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New varieties of the tests for binocular vision assessment

Introduction:

Unfortunately, up to date there is no commonly accepted set of tests for integrative assessment of binocular functions and, therefore the task of novel test elaboration remains of current interest.

Methods:

Two novel varieties of tests for stereovision assessment were elaborated. One of them, like the Lang-test, combined the principles of raster separation and random dot stereogram but, in our version, it was multicolored and had 12 disparity gradations – much more than in Lang-test. The second stereotest was based on the principle of chromostereopsis and implied using ChromaDepth glasses. These tests, along with the widely known Lang-test and Worth-test, were employed for binocular vision assessment in 59 normal subjects, 45 patients with ametropia, and 31 patients with concomitant strabismus accompanying by ametropia.

Results:

In all 59 subjects without ophthalmopathology, the results of all the employed tests were positive. In the group of 45 patients with ametropia, the results of the Worth-test and both raster tests were also positive in all cases. However, some difficulties with the chromostereotests were observed in 9 patients of this group having impaired accommodation joined with myopic refraction. The remained 36 patients (including 3 patients with impaired color vision) were able to perceive depth in all the images of the chromostereotest. In the group of 31 patients with strabismus and ametropia, the results of the raster tests were negative in all the cases. The Worth-test demonstrated normal retinal correspondence only in 5 patients who had proper positions of visual axes after strabismus surgery. These 5 patients were also able to see depth in some images of chromostereotest.

Conclusion:

The results obtained have indicated that our new variants of stereotests could be promising for a comprehensive assessment of binocular functions.

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RUSSIAN ACADEMY OF SCIENCES



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1 Introduction

Nowadays there are a lot of different stereotests, but unfortunately, there is no commonly accepted set of tests for integrative assessment of binocular functions, therefore, the task of novel test elaboration remains of current interest.

In this work we used our varieties of the tests for binocular vision assessment, based on:

- (1)lenticular raster separation technique and
- (2)chromostereoscopic separation technique.

Lenticular raster separation technique is based on the optical properties of lens system, placed on the specially prepared (printed) stereopair. Due to this optical system, this separation technique is autostereoscopic (glasses-free).

Chromostereoscopic separation principle is based on dispersion - difference in refractive indexes for light of different wavelengths [4, 7]. Using prismatic optics, one could produce binocular disparity on the retinas for the images of differently colored test objects, thus making flat colored picture perceived as a 3D scene [5].

The aim of our investigation was to assess clinical usability of two new varieties of the tests for binocular vision functions.

Lang Stereotest



It is the most useful test in younger children over 12 months. The Lang I includes cyclopean images of cat (20'), a star (10'), and a car (9').

The Lang II includes monocularly visible image of star and cyclopean images of an elephant (10'), a car (6.6'), and a crescent moon (3.3')[6].

The patient has to name or point the image he sees. In the case of stereoscopic vision absence, only black and white random dot pattern is perceived. If the child hasn't stereovision, he doesn't fix the gaze on the areas of hidden objects and quickly loses his interest in testing.

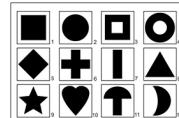
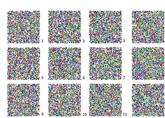
Advantages:

The test does not require special glasses and is indispensable for small children.

Disadvantages:

This test include small number of disparity levels and is more useful for detection of stereovision than for its accurate assessment. Moreover, moving the card can give the impression of blurry images in the areas of hidden objects providing false positive responses.

IITP Raster Test



In the IITP (Russian Academy of Sciences) there was elaborated a novel version of the test, combining the principles of random dot stereogram and lenticular lens raster separation technique - similar to the well-known Lang stereotest, but with significant modifications.

Advantages:

IITP test has larger number of various hidden objects (12 versus 6 in the Lang test) with larger number of disparity levels (12 versus 5: from 2' to 28' for the distance of 50 cm) providing more detailed characterization of stereoaanomaly.

IITP test is colorful, that make it much more attractive to the patient, especially to children. Due to the little modifications in manufacturing, IITP test is almost irresolvable monocularly, whilst the Lang-test has a slight blurriness in the area of a hidden object.

Disadvantages:

In comparison with Lang-test, hidden objects are less stable and more dependent on the position of head in relation to the test card.

3 Results

In all 59 subjects without ophthalmopathology, the results of all the employed tests were positive. At the same time only 29 (49%) subjects of this group were able to perceive all 12 hidden objects in the whole range of disparities from 2' to 28' in our new variant of raster-test. 25 (42%) subject were not able to perceive the hidden object with the disparity 2' and 5 subject (8.5%) subject were not able to perceive the hidden objects with the disparities 2' and 28'.

In the group of 45 patients with ametropia, the results of the Worth-test and both raster tests (Lang test and IITP test) were also positive in all cases. However, in the case of IITP test, only 21 (47%) patient were able to perceive all hidden objects with disparity from 2' to 28'. 10 (22%) patients were not able to perceive the hidden object with the disparity 2', 9 (20%) patients - with disparity 2' and 28' and 5 (11%) patients - with disparity 2', 5', 7' and 28'. Also, in 9 patients of this group having impaired accommodation in addition to myopic refraction there were observed some difficulties with the chromostereotests. The remained 36 patients (including 3 patients with impaired color vision) were able to perceive depth in all the images of the chromostereotest.

In the group of 31 patients with strabismus and ametropia, the results of the raster tests were negative in all cases. The Worth-test demonstrated orthophoria only in 5 patients who had proper positions of visual axes after strabismus surgery. These 5 patients were also able to perceive depth in some images of chromostereotest.

5 References

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2 Materials and Methods

Subjects

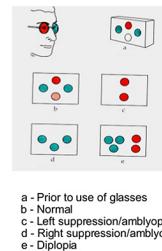
In total, 135 subjects with and without ophthalmopathology were tested. They were divided into 3 groups:

- 1) 45 patients aged 6-17 yrs (13.1 ± 0.4 , average) with ametropia;
- 2) 31 patients aged 10-17 yrs (12.9 ± 0.4 , average) with concomitant strabismus accompanying by ametropia.
- 3) control group of 59 subjects aged 5-17 yrs (13 ± 0.4 , average) without ophthalmopathology.

In the group of patients with ametropia, 33 patients had myopic refraction and 12 patients had hypermetropic refraction. In the group of patients with concomitant strabismus, 15 patients had divergent strabismus accompanying by myopic refraction and 16 patients had convergent strabismus accompanying by hypermetropic refraction.

All subjects of control group had normal vision acuity without optical correction. All ametropic patients had normal visual acuity wearing glasses or contact lenses.

Worth Test



The Worth-test is the most well-known [9]. The test consist of four lights perceived in conditions of color separation of the eyes (using red-green glasses). This method allows to determine the kind of foria (orthoforia, heteroforia) and presence/absence of information suppression from one of the eyes.

Advantages:

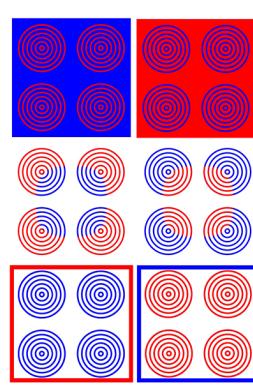
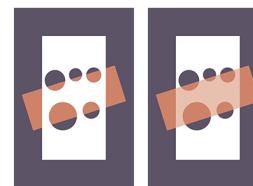
The examination is easy and fast and the test can be used at different distances.

Disadvantages:

The conditions are far from natural: because of red-green glasses used, left and right stimuli have different colors that could provoke binocular rivalry.

The test is rather rough. In some cases, the patient could see four lights despite presence of microstrabismus (false-positive response) or five lights because of not original but induced heterophoria due to red-green separation (false-negative response).

Chromostereotest



The chromostereoscopic principle is known for more than one century, but hadn't been used in binocular vision testing [7]. Our stereotest was based on the principle of chromostereopsis and implied using ChromaDepth glasses [8]. The test provided disparity about 20'.

The test images were proposed by J.Ninio (Laboratoire de Physique Statistique, Ecole Normale Supérieure, Paris, France). The first pair of images is color modification of the illusion of Kanizsa [1, 3].

In another set of test images, there are four disks with contrasting color sectors forming the apices of an illusory square (a variant of the illusion of Varin)[2, 3].

The perception of depth in both sets of images is facilitated by the illusory contours and the neon spreading phenomena.

Advantages:

The easiness of fabrication and use of these tests; the possibility to create a lot of various stimuli that is important in repeating testing.

Disadvantages:

The influence of natural chromostereopsis* and optical correction of the subject (patient) on the perceived image.

* The natural chromostereopsis is a binocular phenomenon, when the equidistant objects of different color are perceived on different distances from the observer; phenomenon may occur without any special extra optics.

4 Conclusions

The results obtained have indicated that our new variants of stereotests could be promising for a comprehensive assessment of binocular functions.

According to our results, it is obvious that there had to be different kinds of tests for different patients, that is especially obvious from the results of strabismic group, where several patient were not able to pass the raster-tests, but were able to perceive the depth in the tests with monocularly visible objects. In strabismus patients, the recovery of binocular vision is one of the most important treatment goals and so it is very important to assess binocular vision correctly.

The chromostereotests is obviously destined only for rough screening, while our variant of raster test with the different disparity levels might be used for progress of binocular vision recovery assessment in the course of stereovision treatment.

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