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Physics and neuroscience synergy in visual analysis

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Summary. — A branch of physics named geometrical optic gave birth to Optometry, the science that measures visual function. Even if this physical approach is still essential not all clinical results of visual function can be explained just with physical formulae. More recently the scientific community has started to consider neuroscience as a new method to explain some visual conditions. Aim of this review is to collect some papers to prove the requirement of an interdisciplinary approach to visual functional problems.

1. – Physical approach to visual problems

Optometry goal is to measure visual function with repeatable and affordable tests. The main functions measured are visual acuity, contrast sensitivity, accommodation, binocular cooperation and ocular motility. To establish the best way of measuring eye abilities the eyeball has been considered as a photocamera with correspondence between retina and film, cornea and external lens, intraocular accommodative lens and zoom lens. Each eye structure is considered in a certain measurable position between the anterior and the posterior structure. In this way is possible to predict and calculate the light path into the eye to the retina. Well known is the contribute of Gullstrand to schematize the eye with more recent modified versions (fig. 1) [1].

This kind of approach allows to estimate visual defects when light path does not converge exactly on the retina. In particular is called myopia the condition of light focusing on a position anterior to the retina and hyperopia the condition of light focusing on a position posterior to the retina. In case of astigmatism defect two different focal points are present and each one can be anterior or posterior to the retina (fig. 2).

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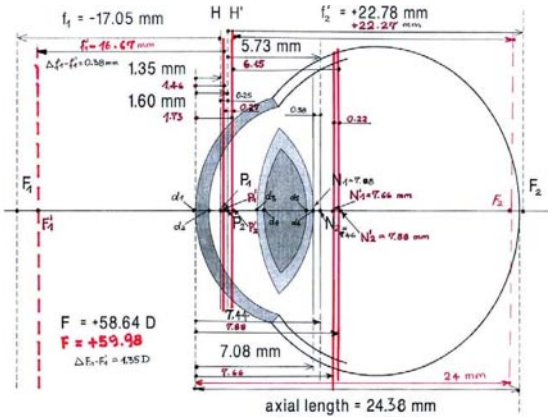

Fig. 1. – Modified Gullstrand schematic eye. Each eye structure is considered to be in certain predictable position among the other eye units.

2. – Neuroscience approach to visual problems

Phenomena like optical illusion are out of the physical objective measures. For example human beings perceive color and luminance considering the characteristics of the surroundings, while instruments capture the amount of radiation reaching them (fig. 3) [2]. The brain tend to interpret figures filling the space to form objects that it is used to see and recognize, like in fig. 4 [3].

Also the way we perceive binocularity and stereopsis is not fully understood, nowadays scientist are proposing different theories about it [4]. The visual pathway beyond retina involve a lot of areas of the entire brain. Visual information are necessary not only for perception tasks but also for motor tasks [5]. Some brain areas involved are talamic nuclei, occipital cortical area, superior culliculi, cerebellum, inferior parietal cortex, temporal cortex, frontal and prefrontal cortex. Most of these areas are also involved in others brain function, for instance audition and equilibrium, object recognition, proprioception and motor program. An intervention on visual system makes the brain rewire his way of work.

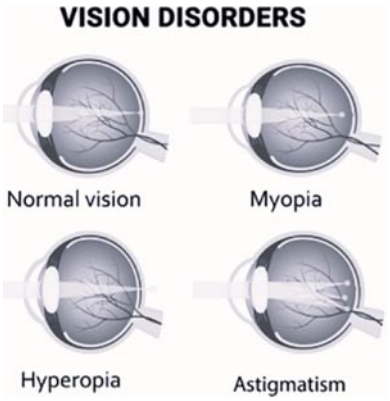

Fig. 2. – Visual defects schema.

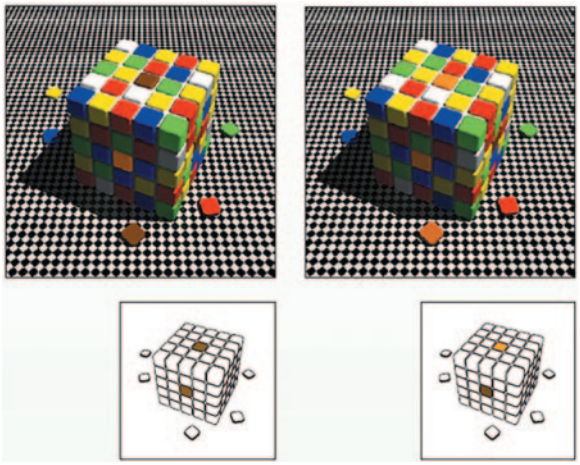

Fig. 3. – Color optical illusion. The perception of color tone depends on the surrounding information.

Fig. 4. – Illusory contours. The brain recognizes simple shapes like a triangle or a square even if they are not really present.

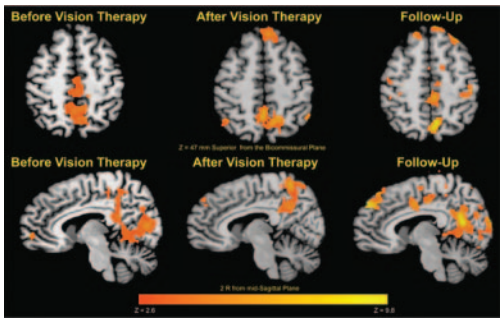

Fig. 5. – fMRI. Brain function changes after convergence insufficiency treatment.

For example some vision therapy programs can change the brain and the functional magnetic resonance can confirm that (fig. 5) [6], or occlusion treatment combine with physical activity can improve amblyopia also in adults [7], not to underestimate the interaction between vision and stomatognathic system. Different papers have established the correlation between ocular disorders (ametropias exophorias, ocular convergence difficulties) and dental occlusion even if is still to confirm the cause-effect relationship [8, 9].

3. – Conclusion

In conclusion it is important to consider optometry and vision from physical and neuroscience point of view to better understand appearance and variability of vision disorders. Interdisciplinary work with different specialist may help to find the cause and set up the best treatment of non-pathological vision problems.

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