Puzzle as assistive technology for early visual stimulation.

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Abstract. The objective of the study is visual stimulation through methods that result positively in the visual development of children who have visual impairment or low vision. The project will be developed in the Laboratory and Innovation in Health Technology (LITS) of the Department of Ophthalmology and Visual Sciences at Escola Paulista de Medicina (EPM), Universidade Federal de São Paulo (UNIFESP) using 3D printing.

Keywords. Visual Impairment, low vision, early visual, visual stimulation, 3D printing.

1. Introduction

Vision is one of the main senses of human beings, mainly because it allows the detection and identification of stimuli at a distance and with grand precision. In addition, vision is the most integrating sense that humans beings have; therefore, any alteration during its development can affect all aspects of a child´s socialization since gestures and social behaviors are learned through visual feedback.[1] [2]

The sensory system of the eye is composed of neural elements, basically organized as the retina - where light is captured and transformed into an electrical signal - and transmitters of this electrical signal to the ganglion cells (whose axons form the nerve, the chiasm and the optic tracts - elements of the visual pathway).[3]During this period, due to constant anatomical changes, there is a gradual maturation of visual functions; due to the immaturity of the cortical structures necessary for good visual acuity (ability to recognize details of an object in space)4, infants have this reduced visual function; moreover, for example, it is only around one or two months of age that the newborn begins to fix his gaze on objects and people.[2]Only at two years old, it becomes possible to distinguish objects, recognize people, have notions of distances. At 4 years old, the child has normal visual acuity and binocular Visual development begins in the prenatal period, still in the thirtieth week of gestation, and ends around the age of ten.[2]

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For the vision to be developed correctly, the child needs to see, that is, his visual system needs to be stimulated. Otherwise, this does not happen, leading to low vision in the child. Obstacles (anatomical and/or physiological) to visual development can occur in any of the three components of the visual system: optical (diseases such as congenital cataracts), retinocortical (problems in the basic processing of visual information) or in the integrative system (problems in assigning meaning to processed visual information).[2]

Although visual development occurs until the age of 10, there is a so-called visual critical period, which is the period where brain plasticity is high. This period goes from birth to five years of age, with its peak occurring around two years of age and tending to decrease.[2]

1.2 Visual impairment

According to the World Health Organization (WHO), visual impairment is divided into 4 groups (in terms of visual acuity):5

- Mild: visual acuity worse than 20/40;5
- Moderate: visual acuity worse than 20/60;5
- Severe: visual acuity worse than 20/200;5
- Blindness: visual acuity worse than 20/400.5

The "moderate visual impairment" and "severe visual impairment" groups comprise what is called low vision. Low vision is a clinical definition that refers to a partial loss of vision in which the bearer uses resources that promote visual efficiency, within the residual vision he presents.[5]

Globally, it is estimated that approximately 1.3 billion people are visually impaired; of these, 217 million have low vision and 36 million are blind. Approximately 80% of these cases would be preventable.[5]

The main causes of visual impairment in the world are: uncorrected refractive errors, cataracts, age-related macular degeneration, glaucoma and diabetic retinopathy. In addition, blindness is also related to countries with low rates of HDI (Human Development Index).[5,6]

In Brazil, the last census carried out by the Brazilian Institute of Geography and Statistics (IBGE) in 2010 indicated that, at the time, 35,774,392 people (15.8% of the population) had some degree of visual impairment.[7]

Among the main causes for visual impairment in Brazilian adults are retinal diseases, such as diabetic retinopathy, age-related macular degeneration and retinal detachment.[8]

1.3 Visual impairment in childhood

In 2010, a global estimate was made that indicated that 37,878 children (from 0 to 14 years old) had some degree of visual impairment, within a population of 184,850 children. Of these children, 17,518 had low vision and 1,421 were blind.[9]

In Brazil, according to the last census carried out by the IBGE (2010), 842,755 children aged 0 to 14 years had some degree of visual impairment.[7]

As in the rest of the world, the leading cause of visual impairment in childhood is uncorrected refractive errors, followed by amblyopia and retinal diseases such as retinopathy of prematurity. Many children are born blind or acquire the condition in the first year of life, and around 40% of all cases of childhood blindness could be prevented.[6,8]

Teachers are often the first to detect problems related to vision, which, even at school age, often go unnoticed by guardians and caregivers of children.[6]

Visual impairment, especially in children, generates many negative consequences, such as difficulty in school learning, low self-esteem, difficulty in social integration, in addition to problems in the development of other systems. In addition, visual impairment also brings financial losses to the State.6

Thus, considering these negative consequences and the period of brain plasticity, the diagnosis of eye diseases and therapeutic intervention should be carried out as early as possible, contributing to the proper development of children with visual impairment.[6]

1.4 Early Visual Stimulation

It is a set of therapeutic and educational procedures, recommended for children with low vision. These procedures aim to enable the maximum use of the child's residual vision, in order to prevent or minimize losses in neuropsychomotor, cognitive and social development.[10]

Children born prematurely or with a congenital disability may have visual problems (including low vision) due to poor development of the visual system. Thus, it is necessary that this visual system be stimulated in an appropriate way so that it meets the needs of the child, including the development of other functions of the human body.[10] Children who have low vision may also have problems with balance. To correct this condition, the correct way is inner ear stimulation from the first months of life.[10,11]

This stimulation can be done by the interaction between the baby and objects, such as toys, however not any type of toy or other object, but those that meet the necessary requirements for the child's visual development in its different stages.[10] In addition, it is not enough just to present these objects to the child, it is necessary that the lighting of the environment is adequate, so as not to jeopardize their habilitation process (for example, in children with intense photophobia).[10]

This is a job carried out by a multidisciplinary team, involving occupational therapists, nurses, psychologists, physiotherapists, in addition to the family members themselves, who are instructed to perform some tasks, in order to extend the stimulation environment to their homes as well.[12]

1.5 Electronic toys used for early visual stimulation

The early visual stimulation technique that uses mechatronic toys to assist in the development of children with visual impairment has very efficient results in pedagogical and neuromotor aspects, since, according to their different characteristics, they can adapt to the needs presented by children. [13,14]

The act of playing helps children in the various segments of child growth, such as cognitive, physical and psychosocial. [14]
In this way, the use of different textures, shapes and colors can represent an important gain in the process of qualifying children with low vision or other disabilities. They could be used to stimulate the different senses.[10]

Despite the possible advantage offered by them, electronic toys for early visual stimulation still have little space in the industry. [14]

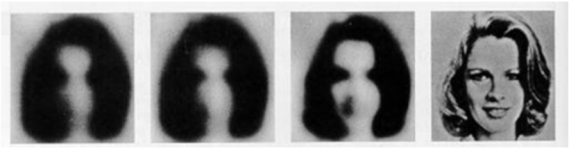
In the early years, where children are learning many of their skills, such as hand-eye coordination, it is important that the objects presented to them are large, colorful and bright. Large, as they can be seen easily by children; bright, as they present the best possible lighting; and colorful, as they present good contrast between their pieces.[15]

In addition to these characteristics, it is important to consider some factors when offering and/or developing objects for this purpose: the paint used must not be toxic, the components of the objects must be of a size that does not allow the child to put himself at risk by handle them, in addition to the age, need and interest of the child in certain objects.[15]

When newborns, objects with simple shapes, such as squares, circles, are preferred by children. As the eye tracking system is also not fully developed at this time, it is important to present these objects at different points in the child's visual field, such as side to side, slowly, to stimulate this function as well.[15] Presenting colorful objects/clothes (red, orange, fluorescent), shiny, or with interspersed black and white stripes, mirrors, all approximately 6 to 8 inches, are desirable options for visual stimulation of newborn children as well.[15]

From two to four months, it is important that the objects presented increase in size, from 12 to 15 inches, but remain bright and colorful. From three to five months of age, objects that emit sounds are suitable for the child's stimulation. From 12 to 15 months, toys that allow you to assemble small towers are ideal for stimulation in this age group. From 15 months to 2 years, toys that allow pushing and pulling, such as carts or the like, or toys that represent animals.[15]
In this way, the development of electronic toys can help even more in the child's stimulation process, since it can allow the stimulation of other senses, not only vision, but hearing, kinesthetics, etc. [13.14]

2. Figures



Child visual acuity ('timeline') Source: Kaufman, Paul L., A. Alm, and Francis Heed Adler. 2003. Physiology of the Adler eye: clinical application. St. Louis: Mosby.[16]

Caption: Figure 1 shows the evolution of human visual acuity, from 1 month of age to adulthood – 1 month, 2 months, 3 months, adulthood.

3.Research Method

The project will be developed in the Laboratory and Innovation in Health Technology (LITS) of the Department of Ophthalmology and Visual Sciences at Escola Paulista de Medicina (EPM) – Universidade Federal de São Paulo (UNIFESP).

3.1 3D printing

The study of techniques and technologies that are necessary for the 3D printing process will be carried out so the necessary skills for making the toy parts can be carried out.

4.Expected Results

It is expected that a prototype of a toy (puzzle) "puzzle" in 3D printing will be produced to be used as Assistive Technology in EVP.

It is expected the toy can stimulate vision and helps the development of the vision.

It is worth mentioning that tests for validation in humans will not be carried out. Only bench tests will be carried out, during the prototyping process, to verify the operation.

5. References

[1] Lent R., *One hundred billion neurons*. Rio de Janeiro: Atheneu; 2010

[2]Graziano RM; Leone CR; *Most frequent ophthalmologic problems and visual development in extreme preterm infants. Pediatric Journal*- Vol. 81, No. 1 (suppl.), 2005;
[2] Nakanami CR; Zin A; Junior RB; *Ophthalmopediatrics*. São Paulo: Roca; 2010;

[3] Bruno OM, Carvalho LA. *Optics and physiology of vision*. São Paulo: Roca; 2008;

[4] *Comparison between self-reported quality of vision and visual acuity in a low-income elderly population in the city of São Paulo.* Vol. 69, Brazilian Archives of Ophthalmology. 2006. p. 17–22;

[5] *World Health Organization. Blindness and visual impairment* [Internet]; [updated on 10/11/2018, cited on 9/20/2018]. Available at <http://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment>;

[6] Ávila.M;Alves MR; NishiM; *Ocular health conditions in Brazil; Brazilian Council of Ophthalmology* ISO 9001; 2015;

[7] *Brazilian Institute of Geography and Statistics* [Internet]; [updated on 04/2018, cited on 04/24/2018] Available at IBGE<http://downloads.ibge.gov.br/downloads_estatisticas.htm>;

[8] Solomon, Sr.; Mitsuhiro, MRKH.; Belfort Jr., R. *Visual impairment and blindness: an overview of prevalence and causes in Brazil Anais da Academia Brasileira de Ciências*, vol. 81, no. 3, September, 2009, pp. 539-549 Brazilian Academy of Sciences Rio de Janeiro, Brazil;

[9] *Global estimates of visual impairment*: 2010. Vol. 96, British Journal of Ophthalmology. 2012. p. 614-618;

[10] Sá F.E; LMPC fleet; Bezerra SC; Almeida AKF; Firmino ALP; *Sensory-Motor Profile of Children with Low Vision Assisted in the Sector of Visual Stimulation of NUTEP*; Rev Fisioter S Fun. Fortaleza, 2012 Jul-Dec;

[11] Estele CWM; Luiz FCL; Gabriel IP; Rudy FA; Clarissa ST; Carlos BM; *Visual impairment: a review focused on postural balance, psychomotor development and interventions*; R. bras. Ci. and Mov 2011;19(1):108-113;

[12] Gagliardo GRGH; Noble MIRS; *Early Intervention in Children with Low Vision*; Rev. Neurosciences 9(1): 16-19, 2001;

[13] Silva RS; Silva PR; Batista VJ; *Development of toys for visually impaired children: a case study*; ISSN 2179-7374 Year 2014 – V. 18 – No. 02;

[14] Silva RS; Silva PR; *Study on the development of the toy project: focus on the visually impaired child*; ISSN 2179-7374 Year 2014 - V.18– N0. 02;

[15] Vykuntaraju KN. *Early Stimulation. In: Cerebral Palsy and Early Stimulation*. New York: Jaipee; 2014. p.183-204.

[16] Kaufman, Paul L., A. Alm, and Francis Heed Adler. *Physiology of the Adler eye: clinical application. St. Louis: Mosby;* 2003.