Medicine Papers, 2015, 1 (1–4): 13–16

Role of the refractive errors during growth

RAFFAELLA MORREALE BUBELLA

PhD MD Ophthalmology Clinic, Department of Experimental Biomedicine and Clinical Neurosciences, University of Palermo, via L. Giuffrè 13, 90127 Palermo, Italy

Summary

Vision defects, including both refractive and motor errors encountered during growth, can significantly slow down, delay and jeopardize, more or less deeply, the physiological development of the individual, representing a handicap, even substantial, that the individual will always carry during his life. Therefore, an early diagnosis of visual disturbances is necessary.

Key Words

Refractive errors; growth; early diagnosis; visual perception; amblyopia.

Received 24.05.2015; accepted 09.08.2015; printed 30.11.2015

Introduction

Living beings interact with their surroundings and with others through sensitivity, the ability to respond to external and/or internal stimuli due to sensors. All the data coming from exteroceptive sensitivity (informations from the outside world), interoceptive sensitivity (informations from our body), proprioceptive sensitivity (spatio-temporal informations from the outside world) and specific sensitivity (the sensitivity of sense organs) are sent to the upper areas of the CNS. The gathered data are elaborated and integrated to allow good posture and a correct motility in the surrounding spaces, on one side, and to allow the specific and fruitful exploration of the adjacent and distant space on the other.

Visual perception, a physiological and psychological complex process, is crucial. It consists of the uptake of visual stimuli from light sensitive receptors (cone cells and rod cells) coming from the ocular dioptre (cornea, crystalline lens, etc...). Then, signals go through the visual pathway to the upper cerebral centres for their interpretation and integration with the psychological component, allowing a unique mental impression, which is the real visual language.

The importance of the visual function stands out because, within all the specific sensitivity, it gives more than 80% of necessary information to allow every organism to develop properly and interact in a more pertinent and complete way to external stimuli.

Considered this, it can be seen how defective vision, including both refractive and motor errors, encountered during growth can significantly slow down, delay and jeopardize more or less deeply the harmonius development of the individual. It could represent a handicap, even substantial, that the individual will always carry during his life (Morreale et al., 2006).

Discussion

The alterations of the harmonious visual function during this delicate moment of life can make it difficult to develop correctly the brain regions responsible for vision, causing a permanent and penalizing visual deficiency. This happens because vision is not an innate function. It gradually develops during the first years of life, improving and strengthening itself via visual experience. There are specific stages of maturity of the anatomical development with formation of appropriate synaptic connections. Even if it is true that the organ eye starts to develop near the 7th week, it's also true that, differently from the other organs, the eye has also a postnatal development, since it needs adequate visual stimuli. During this time, also called “time window”, the brain isn't receptive to the information from the outside world. Consequently, experience plays a key role in the development plan. It's during this period that the development and the coordination of the eye movements associated with the development and the reorganisation of the fovea allow the completion of the visual acuity and the binocularity. The direct effect is the formation of stereopsis, contrast sensitivity and the multichromatic perception of the surrounding reality.

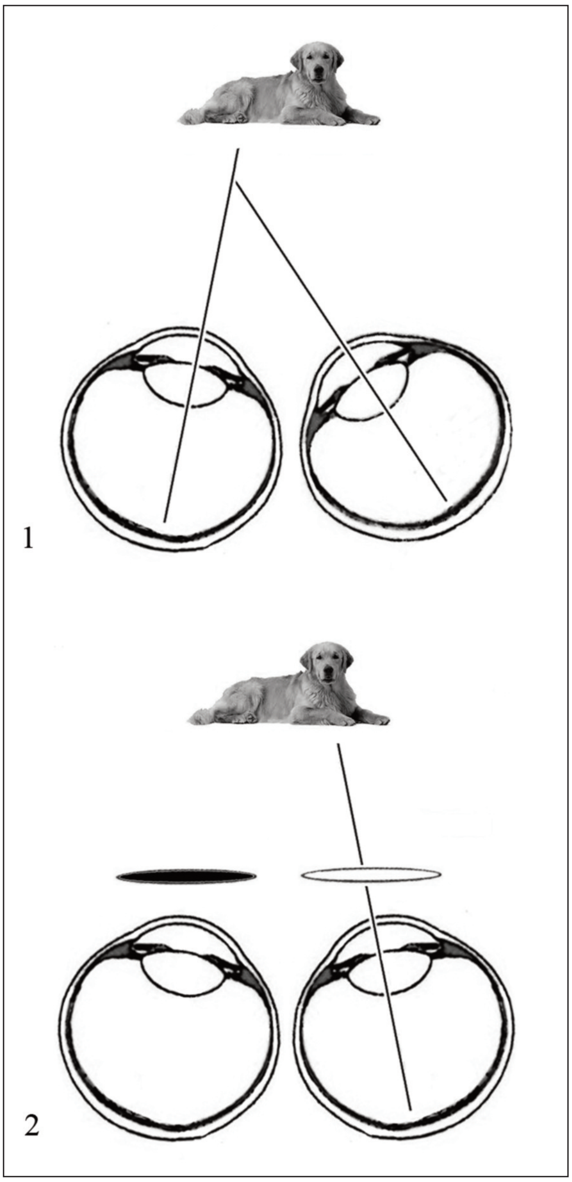

Figura 1. With the amblyopia, the child will not have a binocular vision, jeopardizing the tridimensional vision. Figure 2. The most common treatment is usually performed at an early age (before age 6) and consists in the occlusion of the eye that sees well (bandage).

At birth the newborn is hyperope, doesn't have accommodation and the field of vision is considerably limited, just like visual acuity, approximately quantified as 1/20 (0.5/10).

During the first year of life, also called “critical period”, there is the anatomical and functional development of the fovea followed by the strengthening of the dominance columns in the cortex. In particular, in the first months of life, subcortical structures like the brain stem, the thalamus and the sensorimotor cortex mature. The visual cortex areas, strictly related to the stimulus, start the anatomical and functional development later and advance slowly, just like the frontal regions.

Visual stimulation perceived by the baby is needed to augment even more visual ability via the strengthening and the expansion of adequate synaptic connections. During growth after the critical period follows the plastic period that lasts from 1 to 10–11 years. During this period of time, interactions with the environment are essential to complete in a proper and individual-specific way the stabilisation of the neural circuits responsible for vision control.

If the sensory afferents are inadequate or altered, there will be sensory deficits more or less severe with a disharmonious and not balanced development of the visual sensory system.

The damaged and limited visual function can be restored with a correct and timely therapeutic and rehabilitative aid.

The missed identification of a serious refractive error in the plastic period can bring to the appearance of an amblyopia, namely a permanent and severe visual deficit.

Amblyopia, from Greek αμβλυωπία = "blunt vision", is a reduced visual acuity in an eye, seldom in both. Amblyopia doesn't show anatomical alterations clinically visible. Because of this, it's not unusual eluding the subject and the parents' attention. The child will not have a binocular vision, jeopardizing the tridimensional vision. An early diagnosis and the following treatment can prevent any permanent damage to the visual function (Figs. 1, 2).

It must be stressed that the amblyopia begins to develop only during the critical or the plastic period. After the visual system is developed, any impediment to the vision is not able to modify anymore the already strengthened anatomical-functional structure.

Just like in adult subjects, the refractive errors that can develop during growth are hyperopia, myopia and astigmatism. Anisometropia can be added to the list, making an uncomfortable amblyopia more pronounced, both for the cognitive and motor abilities. Ibironke et al. (2011) point out that children 6 to 71 months of age with general development problems, both motor or memory-related, showed some types of refractive errors, like astigmatism ≥ 1.50D and anisometropia ≥ 2.00D. To confirm the role of these visual deficiencies, development delays in this age range were absent when there were types of refractive errors like myopia. This because the distance of exploration of these little individuals was covered by the visual acuity - allowing the exploration of the world on which the subject is focused. It's essential for the development and the maturation of the visual organ and the corresponding cortex areas (Williams & Holmes, 2004; Atkinson et al., 2005; Friedman et al., 2009).

The role of eye problems during growth seems to be indipendent from socio-economic conditions (Cruciani & Rinaldi, 2005).

The few existing studies in literature make clear that in the Italian population, eye problems during growth have a homogeneous territorial distribution, independently from the socio-economic conditions. It appears that there are not statistically substantial differences between wealthy regions (Tuscany, Lombardy) or more economically depressed (Calabria and Sicily).

Conclusions

From what said up until now, an early diagnosis of visual disturbances, associated or not to the ones of the ocular motility, is necessary. To intervene promptly and efficiently to correct said disturbances, allowing since the first months of life a harmonious, correct and complete development of the eye and body. The alterations of the refraction and of the ocular motility disturbances, mainly heterophoria, could cause not only asthenopeic disturbances, but also postural ones hardly correctable at an older age.

In a recent multicenter research (Gori et al., 2015), finally, it was shown for the first time that the perception of illusory motion, specifically developed by the magnocellular - dorsal pathway, is damaged in children with developmental dyslexia, when compared to typically developing children of the same age, or to children with the same reading skills (therefore of smaller age).

This comparison is important because excludes that such visual impairment is the simple result of the lower reading skills characterizing dyslexia. This has put an end to a thirty year-old controversy proving the existence of a causal link between the visual deficits affecting the magnocellular-dorsal pathway, prevailed prior to the acquisition of reading, and dyslexia.

It has been highlighted, in fact, that:

- in children with dyslexia, the perception of motion is reduced in comparison with either children of the same age or with controls with the same reading skills;
- the visual-motor perception of pre-reading is independent of the auditory-phonological skills and predicts the future development of reading skills;
- training aimed at stimulating the magnocellular-dorsal pathway by no auditory-phonological stimulation determines a better reading skills in children and adults with developmental dyslexia;
- magnocellular-dorsal pathway dysfunctions can be diagnosed well if before the age at which they can provoke reading and language disorders.

All this may lead to the use of prevention strategies through stimulation of the magnocellular-dorsal pathway by means of proper video games that could drastically reduce the incidence of developmental dyslexia.

In conclusion, visual function in its various outward expressions, functional and perceptive, must be studied and stimulated early to allow the proper processing of the outside world and avoid not only sensory deficits but also specific learning disabilities as dyslexia.

References

Atkinson J., Nardini M., Anker S., Braddick O., Hughes C. & Rae S., 2005. Refractive errors in infancy predict reduced performance on the movement assessment battery for children at 3 1/2 and 5 1/2 years. *Developmental Medicine & Child Neurology*, 47: 243–251.

Cruciani F. & Rinaldi A., 2005. Campagna "Vediamoci chiaro". Indagine sulle condizioni di salute oculare nella scuola materna e dell'obbligo. *Oftamologia Sociale*, 1: 6–19.

Friedman D.S., Repka M.X., Katz J., Giordano L., Ibironke J., Hawse P. & Tielsch J.M., 2009. Prevalence of amblyopia and strabismus in white and African American children aged 6 through 71 months the Baltimore Pediatric Eye Disease Study. *Ophthalmology*, 116: 2128–2134.

Gori S., Seitz A.R., Ronconi L., Franceschini S. & Facoetti A., 2015. Multiple Causal Links Between

Magnocellular-Dorsal Pathway Deficit and Developmental Dyslexia. Cerebral Cortex, doi: 10.1093/cercor/bhu234

Ibironke J.O., Friedman D.S., Repka M.X., Katz J., Giordano L., Hawse P. & Tielsch J.M., 2011. Child development and refractive errors in preschool children. *Optometry and Vision Science*, 88: 181–187.

Morreale R., Di Giovanna F., Carità S., Firpo V. & Morreale D., 2006. Prevenzione dei disturbi visivi e qualità della vita. Risultati di uno studio epidemiologico sulla popolazione scolastica di un comune della Provincia di Palermo. *Oftalmologia Sociale*, 4: 23–27.

Williams J. & Holmes C.A., 2004. Improving the early detection of children with subtle developmental problems. *Journal of Child Health Care*, 8: 34–46.