

Research on the relationship between chromatic vision and biomechanics of the posture and the gait cycle

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Abstract. Visual screening is a complex source of information, usable in the medical field, in vision recovery or sports, to increase performance in various sports fields that require the use of the visual system. For the study of the visual system a variety of methods are used, starting from visual parameters analysis, biomechanics, computer simulations and modelling and completing with optical and video analysis on kinematic and dynamic parameters. In many researches, a very close link between visual function and loco-motor function is identified, considering that the visual system is that which, when in dysfunction or overexploited, can cause changes in the characteristics of the gait cycle and posture of the human body. Thus, the first part of the paper analysis the general aspects of the behaviour of the visual system without dysfunctions and its connection with the loco-motor system. In the second part of the paper is presented an experimental setup for the analysis of the influence of chromatic stress on the way of movement and the posture of the human subjects, and in the third part of the paper the recordings made on footscan pressure plate and respectively with the perception assessment software application colour are presented. In the final part of the paper the results of the processing of this information and the conclusions from the experiment are presented.

1. Introduction

Chromatic vision is one of the most important features of the human visual system, providing the human subject with the ability to distinguish and visually perceive elements in the environment at a much higher level (theoretically about 16 million colors) than they would dyschromatopsia (view in gray levels - 256 levels). The ability of eyeball to have good chromatic visual acuity is especially important for assessing the behavior of subjects in various activities in which continuous, intermittent, light colored beams are being used. Changing the biomechanical behavior of subjects in these situations is important to be evaluated through various procedures that meet current standards to prevent musculoskeletal dysfunction, avoid motor dysfunction, and even improve ergonomics of working place. The posture of the human body in stability or in the gait cycle can indicate the status of the subject's behavior and can be related to their health or comfort level and sometimes to the level of adaptability to the environment.

A number of scientific and research papers address various aspects of the whole body or component segments in order to identify and / or use functional parameters in order to achieve performance or to rehabilitate neuro-motor functions affected by various causes. In these cases a visual function at very low levels of its parameters may additionally affect the adaptability level, change the duration and level of motor recovery (where appropriate), or even change the overall perception of the environment [1]. In addition to the chromatic characteristics of the visual function, 3D binocular vision is another parameter that can influence the spatial perception of the depth of the environment, the hierarchy of the dimensions

of the objects in the visual field and, last but not least, the discrimination of the movements and their positions in relation to posture or movement of the human body.

As shown in a series of research, [2] the quality of life in all its components is severely impaired in these visual dysfunction conditions, and its modifications due to dysfunctions are difficult to remove or recover. Also, as stated in World Health Organization documents (WHO) “visual impairment is an increasingly prevalent public health problem, particularly in aging populations. An estimated 1.64 million individuals in Japan and 3.22 million in the US have impaired vision. This number is expected to increase in developed countries because of the increased incidence of age-related eye diseases, such as glaucoma, macular degeneration, and diabetic retinopathy. Vision is a key element of health and quality of life (QoL). Blindness and visual impairment are among the 10 most common causes of disability in the US and are associated with both diminished QoL and a shorter life expectancy. Individuals with impaired vision have an increased risk of road traffic accidents and are more likely to cease or curtail driving. Visual impairment has also been associated with emotional distress and infrequent socialization. Thus, visually impaired individuals may have functional and psychosocial burdens that affect various aspects of their daily lives. Further, visually impaired older adults have difficulties with physical functioning, which increases the risk of falls and fractures. A fear of falls and perceived risks of mobility have been reported to limit physical activity in visually impaired patient.” Color vision is achieved by the ability to transform various wavelengths of light radiation from the photosensitive cells of the retina, although the photochemical process taking place at the level of each cell is not yet well known. The most interesting research on visual color perception is the investigation of the chromatic sensations of human subjects in low illumination levels or the psychological and physiological effects of colors on the quality of life [3,4].

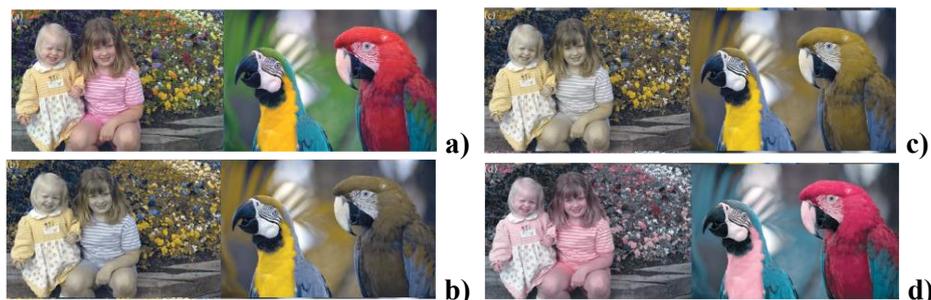


Figure 1. Color vision deficiencies (a) original images, (b) protanop, (c) deuteranope, (d) tritanope [5]

As shown in the paper [6], the authors identified, following research carried out on a sample of 14 totally blind subjects, an intrinsic connection between the postures, respectively the gait cycle and the visual system in dysfunction, concluding that the visual aids can also help improve movement, motor activity, or precision. Later on, these observations have been developed in the field of constructing robotic systems [7,8] with artificial vision for the creation of autonomous locomotion systems in the form of bipedal humanoid [9,10,11]

2. Experimental setup

Experimental setup used in this research consists of a set of equipment that allows the recording of *footscan* planting pressures during a walking cycle and simulation of chromatic stress. The area where the experiment was conducted is sound and optical isolated to avoid the influence of some audio-video parasitic stimuli in the environment. The sample of subjects selected for the experiment were chosen following similar general criteria of the same type: same age, same type of basic activity, average height 1.67 m and body weight 52.4 kg, footwear and leg clothing and the like. All of these conditions were followed throughout the experiment in order not to hurt the measurements made. In addition, the subjects were in a proper metabolic state so that chromatic stress did not affect the well-being they must manifest during the experiment. All the subjects provided informed consent prior to the test. The experimental

protocol was conducted according to the Declaration of Helsinki [12]. They have been informed about the protocol of the experiment and the devices that were used. The Chromatic Stress Simulation Device (CSSD) is built to allow exposure of the subject's visual system to illuminations of varying intensity and illumination with different wavelengths for different periods of time before recording the cycle of movement on the pressure plate (see Figure 2).

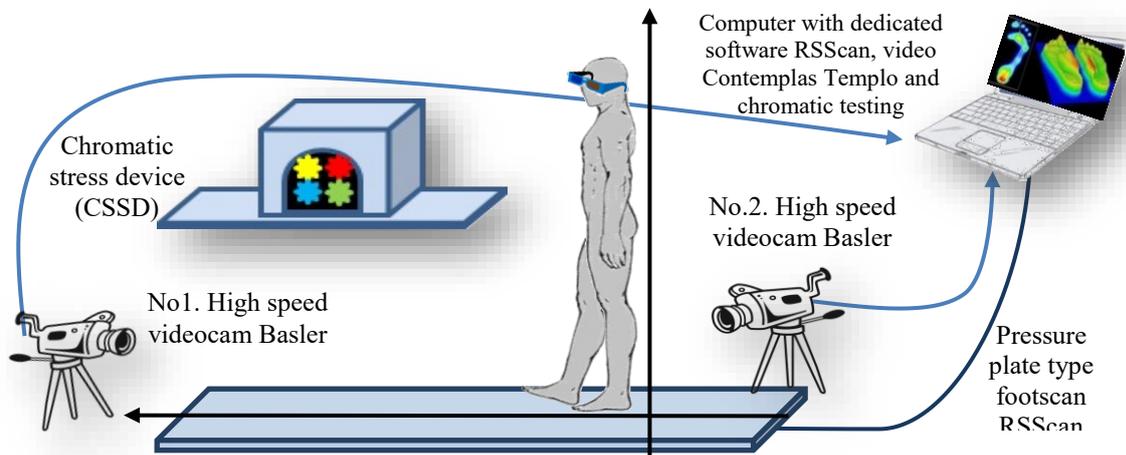


Figure 2. Experimental setup



Figure 3. The device for chromatic stress exposure of the visual system of the subjects

The registration and evaluation procedures were carried out with all the subjects in the sample and they required at their onset to perform initial tests in order to identify the level of normality in all the subjects involved. The initial tests were based on measurements on two systems: biomechanical by measurements of the normal (no stress visual) cycle on the *footscan* pressure plate and the second, the history of the visual system and the evaluation of the chromatic performance.

All determined values are the initial values that will be compared with those obtained following the application of chromatic stresses by CSSD. During the 20 minutes of the chromatic stress procedure, the subjects were followed up with a video camera (Figure 3) mounted inside this device. The investigator's attention during the exposure was focused on the position and the way the subjects keep their eyes open by watching their visual behavior.

The system is equipped with 5 types of colored LEDs: red, green, blue, yellow and white, and the maintenance time on the stage was set at 20 min, since the test subjects are very young (23 years) and accommodated it occurs very quickly. In the procedure, it was chosen that the subjects were tested in turn in exposure to 3 types of consecutively colored light. The first time was red (5 min), then blue (5 min), and the last type of stimulation was done with all types of colored LEDs on, so the stimulation was strong (10 min).

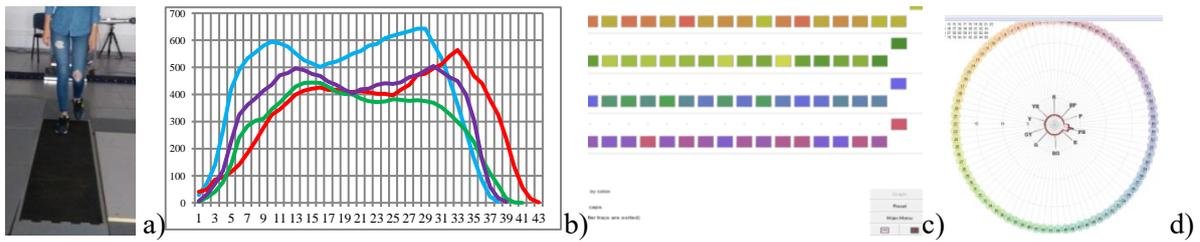


Figure 4. Records on the RSScan plate and respectively chromatic performance

The second stage was identical, changing only the wavelength of the light sources used (green, yellow and white). To enhance the chromatic effect, the subjects also wore glasses with the same filter at the exit from the CSSD during the recording on the pressure plate [13].

3. Results and conclusions

The recorded data was processed by software dedicated to the pressure board, namely *RSScan footscan 7.97 Gait 2nd generation*, and chromatic performance through the *Visiontest* software. At each stage of the procedure, immediately after exposure to chromatic stimulation, visual acuity was evaluated in all subjects to track the influence of bright radiation on visual perception and to correlate with the gait cycle typology (see Table no.1).

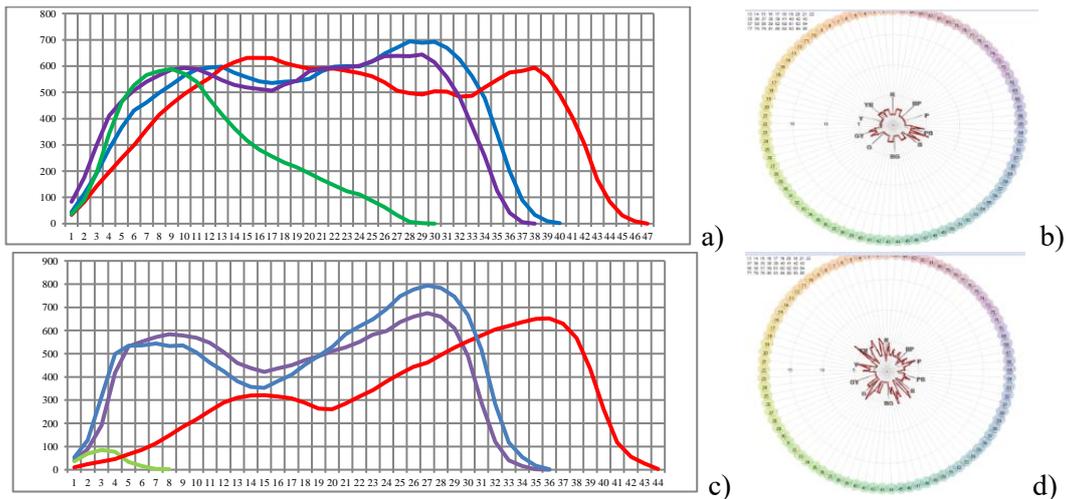


Figure 5. Pressure plate pressure (*a* and *c*) and chromatic performance (*b* and *d*) at all wavelengths

Table no.1. Visual acuity (VA) for right (RE) and left eye (LE) in different color light

Human subject	Visual acuity VA			Visual acuity VA			Visual acuity VA			Visual acuity VA		
	Red color light			Blue color light			White color light			Ambiental light (300lx)		
	RE	LE	B	RE	LE	B	RE	LE	B	RE	LE	B
1.	0.9	0.9	1	1	0.9	1	0.9	0.8	0.9	1	0.9	1
2.	0.9	1	1	0.9	1	1	0.8	0.9	0.9	1	1	1
3.	0.9	0.8	0.9	0.8	0.9	0.9	0.8	0.8	0.9	1	0.9	1
4.	0.9	0.8	0.9	0.8	0.8	0.9	0.8	0.8	0.9	1	1	1

The graphical representation of this feature indicates a decrease in visual acuity from normal to white light exposure of about 20% for right eye vision, a decrease of nearly 10% for the left eye, and in binocular decrease to 5%. After all the records, the following aspects were highlighted: the biomechanical behavior of the subjects after exposure to chromatic radiation (all categories) changed substantially, subjects doing on average a larger number of steps on the same plate length (by 10%

more); their movement was much slower (duration increased by an average of 26%); the posture of the subjects has changed many times many times down to the ground at a small distance; they used the arms to compensate for the slight imbalances observed both in movement and in plantar pressure values. In addition to these aspects of posture and movement, subjects were temporarily diminished monocular and binocular visual acuity, causing uncertainty in movement and discomfort in the perception of the environment.

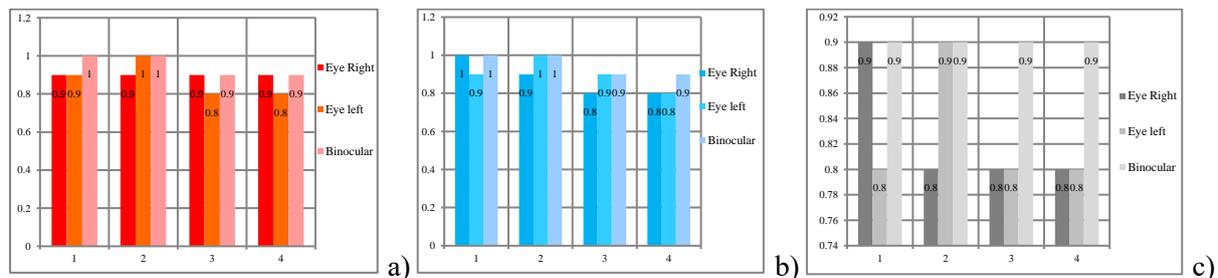


Figure 6. Visual acuity for right, left eye and binocular, in red (a), blue (b) and white (c) light

The issues emerging from this experiment, chromatic visual perception of subjects correlates with displacement parameters in the walking cycle, confirms the hypothesis that visual function can be considered an important component of the locomotion process.

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