UNIVERSITY OF LATVIA
FACULTY OF PHYSICS AND MATHEMATICS
DEPARTMENT OF OPTOMETRY AND VISION SCIENCE

EFFICIENCY OF VISUAL ACUITY TRAINING

BACHELOR THESIS

Author: **Angela Fersino**
Student card number: af15003
Supervisor: Docent, Dr. phys. Gatis Ikaunieks

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ANOTĀCIJA

Bakalaura darbs ir uzrakstīts angļu valodā uz 27. lappasspusēm, satur 12 attēlus, 1. tabulu un tajā ir atsauksmes uz 21. literatūras avotu.

Darba mērķis ir novērtēt redzes asumu uzlabojošo treniņu efektivitāti. Viens no iemesliem pazeminātai redzei var būt palielināta tuvuma slodze, kā arī pazeminātas spējas veikt dažādus vizuālos uzdevumus. Trenējot šīs spējas, redzes sistēma labāk pielāgojas palielinātai tuvuma slodzei.

Pētījumā piedalījās 24 bērni, kuriem tika doti dažādi redzes treniņi 3 mēnešu periodā.

Redzes asums treniņu beigās būtiski uzlabojās ($p<0.0001$), salīdzinot ar treniņu sākumu. Vidējais uzlabojums bija 0,19 logMAR vienības. Dalībniekiem ar miopiju ametropijas lielums treniņu beigās būtiski samazinājās.

Atslēgas vārdi: redzes asums**,** redzes treniņi, redzes stress, akomodācijas spazmas

ABSTRACT

The Bachelor thesis is written in English on 27 pages. It contains 12 figures, 1 table, and 21 references.

The aim of this research is to assess how effective are visual training for visual acuity improvement. One of the causes of the lowering of VA could be proximal visual stress associated also with low-quality general visual skills. By improving visual skills, the visual system will be more fluid and flexible to support the proximal work required by study /work.

Different visual tasks were given for 24 children during 3 months period.

Visual acuity after training was significantly better ($p<0.0001$) comparing with acuity values before training. The average improvement was 0.19 logMAR units. Optical refraction for myopic subjects after training significantly reduced.

KEY words: visual acuity**,** visual training, visual stress, accommodative spasm

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INTRODUCTION

The stress is the complex of phenomena that gives the start to a reaction of defense of the body. It represents the set of specific reactions that the body develops under the stimulus of factors that tend to modify the habitual environment and jeopardize homeostasis (Forrest 1993).

The studies of Birnbaum lead to deduce that many refractive variations and many disorders of the accommodation and the convergence have been attributed to proximal visual stress and explained as an adaptation processes developed by the organism in order to reduce discomfort during proximal activities. Altered visual conditions are functionally seen not as primary problems but as adaptive secondary changes to the proximal stress induced by over-convergence (Roncagli, 1996).

Several studies have shown that visual training leads to neuronal modifications and neuronal improvements, thus indicating the presence of cerebral plasticity. In visual function, cerebral plasticity is present independently of age. (Polat et al., 2004).

Very often the visual conditions are negatively affected in population; the visual conditions that are easily damaged are visual acuity degradation, loss of stereopsis, ocular motor palsy dysfunction, inadequate binocular fusion, and visual-motor integrative skills (Benjamin, 1970).

Visual function plays a fundamental role in the rehabilitation process. (Godnig, 2001).

Visual training is the set of visual exercises most often used by optometrists with the aim of improving visual efficiency (Harris, Emptage & Lum, 2013).

During my work more and more school-aged children showed difficulties in achieving a good level of VA. When refractive evaluation, I noticed that VA only improved one or two extra lines, arriving hardly at 0.10 logmar. The subjects needed something different than a new pair of graduated glasses. I thought about proposing visual re-education before choosing or assessing whether they really needed to wear new glasses.

So I thought about studying the changes of VA that could have received the eyes if trained and educated.

The aim of my research was to assess how effective are visual training for visual acuity improvement in different subjects in the absence of pathology.

Tasks

1. To compare visual acuity values before and after visual acuity trainings.

2. To find out is there a correlation between visual acuity values before visual training and improvement in visual acuity after trainings.

3. To find out are there changes in optical refraction after visual acuity trainings.

Here has been investigated a new method of general visual skills training as a treatment for enhancing VA. The visual training procedures used to improve the overall visual skills were, monocular jumps accommodative near and far with chart, purses Marsden ball, saccades strips for saccadic movements, Brock string.

The treated children experienced significant improvements in VA in three months, organised with six session meetings and also 10 minutes of work at home everyday.

1. REVIEW OF LITERATURE

1.1. Types of visual acuity

Visual acuity

The detection of visual acuity (VA) is one of the starting points for the visual function evaluation.

When we evaluate VA, we consider the resolving power of the foveal area and this area is influenced by refractive errors, retinal and optic pathway diseases and opacity of optical media.

The detection of VA is used not only for the evaluation of refraction, but it is also used by various experts in order to monitor the state of the visual function or the evolution of diseases, comparing the values before and after. Therefore, it is necessary to use the same criteria. (Ricci et al, 1997)

Visual acuity indicates the ability of the eye to discriminate the smallest visual angle.

There are several types of VA (see Fig. 1.1.):

- Acuity detection: the smallest point or the thinnest line that can be seen on a brighter or darker background.
- Location accuracy: Move visible position smaller than a point or line relative to another point or line.
- Acuity resolution: the smallest space between points or lines that can be seen. If it is a set of parallel lines, it is called grating resolution .
- Letter or optotype acuity: smaller letter or other object that can be correctly identified. and it is related to the acuity of the resolution.

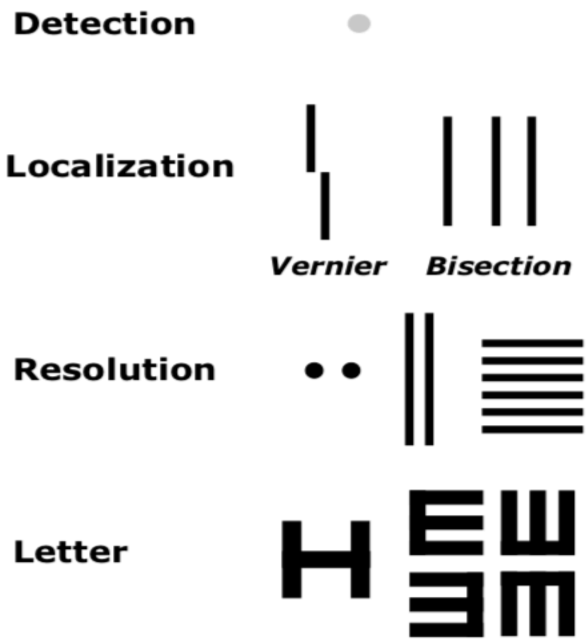

Fig. 1.1. Types of visual acuity[1].

For the relief of the distant VA, optometry tables are used, positioned between 4 and 6 m far from the subject. The optotypes may consist of letters of the alphabet, numbers, symbols, E of Snellen or Albini or the rings of Landolt.

VA can be expressed in MAR , LogMAR = $\log_{10}$(MAR) ,Snellen: 20/ (20 x MAR) , or 6/(6 x MAR) ,Decimal = 1/MAR

For example, if MAR is 10 arc minutes LogMAR = $\log_{10}(10)$ = 1.0 Snellen = 20/200 or 6/60 Decimal = 1/10 or 20/200 = 1

The expression of VA in Snellen is the most used format (in all English-speaking countries.). It is based on the requirement that a subject with normal recognition acuity can solve an optotype with a visual angle of 5 and a resolution (stroke) angle of 1 (arc minute).

"The V.A. level is expressed as the ratio between the reading distance and the distance in meters in which the stroke width of the equivalent Landolt ring subtends 1 minute of arc:" (Ricci et al., 1997).

The charts for visual acuity measuremen have been prepared following standardization guidelines, to improve ETDRS charts (see Fig. 1.2. and Tab. 1.1.).

[1] https://www.opt.uh.edu/onlinecoursematerials/stevenson-5320/L08Acuity.pdf

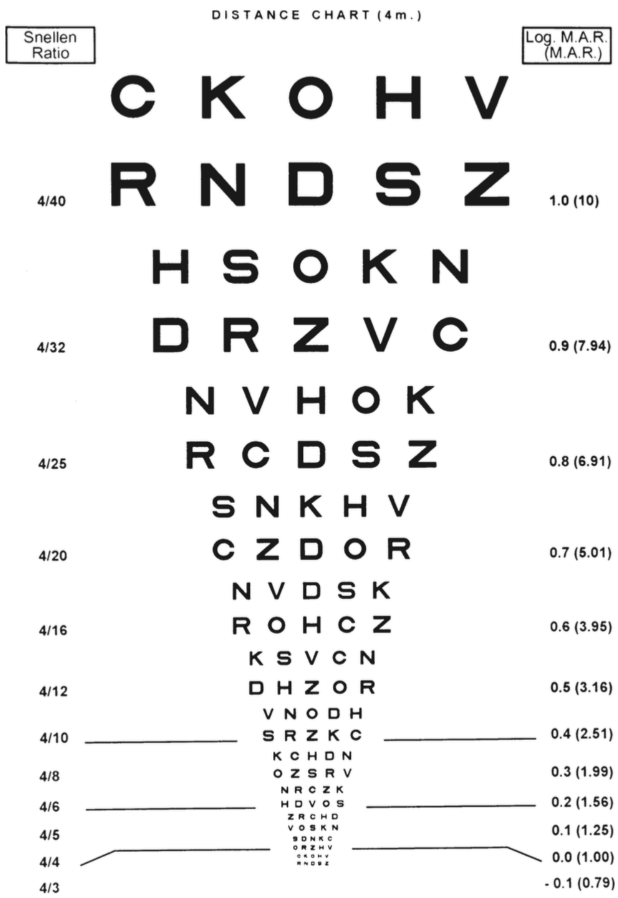

Fig. 1.2. LogMAR type chart

Table 1.1.

Conversion table (sizes in steps of 0.1 log unit taken standardized measurement of visual acuity (Ricci, 1997)

Equivalent Snellen Ratio	*Snellen Ratio (centimeters)*	*Snellen ratio (inches)*	*Decimal acuity*	*Log.MAR*	*Sloan M system*
4/100	40/1000	20/500	0.04	1.4	10
4/80	40/800	20/400	0.05	1.3	8.0
4/60	40/600	20/300	0.06	1.2	6.4
4/50	40/500	20/250	0.08	1.1	5.0
4/40	40/400	20/200	0.10	1.0	4.0
4/30	40/300	20/150	0.13	0.9	3.2
4/25	40/250	20/125	0.15	0.8	2.5
4/20	40/200	20/100	0.20	0.7	2.0
4/16	40/160	20/80	0.25	0.6	1.6
4/12	40/120	20/60	0.30	0.5	1.25
4/10	40/100	20/50	0.40	0.4	1.0
4/8	40/80	20/40	0.50	0.3	0.8
4/6	40/60	20/30	0.65	0.2	0.6
4/5	40/50	20/25	0.80	0.1	0.5
4/4	40/40	20/20	1.00	0.0	0.4
4/3	40/30	20/15	1.30	-0.1	0.3

Visual acuity is influenced by:

- physical factors (optical characteristics of the eye or of tools used by the eye, refractive error)
- physiological (pupillary diameter related to retinal eccentricity (Fig. 1.3.), eye movements)
- psychological (attention to motivation)
- other factors (influenced by the characteristics of the letters optotype.)
- use of chemicals (Bardini, 1986) .

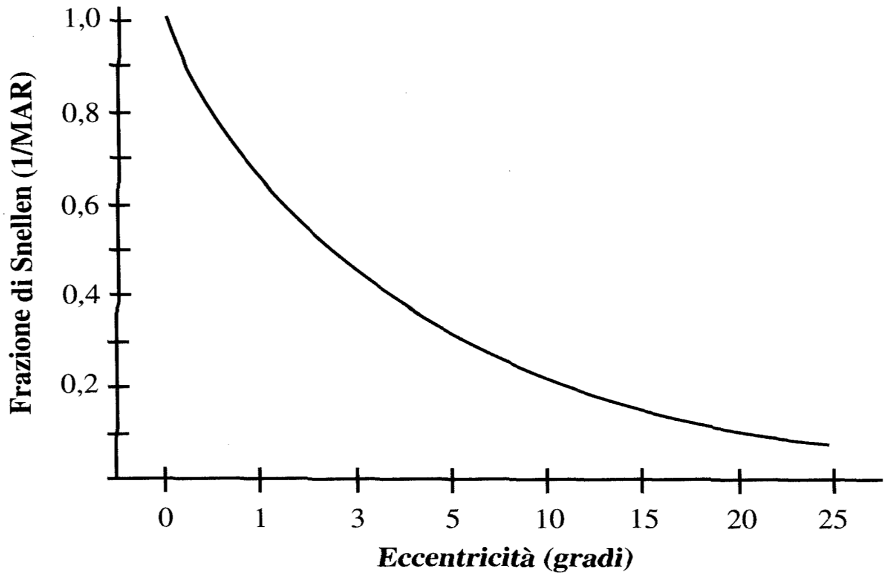

Fig. 1.3. Eccentricity and visual acuity (Rossetti, 2003)

1.1.1 Retinal eccentricity and visual acuity

VA it is optimal when the retinal image is formed on the foveola and it decreases quickly going to the retinal periphery, due to the organization of the receptive fields and distribution of photoreceptors (see Fig. 1.3.) .

In the Rossi and Roorda 's chart (Figure 1.4.) we can see how VA change in function of retinal eccentricity .The maximum visual resolution outside the foveal center decreases rapidly. They have been used "adaptive optics imaging and psychophysical testing to measure cone spacing and resolution across the fovea, and show resolution is limited by cone spacing only at the foveal center. Immediately outside the center, resolution is worse than cone spacing predicts and better matches the sampling limit of midget retinal ganglion cells." (Rossi, E.A. & Roorda, A., 2010).

1.2. Stress concept

In his book, Forrest (1993) described the term stress based on the description given by Hans Selye. Thus, the stress is the complex of phenomena that give the start to a reaction of defense of the body. It represents the set of specific reactions that the body develops under the stimulus of factors that tend to modify the habitual environment and jeopardize homeostasis.

Roncagli (1996) also described the studies of Selye that involved the theory defined by Dr. Skeffinton who sensed the correlation between the stress and the visual system. In the 1950s, Selye introduced the concept of "visual stress" defined as "near-point visual stress" attributed to prolonged visual attention at a proximal distance during challenging visual cognitive activity. Electrophysiological variations have been demonstrated in numerous studies for over 20 years. The symptoms are different disorders and problems of the nervous system, such as changes in the conductivity of the skin, heart rhythm, muscle tension, posture, respiration rate. The symptoms of "perceptive" visual stress (not measured on tissues and organs) cause a variation of visual performance of the qualitative level such as the reduction of speed and comprehension during reading. The other “neuromuscular “ symptom is observed through the deterioration of the visual performance such as "fog" headache, asthenia etc. In the third “somatic" symptom we can already register an adaptation phenomena and therefore the adaptation is the body's response to stress.

1.2.1 Proximal visual stress and its clinical implications

Roncagli (1996) described other studies of Birnbaum that many refractive variations and many disorders of the accommodation and the convergence have been attributed to proximal visual stress and explained as adaptation processes developed by the organism in order to reduce discomfort during proximal activities.

Conditions such as blurry far away vision, short-sightedness, accommodative insufficiency, convergence insufficiency, are functionally seen not as primary problems but as adaptive secondary changes to the proximal stress induced by over-convergence. (Roncagli, 1996)

1.3. Visual process according to Skeffinton

Visual function plays a fundamental role in the rehabilitation process. Using Skeffington's behavioral model for vision development and learning, optometrists can develop clinical strategies and treatment strategies based on antigravity: anti-gravity (locomotion), centering (location), identification (labeling) and speech-auditory (language). This model can be used as a reference to set up the visual training treatment (Godnig, 2001).

Dr A.M. Skeffington created in the 40s and 50s a model that today is used and is current in the era of treatments in holistic matter. The visual model in its entirety is created by the intersection of four circles. (Roncagli, 1996)

This model can be used to plan a rehabilitative pathway and restore visual skills. This model has been used for rehabilitation treatments in people with impaired vision, with the aim of creating motor independence in daily activities, maximizing residual vision.

Very often the visual conditions are negatively affected in the population; the visual conditions that are easily damaged are visual field loss, visual acuity degradation, loss of stereopsis, ocular motor palsy dysfunction, inadequate binocular fusion, metamorphopsia, and visual-motor integrative skills. (Benjamin, 1970)

1.3.1 The four circles of Skeffington

Godnig (2001) describes I four circles of Skeffington. Each circle corresponds to a model and to a question. The first circle is about "anti-gravity" and answers the question "where I am?" in space (Fig. 1.5.). It is related to the general gross movement in relation to the gravitational world. Our body, to integrate the antigravity, must have matured, with its own body, the different coordinates such as up right and down left. (Getman, 1993).

In everyday life this integration of the antigravity makes us judge where objects are in space with respect to one's body. This skill dominates the air of vision learning (Suchoff, 1981).

The second circle is the one about "centering", and answers the question "where is it?" in space and it is linked to the spatial localization. To be integrated, individuals must perform visual motor experiences through the eye movements of convergence and proprioception of divergence. The integration of "where is it ?" takes place in full awareness of where objects are located in space. That is, in the presence of coordination of the eyes on the object simultaneously with its will to place it in space. The "centering" skills are linked to a careful oculomotor control, stereopsis, advanced directional orientation skills and visual spatial memory ability.

The third circle, "identification," can be defined as "labeling circle" and answers the question of "what is it ? ". To develop this capacity it is essential to use the fovea, suitable for the visual recognition of color and size shapes, together with the accommodative system. Visual perceptual abilities of visual perception of form, visual memory, and visualisation lead to "identification" development.

To better understand the behavioural visual, we introduce neurological notions (Bassi, J.C. & Lehmkuhle, S., 1990). The "focal" areas (labeling) and "ambient" (locomotion) travel in parallel through the two magnocellular and parvocellular visual areas, each path is sensitive to different stimuli for spatial and temporal frequencies. The magnocellular pathway (M-pathway), is linked to the environmental system, to the locomotion system, to peripheral vision, responding to the question "where am I?" in space. The parvocellular pathway (P-pathway) is correlated with focal or labeling systems, to the central vision system, sensitive to detail and recognition and answers the question "what is it?"

The fourth and last circle is the circle "speech-auditory", defined the LANGUAGE CIRCLE and answers the question "what do I know about it?" And "what can I tell you about it?" Linguistic skills and language are indispensable components for sharing visual experiences and for integrating the visual learning process.

Skeffington with its four circles developed this model where the integration of each of these had to be necessary for the complete development of the "VISION." The use of all four skills was necessary in the mutual integration of each of them. This model is used as visual training design also for the rehabilitation of the visually impaired.

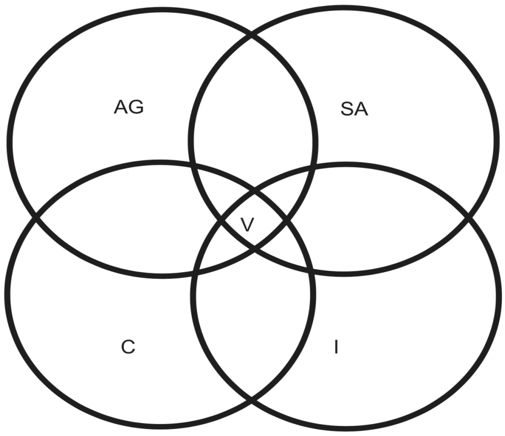

Fig. 1.4. Representation of the four circles of Skeffington. AG =Antigravity System. C =Centering System. I= Identification System.SA=Speech-Auditory System. V =Vision.

1.3.2 Rolle of visual training

Visual training is considered a set of procedures that change from one professional to another, based on their approach and the technique used while having the same purpose.

Visual training is considered practical to improve the efficiency of basic visual skills such as oculomotor skills, binocularity, convergence accomodation relationship, hand eye coordination, visual-postural motor organization, motor sense integration, visualization and visual memory function, etc. Some professionals use tools, others prefer open spaces etc. others use lenses other prisms and stereoscopic tools. But the aim is the same: to change the behavior of the individual, coming to a form of learning.

Visual training aims at unifying the various visual functions with the action of the whole body using all the "sensory-motor" abilities (considering the parvo and magno areas) and improving visual performance in the visual-spatial world (Forrest, 1993).

Visual training is the set of visual exercises most often used by optometrists with the aim of improving visual efficiency, including eye exercises, muscle relaxation techniques, biofeedback, lenses and prisms, and more. Certain studies show that biofeedback and visual training on myopia control has not brought significant benefits. While visual acuity improvements have been found in myopic subjects. Studies on visual training for accommodation control in myopic subjects have shown that there is no effect on improvement of myopia but an improvement in visual acuity in myopic patients. Failing to demonstrate the physiological causes of improvement, it is the variation that has been attributed to improvements in the interpretation of blurred images, tear film changes, or miosis. No effects on myopic progression, visual function in hypermetropic or astigmatism or improvements in lost vision in patients with pathologies have been found (Harris, Emptage & Lum, 2013).

Yuda et al. (2010) used training with the objective to cyclically induce pupil constriction during far accommodation and improve visual acuity in myopic children.

Yuda treated the problem about Myopia in school-age children, considering the myopias have increased since the arrival of industrialization, but in recent years there has been a peak in Europe but especially in the Asian countries.

A visual training strategy is treated to stress the pupillary constriction during the accommodation phase, in this case it is to stimulate the accommodation from afar, thus creating an increase in visual acuity.

The studied group is 95 myopic patients treated for 3 minutes up to twice a week for 12-106 weeks.

Rapid cycles of accommodation near / far were stimulated by visualizing a visual object from a distance of 70 cm and then close to 25 cm maintaining luminosity of the retinal projection of the object constant.

In this research a visual training was carried out following a new, simple, non-invasive and safe methodology to improve visual acuity in myopic children. The technique used consisted of positioning the eye closely (25 cm) and far (70 cm) showing an object of the same size and brightness, and after showing a moving object at high speed without difficulty or discomfort.

During the training the most evident data was that of the pupillary constriction during the close accommodative phase, but the most interesting event was that after 12 weeks, it was noted that the subjects showed pupillary constriction even from a distance. This pupil behavior is the key mechanism that leads to the improvement of VA.

This method produced effective training in sessions a few minutes during the week. The speed of the training and the visual comfort obtained during the training, solicited the subjects to practice the exercises. The improved VA has remained constant with the practice of training in the following weeks. In addition, the study suggests that we should study with 20/20 object with less corrective glasses than those estimated by their refraction.

This study leads one to think that training can also improve the corrective level of glasses. The improvements in VA occurred in children who followed the protocol on a regular basis until the end while in children who stopped exercising, the beneficial effect was gradually lost slowly in a few months.

The search has ended several months after training. It has been compared the VA of children treated with the VA untreated myopic children. The VA was similar among these. The difference was found with the trained subjects, as soon as the treatment is restarted, the VA has improved again. It is also to be kept in mind that the decline of VA and SR reported in myopic children in Singapore (0.88 D / year) and in Japan (0.81 D / year) have been linked to the continued growth of the eyeball in most cases. (Yuda et al., 2010).

The improvement in VA is due to the diminished size of the pupil, and the consequent greater depth of focus and a decrease in spherical aberration.

The regulation of pupil size has been studied mainly in response to light stimulation but not in response to long-distance accommodation.

The constriction of the pupil during distant accommodation is a new discovery.

These findings suggest that close accommodation or convergence cannot influence the response of pupils of short-sighted school-age children to distant settlements.

Eighty-five percent (52/61) of the myopic eyes showed better visual acuity (VA) of more than 0.1 logMAR units with an average improvement of 0.30 +-0.03 SEM logMAR units, paired t-test $P < 0.001$), with 12 cases improving by 0.5 logMAR units.

Improved VA has remained almost constant, for more than 50 weeks in the case of 12 long-trained subjects.

In conclusion, the children of school age have a decreasing VA with myopia increasing of 0.33 logMAR / year with this visual training technique there is a significant improvement of VA by blur adaptation and enhancement of iris function, and the improved VA remained almost constant with maintained training. The pupil size leads to a greater depth of focus and a decrease in the spherical aberration of the trained eye.
The pupillary constriction during far accommodation shows that the training is also able to enhance blur adaptation to correct a blurred image, so that occurs a further improvement of VA.

Yuda's training can improve Va in a fast and comfortable way, improving the vision's quality in subjects with refractory abnormalities. This method can enhance Va in children so it can give personal accommodation training system. All of this is convenient and safe. The following works can be addressed in order to improve the vision of myopic adults. This simple visual training treatment has greatly improved the quality of vision in this small group. Lowering of VA is increasing as myopic progression is, and it is important to go to solicit our skills to keep our visual system ready and prepared not to absorb the sources of stress that everyday life offers us. (Yuda et al., 2010).

Jia et al. (2017) have showed that intensive monocular perceptual learning training resulted in an improvement in monocular visual acuity in the amblyopic eye in adults with amblyopia.

In this study, the effects of visual training on the binocular system were assessed, although the binocular visual function is a counterpart of this training and it hasn't brought significant benefits to the increase of binocular VA. However, monocular training was essential in the amblyopic eye for restoring visual functions (Jia, W., et al 2017).

The most significant result was the fact that VA of the amblyopic eye improved significantly compared to the fellow eye, from 0.51 (logMAR) to 0.34. The worst the initial Av was, the greatest the improvement was. (Polat et al. 2004).

Also in the article by Elvan Yalcin and Ozlem Balci " Efficacy of perceptual vision therapy in enhancing visual acuity and contrast sensitivity function in adult hypermetropic anisometropic amblyopia " we can find a research about "enhancing best corrected visual acuity and contrast sensitivity function in amblyopic patients."

Many hypermetropic amblyopia subjects were enrolled and were strictly selected because " the nature of the treatment demands hard work and strict compliance " (the minimum necessary to obtain statistical date).

The basis of the treatment used can be defined by the term "perceptual learning".

"Visual performance can be improved with repetitive practice on specific controlled visual tasks." (Yalcin & Balci 2014)

The studies have shown that visual training leads to neuronal changes and neuronal improvements, thus indicating the presence of brain plasticity.

In visual function, brain plasticity is present independently in young subjects and adults. (Polat et al., 2004).

1.4. Accommodation

Schmid, (2017) and Goss et al. (1997) talk about the relationship between pseudo-myopia and accommodative spasm. Let's understand what mechanisms trigger when we use accommodations, so let's start to briefly define the accommodation, which is the visual ability to adapt the focus to various distances. To be able to accommodate, we need the ciliary muscle, Zinn's zunules and crystalline. When the eye looks from a distance, the ciliary muscle is relaxed. When the eye looks close the ciliary muscle contracts while Zinn's zunules are relaxed, and the lens increases the optical power. To be able to focus from a distance again, the process goes in des-accommodation and the ciliary muscle goes back to being relaxed. The importance of the accommodative response comes from a mis-focusing of the image on the retina in optimal conditions. Disorder accommodations can be: asthenopia, accommodation spasm, accommodation paralyses, presbyopia .

1.4.1 Accommodative spasm and pseudo-myopia

De Angelis (2011) describes myopia in its stages and pseudo myopia, describes the passage's phases of the pseudo myopia before it becomes fixed.

High stress periods caused by an excessive request of close distance work, leads to an over-accommodation. When our body is stressed, it puts the sympathetic system into action and the response to this state is the accommodative spasm. Accommodative spasm takes place when we have to focus on a closer distance and when it puts into action a higher accommodation . The accommodative spasm is also defined as accommodative stress caused by an adaptation from the retinal defocus. This event is subjectively presented as a phenomenon of fogging to distance vision after being in a close gaze position. This accommodative request, superior to necessity, creates the condition for establishing a pseudo-myopia. This pseudo-myopia produced by accommodative excess is the condition when we might see blurry and when the visual acuity might be reduced and subsequently might become myope. Over-accommodation can also be seen as a lack of ability to relax the accommodation. Pseudo-myopia is a transitory phenomenon, it is an alarm bell to prevent the establishment of myopia.

Generally involuntary active accommodation is maintained in the absence of lens stimulation when there is accommodative spasm, accommodative excess, pseudo-myopia, or ciliary spasm (Rutstein & Marsh-Tootle, 2001). The symptoms reported by the subjects are varied but mainly bilaterally blurred and fluctuating vision but also headaches, ocular pain, micropsy, macropsia, and diplopia. When there is accommodative spasm, the subject will request in refraction negative lenses because the power of the eye is increased; therefore a myopic subject will seem more myopic, an emmetropic will seem myopic, hypermetropic will seem less hypermetropic. The accommodative spasm can be of a functional or psychogenic nature or even organic nature caused by injury. The accommodative spasm can suddenly present itself in a constant or intermittent way but disappears with cicoplegia. Since accommodation is connected to convergence the accommodative spasm can be accompanied by the convergence spasm and precisely because these are connected to the accommodative spasm which is typically a bilateral phenomenon. (Rutstein & Marsh-Tootle, 2001).

The accommodative spasm in children, today, is considered the functional disorder that is the main cause of myopia in children. To understand that there is an accommodative spasm it is important to prevent the development of myopia. Since pseudo-myopia is presented with a reduced visual acuity, visual training treatments can help restore it. The treatment can be made only when the pseudo-myopia goes from functional problem to structured problem. Visual training treatments are suitable for pseudo-myopia in order to restore visual acuity and not to reduce myopia. Visual training can be combined with visual hygiene advice in order to maintain a suitable far-near relationship. Other advice is doing activity in the open air and physical activity to make more blood flow in the body. (Goss et al., 1997)

Schmid, (2017) lists several studies where they report myopia connection with choroidal activity, in specific the reduction of ocular blood flow with increasing eye length and refractive error. Although it is incorrect to say that the reduced blood flow is a consequence but it is only one of the reasons for a myopic establishment or increase. It can be said that the increase in choroidal blood flow protects from eye stretching.

2. RESEARCH

2.1 Aim and tasks of research

Aim.

To assess how effective are visual trainings for visual acuity improvement.

Tasks .

1. To compare visual acuity values before and after visual acuity trainings.

2. To find out is there a correlation between visual acuity values before visual training and improvement in visual acuity after trainings.

3. To find out are there changes in optical refraction after visual acuity trainings.

2.2 Participants's selection.

The participants are 24 subjects, (11.5 ± 2.60 years), divided into two groups. Those who did not wear glasses (11 ± 2.5 years, first group) and those who wore glasses (13 ± 2.3 years, second group) Both groups had several common symptoms, such as: asthenopia, blurred vision from afar after prolonged activity close and vision blurred from afar. So this research came from the need to improve visual acuity, in a part of subjects that complained of blurring, not presenting large refractive changes and although there were no major changes in visual acuity.

In the subjects where the VA improved in refraction, the lens gradation was changed so these subjects were excluded from my research. If VA did not improve, trying visual training sessions was suggested.

Subjects who have been excluded from the protocol, they are those who interrupted the course during the first two/three meetings and they failed to follow the required procedures during the week. Generally started from the will of the parent more than from his own will.The emphasis and the subjective motivation in following the path have been a key element in achieving the improvement of the VA.

The measurements of visual acuity was detected using the standard Snellen chart by Shin-Nippon CP-30 chart projector in lux 200 ambient. In the first group the VA was detected in monocular by placing a translucent pallet (transparent occluder), while in the second group the gradation of the lenses in abitual correction use was inserted into the trial frame and then the VA was detected.

2.3 Methods and protocol used

The starting point of this research was the detection of visual acuity, later they have begun visual training sessions and finally it was rechecked visual acuity after three months.

The meetings in the studio were done once a week distributed in three consecutive weeks, three more meetings interspersed with 1 week (one week yes and one no). For a total of +/- 6 meetings.

The session in the studio lasted 45/50 minutes plus 10 minutes to organise the work at home for a total of 1 hour. The work at home was part of the protocol, had to be done for a minimum of 10 minutes every day until the end of the 3 months.

The visual training path was interrupted and the subjects were eliminated from the sessions and the research when these did not train at home and did not follow the required tasks. The requested homework was strictly necessary in order to proceed with the integration of each execution. The interruption generally took place at the second / third meeting. The interruption of cases occurs because of a low motivation, for the young age of the subjects, because parents do not help small subjects or because they missed appointments.

2.3.1 Procedure : monocular jumps accommodative near and far with chart

Purpose: develop the ability to move the focusing point from near to far, constantly, keeping at the same time good ocular coordination. Train the awareness of space over time. It harmonises the times of accommodation / dis-accommodation.

Instruments: for far hart chart, for near bullseye targets, metronome, balance board.

Procedure: the subject is standing in front of the far hart chart at a distance that the letters from a far are visible with both eyes. The subject will occlude an eye with the translucent palette and will optimise the distance for the letters to be visible, then he will position the target closely, bullseye targets, at a distance Harmon in such a way that the two sights are aligned to his eye. He will start reading the letters aloud one from a far and one from near, in vertical order until he has read the lines of letters, everything will also be performed in the other eye.

In the practice in the studio after a few sessions, it is noted that the subjects use an ever greater distance of execution. When the execution was fluent, a difficulty level increased to keep the level of learning high. Difficulty levels are entered according to the possibility of such execution that is possible without causing the subjects to frustration. The variations were made with the insertion of a metronome, respecting the beat of time on the focus of the letter in coordination with the control of the position of gaze on the letter. For the variations, the balance board was also used.

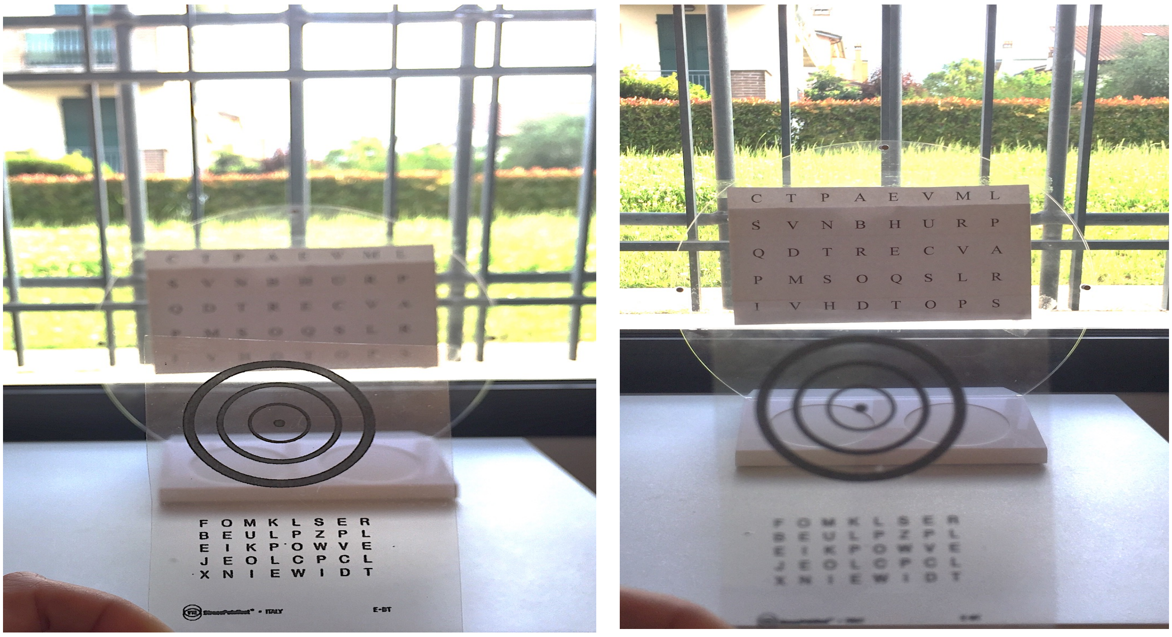

Fig.2.1. Images of the near focus with bullseye targets and, image of the focus from far hart chart targets used.

2.3.2 Procedure: purses marsden ball

Purpose: to develop the skills of accurate eye chases.

Instruments: Flash with cross mask to create post-image, Marsden Ball, translucent palette.

Procedure: the standing subject is positioned in front of the Marsden Ball at eye level remote Harmon. It is required to follow the ball that is pushed in movement along the horizontal axis in the arc of 60cm. The procedure takes place first in monocular we use a translucent pallet to occlude an eye then in binocular. The gaze must be kept above the moving ball, without the help of body or head. With practice, the pursuit becomes refined and precise, when this procedure is done fluently, you move to a higher level. A key variation, in this execution, is the use of the post image. The subject repeats the same procedure, keeping the post image on the ball and it will continue to follow the moving ball until the cross is visible. All of this will be done in the other eye. Other variations, to increase the level of difficulty, were made inserting the trajectory to the ball in different axes (x, y, z) and / or using Balance board, to increase the level of difficulty.

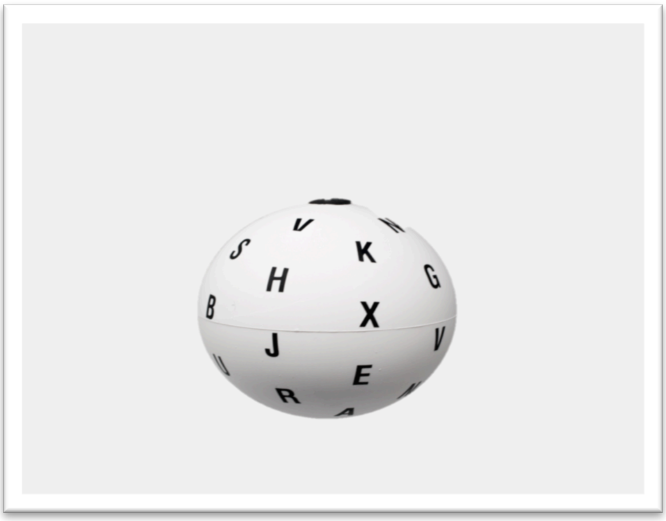

Fig.2.2. Purses Marsden Ball

2.3.3 Procedure: saccades strips for saccadic movements

Purpose: develop or improve the ability to perform quick and accurate saccadic movements.

Instruments: vertical letter strips, translucent occluder, metronome, balance board.

Procedure : the subject standing positioned in front of and in the middle of the Saccades Strips at variable distance indicative of about 1m. Saccades Strips are attached to a shelf or at the door jambs placed at the same height initially spaced from each other at no less than 60 cm (to start)at most 90 cm (harder).

On a first level of difficulty, it requires reading the letters aloud from left to right and to go down then from right to left. In later levels is required a change of direction in reading.

The procedure is performed, first in monocular, using a translucent occluder, then in binocular.

The variations are needed to improve skills, as soon as the procedure is performed smoothly, then the variations are inserted. For the variations have been used metronome and balance board.

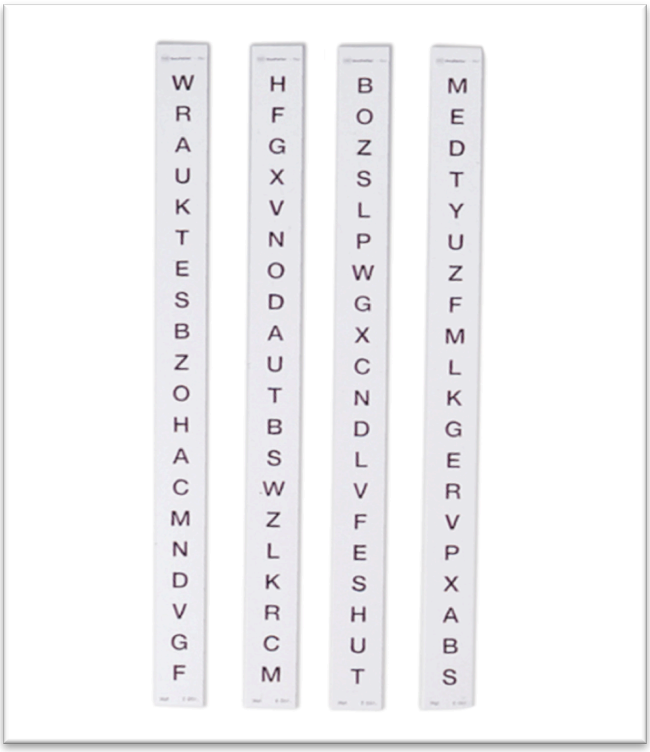

Fig.2.3. Saccades Strips

2.3.4 Procedure: Brock string

Purpose: awareness of physiological diplopia/integration of binocular vision and the different anomalies of binocular vision. Improve the ability to perceive objects in space at different distances.

Instrument: Brock string, balance board.

Procedure: the subject is positioned standing in a relaxed balanced posture. The string is held at a height under the nose, tight hold with a hand of the subject in different positions, according to the different purposes of the executions. You want to get it from this procedure that the subject looks at with both eyes a ball and sees two strings, that cross in the middle of the ball, creating an "X".

It is explained to the subject that if you close one eye, one of the strings disappears so that it appears only one string. This experience is introduced to give awareness to the subject of their binocular vision and physiological diplopia, necessary experience to overstep all phases of this procedure.

In a first step, it is required to keep the ball in focus, keeping in mind the awareness of having these two strings that cross at the center of the ball, with the aim of having and maintaining stable binocular vision in different look positions.

In a second phase it is requested try to make the two cords in focus in the same way, to solicit the equality of the two strings.

In the subsequent phases, all three balls present in the string, they have been used with the aim of keeping the "X" in different positions in which the ball was put on the string.

Finally, it worked on a fictitious display of the “X" on all the length of the rope but without using the balls.

Fig.2.4 Brock String

2.4 Results and analysis of data

The results demonstrate that visual training significantly improves visual acuity in all subjects (t-test, paired, one-tail, $p < 0.001$). Before the training the average visual acuity was 0.21 +/- 0.03 SE. But after the training it was change to 0,02+/-0.14. So average improvement in visual acuity was by 0.19+/-0.02 (logMAR units).

It is possible visualize in the box plot in figure 2.5 the main central tendency and dispersion measures, how was AV before and after.

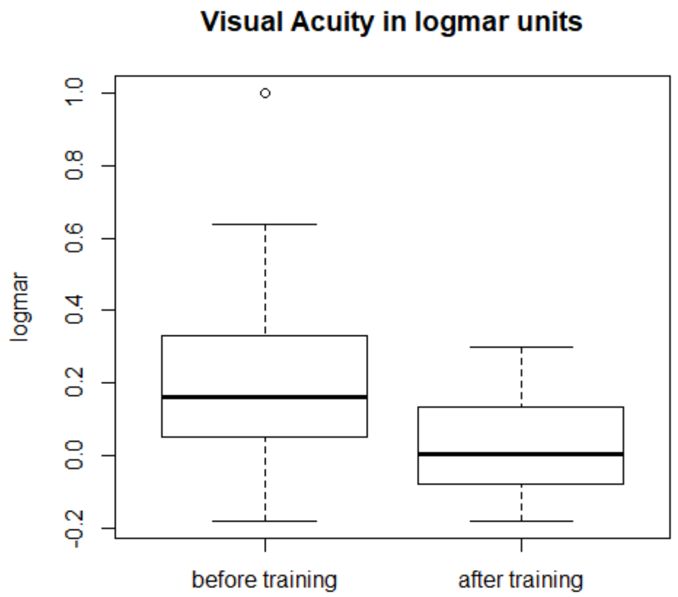

Fig.2.5 Visual acuity in logMAR units before and after visual training.

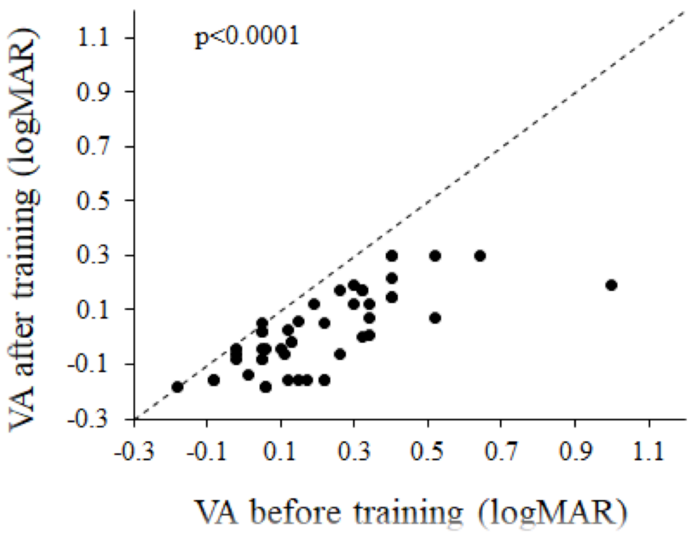

Fig.2.6. Visual acuity VA before and after visual training for all subjects. VA was significantly better after training (p<0.0001; paired t-test). Dashed line shows perfect agreement.

The scatter plot in figure 2.6 demonstrates graphically the correlations between in VA before training and VA after training (logMar units), (r=0.73) correlation as statistically significant ($p < 0.001$) in a linear association.

The results demonstrate that visual training significantly improves visual acuity in the subjects with lower VA values than for subjects with better VA (R^2=0.53).

Visual acuity in the eyes significantly improved, from 0.21 +/- 0.03 (logMAR) to-to 0,02+/- 0.14. ; the improvement VA 0.19+/-0.02 (logMAR units) that is a improvement of about 3 lines. The regression line (r2 = 0.53, p < 0.01) had a slope of 0,5 indicating that the worse the initial acuity was, the greater the improvement as shown in the figure 2.7.

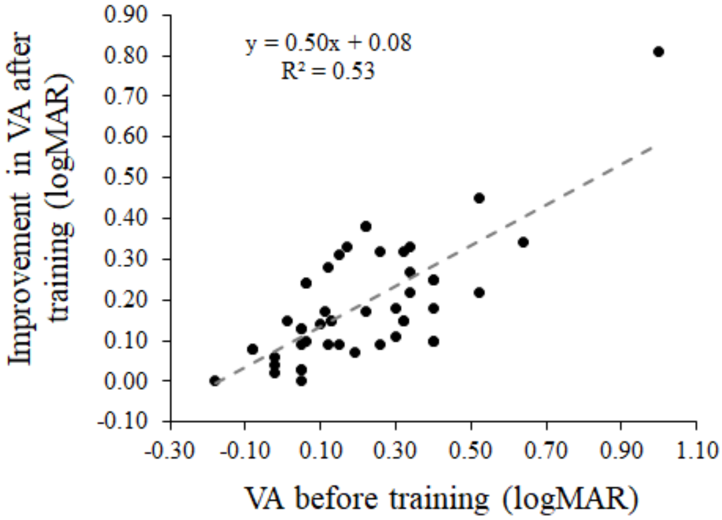

Fig.2.7 Visual acuity VA improvement depending on VA value before training. Determination coefficient R^2 between both values and regression equation is shown. Dashed line represents linear regression.

The results demonstrate that after visual training also optical refraction for myopic subjects after training significantly reduced (p=0.003; paired t-test). Before the training

Average in refraction was -0,97 +/- 0,31. But after the training it was change to -0,77+/- 0.29. So improvement it was by 0,20+/-0.07 (diopters) (figure 2.8).

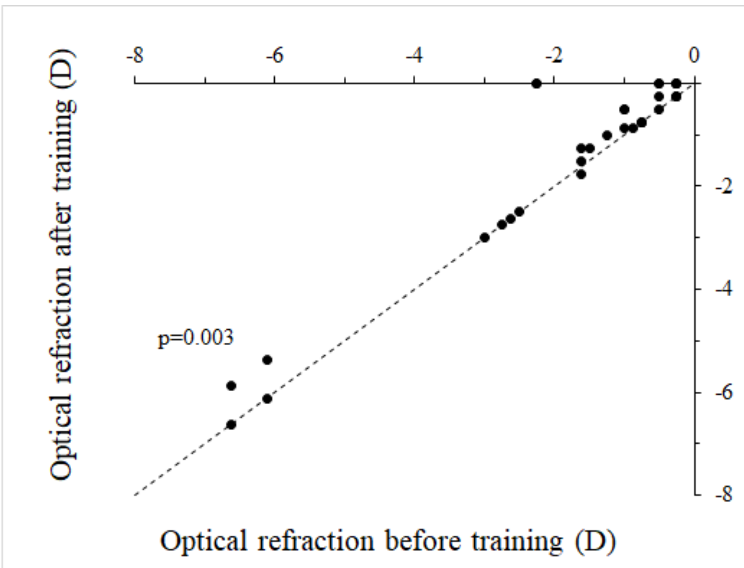

Fig.2.8 Optical refraction (spherical equivalent) before and after visual training. Data only for subjects with myopic refraction before training is shown (p=0.003; paired t-test). Dashed line shows perfect agreement.

CONCLUSIONS

1. Visual acuity after training was significantly better ($p<0.0001$) comparing with acuity values before training. Average improvement was 0.19+/-0.02 (logMAR units).
2. Improvement in visual acuity after training was larger for subjects with lower VA values than for subjects with better VA ($R^2=0.53$).
3. Optical refraction for myopic subjects after training significantly reduced ($p=0.003$). Average changes in refraction were 0.20±0.07D.

FINAL WORDS

In the current study, it is found to training to improve and restore VA, training general visual skills.

Training the general visual skills improve VA and can improve a small amount of refractive error in myopic subjects.

This simple visual training treatment has greatly improved the quality of vision in this small group people. Lowering of VA is a symptom of stress visual and it is important to go to solicit our skills to keep our visual system ready and prepared not to absorb the sources of stress that everyday life offers us.

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Author: / Angela Fersino /

Student No:af15003

Recommend/unrecommend thesis for defensing

Supervisor: Docent, Dr. phys. Gatis Ikaunieks

Reviewer: Docent, Dr. phys. Jānis Dzenis.

Thesis is submitted in Department of Optometry and Vision Science ________________

Dean’s authorized person: _________________________

Thesis is defended in bachelor final examination commission session

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Commission secretary: __________________________