# A new approach to investigate peripheral vision: Contact lens with opaque central part

Rozhkova Galina[1], Selina Olga[2], Nikolaev Petr[1], Belokopytov Alexander[1]

[1]Institute for Information Transmission Problems (Kharkevich Institute) - IITP RAS, Lab 11 - Vision Systems

[2]Helmholtz Research Institute of Eye Diseases, Department of Contact Lens Correction

A typical paradigm for studying peripheral vision implies simultaneous presentation of peripheral test stimulus and of central fixation target to prevent involuntary turn of the eye to the peripheral stimulus. Such conditions require splitting attention between the central and peripheral stimuli thus hindering investigation of peripheral vision per se. To overcome this hindrance, we have developed an approach based on earlier attempts of Rozhkova & Yarbus (1977) to study isolated peripheral vision by means of a suction cap with opaque lid for central part. Now we employed a contact lens with opaque area in the center. Preliminary experiments demonstrated significant benefits of this technique for studying peripheral vision capabilities. At the same time, specific conditions of viewing through our lens and eye fixation could evoke some phenomena not observed in the case of usual paradigm and could complicate the analysis of experimental findings.

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# A NEW APPROACH TO INVESTIGATE PERIPHERAL VISION: CONTACT LENS WITH OPAQUE CENTRAL PART


***Galina Rozhkova, Olga Selina*, Petr Nikolayev, Alexander Belokopytov***

Institute for Information Transmission Problems (Kharkevich Institute) Russian Academy of Sciences, Moscow, Russia

*Moscow Helmholtz Research Institute of Eye Diseases, Russia

E-mail: gir@iitp.ru


## Purpose

***The purpose:***
to develop an effective and convenient techniques for studying peripheral vision and, in particular, the role of the extreme retinal periphery in color constancy mechanisms.

Until the present time, human peripheral vision is poorly investigated despite the fact that visual field area considered as peripheral is larger than considered as central. Nowadays, promotion of new technologies for training (e.g. virtual and augmented reality) and new means for optical correction (e.g. various intraocular lens) revealed the need to characterize peripheral vision more comprehensively (Simpson, 2017).

Surprisingly small number of psychophysical and psychological publications on peripheral vision indicates lack of satisfactory methods for its investigation.

A typical experimental paradigm for studying peripheral vision implies simultaneous presentation of a desired peripheral test stimulus and a central fixation target to prevent involuntary eye turn and foveation of the peripheral stimulus. Actually, this means simultaneous fulfillment of two visual tasks and, therefore, requires bifurcation of visual attention thus hindering investigation of peripheral vision *per se*.

To overcome this hindrance, we have developed an approach based on the earlier attempts of A.L.Yarbus and G.I. Rozhkova (1978) to study "isolated" peripheral vision by means of a suction cap with opaque lid for central part of the visual field. Now, instead of such uncomfortable device, we employ contact lens with opaque central part. Here, we present the results of some preliminary experiments demonstrating significant advantages of such technique.

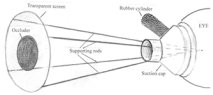
***Experimental series 1:*** Free monocular observation of surroundings in conditions of wearing contact lens with occluder.

***Experimental series 2:*** Perimetrical presentation of computer-controlled stimuli in conditions of wearing contact lens with occluder.

## Methods

### Optical devices

**Prototype**: Suction cap with occluder (Rozhkova & Yarbus, 1978)

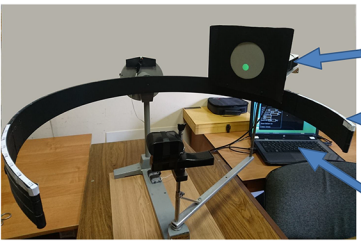


**Advantages**:
-Stable blockade of central vision and separation of desired part of peripheral visual field
-Absence of prohibitions on voluntary eye movements

**Shortages**:
-Limited area of the peripheral visual field accessible
-Impossibility of investigating far periphery
-Limited duration of experiments because of uncomfortable conditions of viewing

### Experimental set up

Upgraded standard perimeter with extended arcs and movable LED-projector

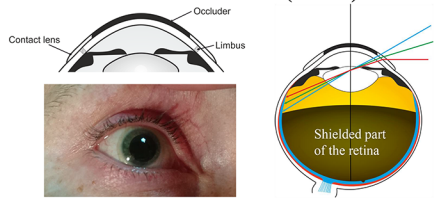


LED –Projector Optoma ML750ST

Perimeter

Computer for control of the stimulus parameters

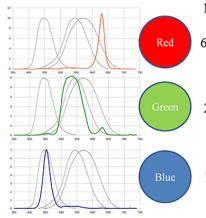
### A new approach: contact lens with implanted central occluder (CL+O)




Visible part of the visual field had size and shape depending on the occluder diameter and the pupil size. Visible diameters of occluders: 8, 10 and 12 mm; the pupil size depended on light conditions. Typical diameter of cornea was 11-12 mm.

**Experimental conditions and stimulus parameters**

Ambient illumination: 300 lx; 20 lx
Viewing distance: 33 cm. Stimulus size: 1 cm; 2 cm
Mode of presentation: stimulus duration 1,5 s / 1,5 s blank
Spectral characteristics of the displayed stimuli:

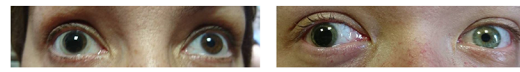



Stimulus brightness, size and shape can be varied by means of proper software.

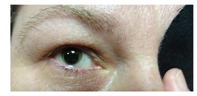
### Subjects

5 adults 28-74 yo

2 females 3 males



Preparation to the experiment.
Contact lens with 8 mm-occluder is placed on the right eye of Subject P.N.



Subject T.E. with contact lens on her right eye and black cover on her left eye

**Subject's task** was always one and the same: to describe perceived shape, color and sharpness of the stimuli presented at some peripheral area of his/her visual field (60-95°)

## Results

***Experimental series 1***

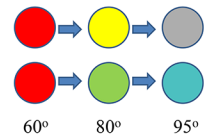
In the experiments with CL+O, the perceived sharpness of the peripheral stimulus contours appeared to be good enough up to 80° and better than in similar experiments with gaze fixation. The quality of perceived visual image depended not only on physical parameters of the test-object but also on its familiarity to the subject. For each subject, the visual image of his/her palm was close to normal barring low-contrast details and low saturated colors, i.e. the visible images of palms have adequate shape and sharp contours but were grey instead of pink and lacking fine texture. The subjects could recognize rather small but familiar objects and cloths with distinct patterns.

***Experimental series 2***

It has been found that vivid red, green and blue colors can be perceived at the periphery of the visual field as far as 95°, at least. These data extend farther to the extreme periphery the data of Tyler (2015) who created a demo to support the view of rather good color vision at the periphery up to 50° for sufficiently large and bright stimuli scaled with eccentricity (taking into account morphology). The appearance of the stimuli having invariable intermediate size and brightness underwent regular transformations with eccentricity and ambient illumination level. Wearing CL+O could change these transformations significantly indicating the influence of the balance between illumination of the extreme periphery by scattered light entering the eye through pupil, on one side, and through the eye ball tunics, on the other side.

*Typical transformations of the red stimulus described by many authors and also observed in our experiments*

*Unusual transformations observed in certain experiments with CL+O. These data correlated with changing Yarbus' color coordinates: $ln(r/r_a)$; $ln(g/g_a)$; $ln(b/b_a)$, where $r_a$, $g_a$, $b_a$ – responses of the extreme periphery to the scattered light coming to photoreceptors through the pupil and eye tunics, the second component being more reddish*




## Conclusions

**In natural viewing conditions,** CL+O technique makes the task of gaze fixation unnecessary and facilitates study of peripheral vision capabilities due to excluding bifurcation of visual attention and possibility to carry out prolonged experiments.

**In perimetric experiments,** shielding a large central area of the visual field by means of CL+O technique leads to decrease a tendency of turning the viewing eye to the peripheral stimuli and guarantees eccentricity of stimulus location not less than that of the occluder edge.

**In studies of blind peripheral retina contribution** to assessment of ambient illumination for color constancy mechanisms, CL+O helps vary the balance between the amounts of light entering the eye through the pupil and through the eye tunics.

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