATION OF STEREOSCOPIC VISION

At first the special stereoscopic slides are place in the slots and adjust the tubes precisely to the horopter area so that the images irritate the corresponding retina points for example the central fovea, and the image is perceived in two dimensions or if the image is three dimensional before the horopter area and beyond. These points do not have corresponding retinal irritations, but if they are within the Panum area, the two retinal images can be fused simultaneously having depth perception (stereoscopic vision).

The two retinal images created by the 3D slides present a horizontal difference due to the different position from which each eye sees the object depicted. The minimum horizontal difference that can cause depth sensation corresponds to the stereoscopic vision threshold and determines stereoscopic acuity. The lower its value in (arc/sec) the better the stereoscopic acuity, this method is more qualitative than quantitative [20,21].

7. CONCLUSION

Synoptophore is an ophthalmic Instrument, used for diagnosing disorders of eye muscles and it is used for treating them through orthoptic methods. For many years, the Synoptophore was the standard ophthalmic instrument used in an orthoptic daily routine. It is the ideal ophthalmic instrument for the assessment and treatment of ocular motility disorders. It is the most common and comprehensive binocular vision assessment technique available today.

Knowledge of basic stereoscopic binocular vision parameters is required not only for ophthalmologist but also for optometrists, who are able to provide, the correct prismatic correction and for visual training.

Synoptophore range of slides can provide assessment on a wide range of binocular vision anomalies. The slides can aid the assessment of nine positions of gaze, indicate depth perception and stereopsis assessment can be obtained.

Also, it can assess sensory fusion, perception, the presence of suppression and abnormal retinal correspondence. Slides can provide information on the presence of aniseikonia, when there is a difference in the perceived size of images.

Some of its slides are designed for patients with ocular motility symptoms which require orthoptic treatment. All the standard measurements and treatments are possible on this instrument including assessment of cyclophoria, hyperphoria, horizontal vertical vergences.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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