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Extended Abstract
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Theory: Morpho-physiological characteristics of macula for forming shaped binocular vision

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1. Morphology and physiology of the macula.

Cones in the Fovea are susceptible to three colors: blue spectrum (440-480 nm), green (510-550 nm) and red (620-770 nm). The foveola (2.2 mm diameter) consists from only red and green cones. Dark blue cones are found inside the rings located around the foveola, with an outside diameter of approximately 4.5 mm (stereo-angle of 180°). The density of blue cones within this ring has the highest concentration [1]. This ring apparently plays a leading role in the physiological mechanism of aiming the eye for the highest accuracy of the image (fig. 1).

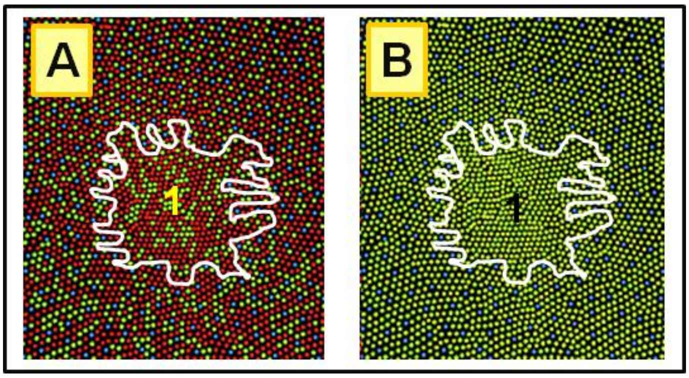

Fig. 1. Electron Microscopy [1]. Foveola (1) and the ring of blue cones within the macula of the normal eye(A) and in color blind eye (B) [2].

This morphofunctional structure of the macula allows you to reliably "aim" for the area of space even in low-light conditions when the coming light mostly consists from the most powerful violet-blue part of the spectrum. Chart of optical center organization in retina presented in Fig. 2 will help you to better understand the Organization of the incoming optical signal with the functioning of the accommodation system.

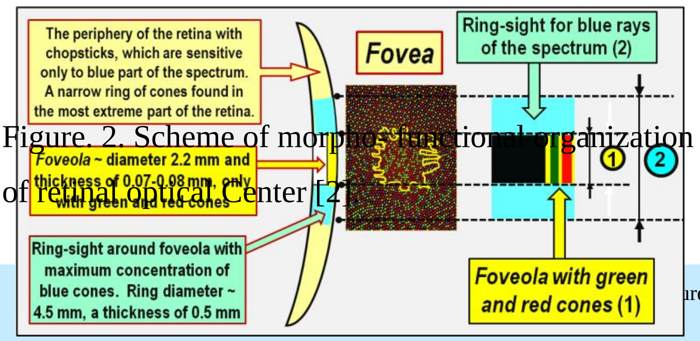

Figure. 2. Scheme of morpho-functional organization of retinal optical Center [2].

In addition, there are horizontal cells located in the outer layer of the retina and amacrine cells located in the inner plexiform layer, which ensures the maintenance of the horizontal linkages among all fields of excitation of cones and rods. It is very important to note that the morphological and physiological structure of macular structure differs considerably from its distant periphery. It can be schematically represented as two layers model: with two layers of rods in the macula from each of hemispheres of the retina in each eye. It is clear that these layers are not present, and each of the neighboring rods is connected through its own axon with different but adjacent neural excitation fields from different hemispheres of the retina (fig. 3).

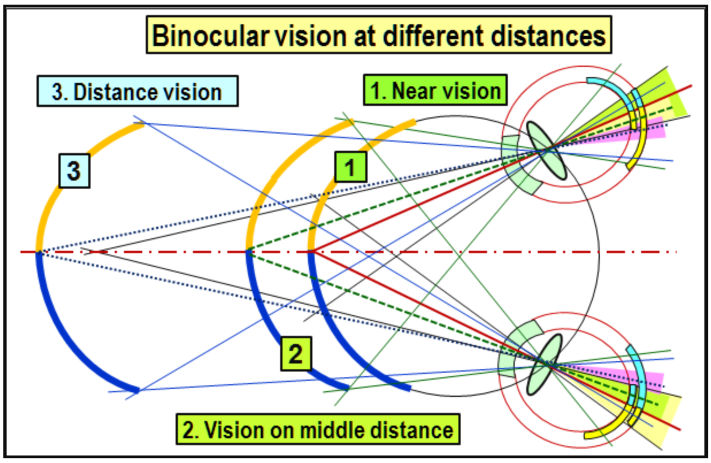

Fig. 3. The binocular work at different distances. To change the location of the field excitation field blending in different half dome of the retina each eye [2].

Secondary representation of signals from part of the cones in different hemispheres of the brain associated "Criss-Cross" with different eye retinas is an essential morphological and physiological feature of the visual system. This allows to use parameters overlapping naso-temporal excitation fields of blue, green and red rays (BGR- rays) not only when you require acuity, but also to correctly steer the binocular sight to a certain point. Maximum area of overlapping excitation fields of rods in the foveola will correspond to the precise binocular guidance for both eyes at an object accentuated from visual background for more detailed analysis (case 1 in Fig. 3). Figure 3 also shows that, with the gradual removing of the analyzed part from a far, the overlaying fields are narrowing (cases 2 and 3 in Fig. 3). The excitation regions at the periphery of the retina are reducing. And of course, the brain will give a control command to the extraocular muscles to rotate both eyes in such way to maximize the area of overlap. That is necessary to obtain the maximum command signal level. A qualitative and highly sensitive input signal for the functioning of the entire accommodation control system is a preliminary estimate of a relative location of the BGR-bands of excitation in the macula. Apparently, the two areas overlapping in optical signal "layers" inside the foveola are primarily responsible for more precise guidance of eyes on the object. After all, for the best vision, the level of excitation of green and red rods belonging to superimposed concentric "layers" in the foveola should be maximized. To do this, the brain must synchronously submit adequate electrical control signals feedback on ciliary muscle and the extraocular muscles. Due to the horizontal links between fields of green and red cones in the foveola, apparently brain is able to distinguish between cases of touching, overlaying or divergence of BGR excitation bands at the moments of work at far, medium and close distances.

2. Physiological mechanism of binocular guidance.

We assume that a powerful excitation signal from the blue cones located within the ring around the foveola is a borderline signal of "detection" for the beginning of the executor mechanism for a finer eye guidance . It is possible to define the circular boundary of the fixation of blue rays in the ring-sight of the macula as a mechanism for preliminary search and guidance. Fig. 4 shows the the search and aiming mechanism when moving the fixation object from the eye [2]. One can clearly see how the binocular spatial "optical aim" synchronously works, while located in the retina of each eye in the form of a peripheral ring around the foveola and having the maximum concentration of blue rods reacting to the most powerful part of the spectrum-the blue band of excitation. Such a morphofunctional structure of the macula allows reliable "aiming" even in low light conditions, when the most powerful violet-blue part of the spectrum is present in the incoming light. Evolutionary selection of the blue part of the spectrum for reliable functioning at any illumination and at any time of the day suggests that, apparently, the eyes of a man and animals were originally perfectly adapted to night vision.

References.