Assisted assessment of visual stress – method to prevent and reduce the risk of visual function loss

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Abstract. The paper deals with the problem of visual stress. In the first part, the concept of visual stress is explained, when it occurs and what risks it can involve. The second part presents a method by which the influence of visual stress can be effectively and objectively evaluated, in a form that occurs very frequently in everyday life. The method consists in evaluating 10 subjects, both in the abscess and in the presence of visual stress, 5 of them being emmetropic, the others having different refractive errors. The assessment of people consisted of testing them in front of the Laptop screen, they had to identify and select from a list certain randomly generated words. In the first stage the subjects were tested under normal conditions, later they were tested under conditions where two large lights of different colors flickered randomly on the background of the screen. Assisted evaluation was possible thanks to a software interface that was designed, programmed and verified during this research. In one of the sections of the paper, the way in which the interface was created, as well as how to use it, is presented.

Keywords: Visual Stress, Interface, Vision, Assessment

1 What is Visual Stress

1.1 Visual Stress - Major Cause of Visual Function Deterioration

Visual stress could be defined as a factor that creates strong visual discomfort and can affect it in the short or long term. Generally, short-term exposure to visual stress can lead to vision impairment for a short period (a few minutes).

A long and repeated exposure, however, even to relatively low factors of visual stress (computer 0or smart-phone working) can lead to deterioration of the visual function over time, also having related effects (vertigo, nausea, dizziness, fatigue, lack of concentration, etc.). Another situation of this kind can be encountered in the case of working for long periods in artificially lit halls or rooms, with blue light bulbs, which can sometimes have fluctuations in intensity [1], [2].

1.2 Visual Stress Assessment Methods

Currently, there are various methods of assessing visual stress, some of which involve sophisticated and very expensive equipment and devices. Others simply involve checking and recording how vision may be affected during and immediately after exposure to stress. All should have one main goal: to identify to what extent different situations involving a lower or higher dose of visual stress momentarily affect visual function [3], [4]. This aspect is extremely important, because in this way it is possible to extrapolate and draw up scenarios regarding the medium and long-term influence on vision for each of the stressors. Either this, once known, can be extremely useful to know which situations involve visual stress with major impact and, therefore, they should be avoided from the very beginning [5], [6], [7].

2 Proposed Method

2.1 Assisted Assessment of Visual Stress – Main Advantages

The assessment of visual stress in a computer-assisted form seems to be a practical option, while also being an efficient procedure, which allows an objective assessment of the results. On the other hand, this method helps the examiner, who, by means of a software application, can, based on the automatically generated results, quickly, but at the same time rigorously express certain conclusions regarding the testing done in the different situations.

In general, the main aspects targeted in the presence and absence of visual stress, the most important parameter affected by visual stress seems to be acuity, which is why, it is particularly determined with great care [8], [9].

2.2 Development and use of a Specific Software Interface Within the Proposed Method

The research have focused on the development of a low-cost simple method, and also efficient. A solution was found to develop and use a software application that can simultaneously induce visual stress and determining to what extent it can influence vision during exposure. Thus, an interface was designed through which testing can be done both in the absence and in the presence of visual stress.

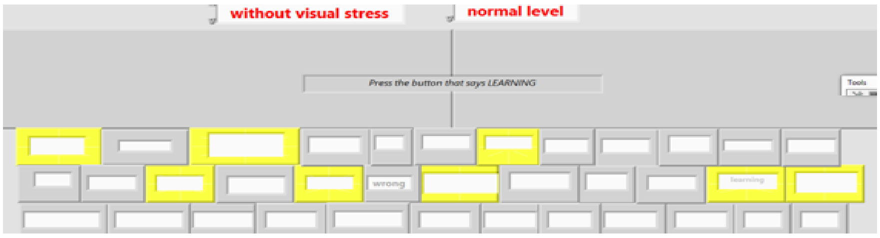


Fig. 1. Example of application running for testing without stress conditions

Figures 1 and 2 show two situations during the software running: testing is done without visual stress, and when visual stress intervenes during testing.

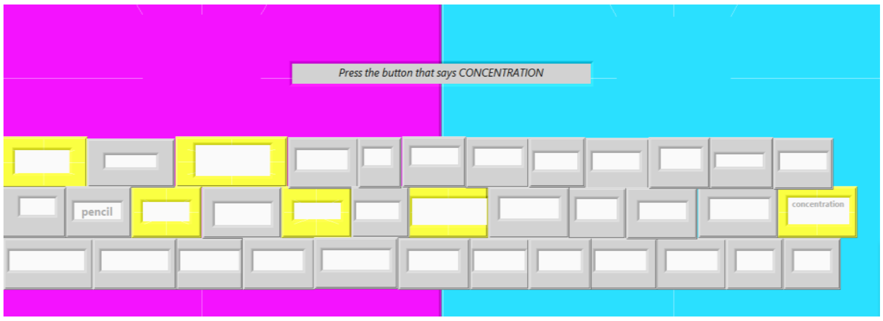


Fig.2. Example of application running for testing with visual stress

The basis for programming was a repetitive While-Loop structure for conditioning all logical events during a test run cycle. An image meaning the use of the structure can be seen in figure 3.

The main logical events that must take place during the running of the test refer both to the induction of visual stress, and to the generation of words takes place that the concerned person must to identify. The first events involved the establishment of variable time intervals, with random occurrence, for the continuous on and off of two large rear buttons, throughout the period of the cycle. Both were defined as Boolean input variables, in the "0" logical state they are gray, and in the "1" logical state they are colored (figures 1 and 2). The time intervals for successive turning on was related to the specific index of the While loop, imposing as many time constants as possible that define the intervals. The conditioning of switching on and off was done using two Boolean structures (True/False).

The outputs of the two Boolean structures were connected to the two buttons with the role of light stimulus (figure 4). The conditioning of the logical events specific to the display of text-messages was made so that they start to be displayed only after a period of time after the start of the test cycle.

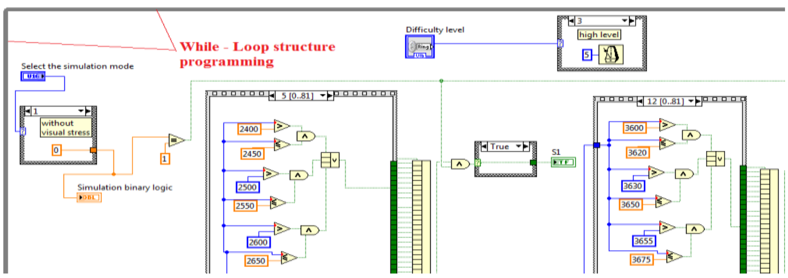


Fig. 3. While – Loop structure for all logic events programming

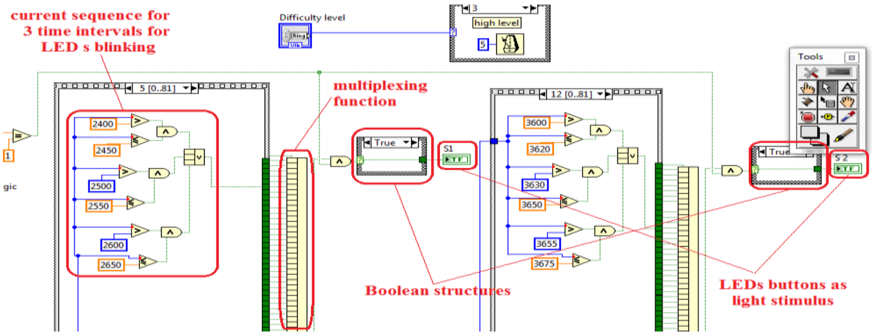


Fig. 4. Conditioning repeated for light stimuli turning on and off via Boolean structures and preset time intervals

The reason was that the subject had enough time to settle down and properly fixate on the text box located next to the two light stimuli. Specifically, the display of text messages was scheduled to begin about one-third of the way through the total test run.

Just as in the case of random flashes, time intervals have been predefined for which one word at a time will be displayed, in this case the time intervals are related by means of successive Boolean structures, as can be seen in figure 5. In figure 2, an example can be seen in which, at a given moment, a text message is displayed, and the yellow boxes represent the answers of the subject by which he spotted the text messages that were displayed previously. For this, an appropriate number of virtual button-type Boolean input variables were used, which the test subject could switch to.

An important aspect referred to the possibility of establishing its degree of difficulty, using a selector Case function with three values, low level, medium level and high level of difficulty. It was related by a multi-case structure of Switch type, as can be seen in figure 6.

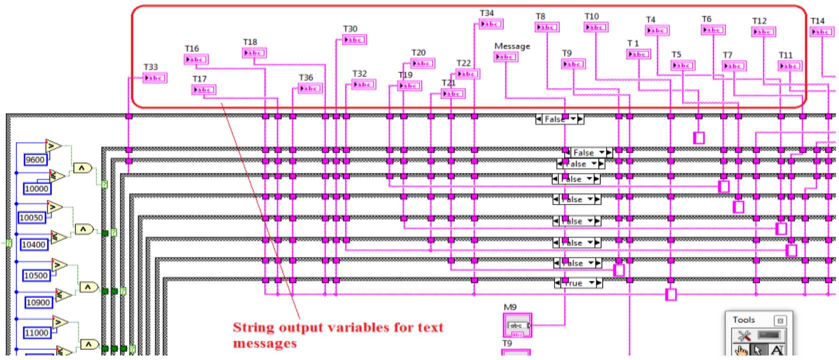


Fig. 5. Conditioning repeated for successively message text displaying during the test

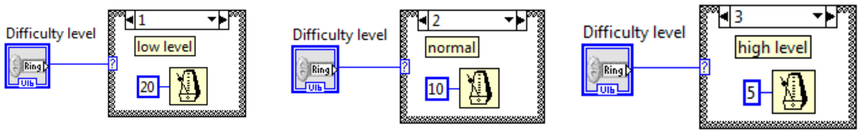
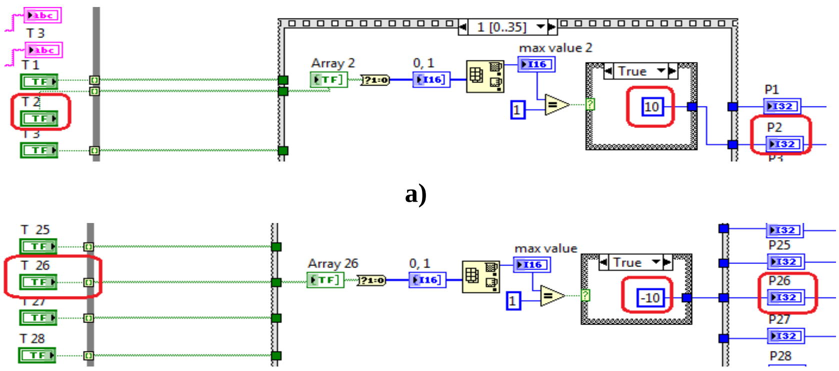


Fig. 6. Programming algorithm for degree of difficulty selection

For each case, another specific time constant was established for the cycle timing, practically modifying the speed of the test. Besides, another almost equally important aspect in terms of programming referred to the possibility of establishing the regime for testing: with or without visual stress; for this, another selector function was used, this time with two cases.

The ability to automatically quantify subject responses during testing was another particularly important aspect of the application's programming. For this, an algorithm was created to add up all the positive and negative partial scores recorded for each answer. By partial positive scoring is meant the awarding of a score for the situation in which the subject correctly identified and spotted the current displayed word at a given time. By negative scoring is meant the penalty given for false-positive errors, more precisely for indicating a different word from the list than the one indicated during the test run. This meant that each string output variable must have a corresponding LED button, through which the subject can indicate the answer.

In the following, the specific program routine involving a specific partial score to an answer will be described, in total there are 30 possible answers, but only 18 of them being correct. If during the test run cycle the button associated with the word the subject believed to have identified was toggled at least once, then a partial positive or negative score will be given for that step, depending on the correctness of the response.



a)

b)

Fig. 7. Example of subroutines specific to the partial scoring approach: a) for positive scoring; b) for negative scoring

Otherwise, the partial score awarded will be 0. For this, an option to index Boolean values has been set on the output of the While loop, so that, through a vector of Boolean values, converted into binary code, it can be identified if in that vector there is at least one value equal to 1. If so, meaning that a partial score must be given, it will be equal to 10 or -10. Because this routine must be repeated 30 times, as many possible answers as can be given during the test, it was necessary to use a sequential structure with 30 sequences, each one containing a sequence.

Figure 7 shows an example showing two distinct sequences, one corresponding to the awarding of a positive score and another specific to a de-pointing for a wrong answer.

In terms of using the application, the examiner has a series of clear and simple steps to go through: the first of them would be to choose the degree of difficulty, through the dialog box on the interface - panel (figure 8).

The same procedure applies to choosing how to conduct the. Both postures are illustrated in figure 9.

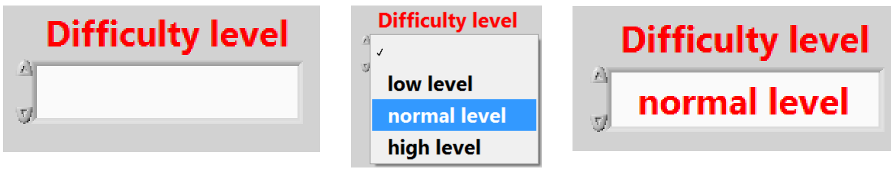


Fig. 8. Selecting the degree of difficulty

In general, the application serving for a comparative, it is recommended that, for the same subject, first the test is carried out under normal conditions and, after a period of time, but under the same physiological and environmental conditions to repeat the test in the presence of visual stress. Ideally, the test should be repeated on the next day at a time close to the time when the stress-free test was taken.

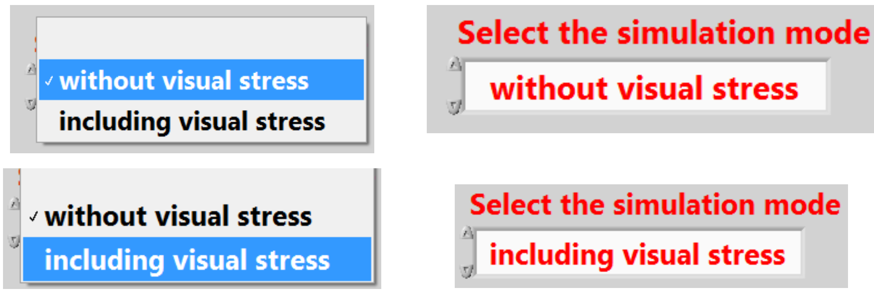


Fig. 9. Selecting the way to proceed for testing

The next stage consists in the actual running of the test, in which the person in question has a leading role, with the examiner even intervening when necessary. An example of this stage can be seen in figure 2.

The last stage, and the most important one, is the visualization of the results after the test, an example is illustrated in figure 10.

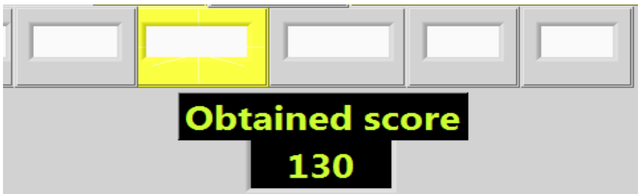


Fig. 10. Example of final score displaying

3 Results and Discussion

3.1 Selection and preparation of subjects for testing

Once the software has been completed, 10 people were identified who gave their consent to be tested both under normal conditions and under visual stress conditions. These were identified in the 40-50 age group, all of whom were male. 5 of these were identified as emmetropic, while another 5 were found to have myopia ranging from -0.75DS to -1.5DS.

To complete the tests, the subjects were clearly explained what they would consist of and what they had to do during the test. More specifically, they were told that they would first go through the test without any kind of visual stress, all subjects being evaluated, one by one, then they, in the same order, would be retested, but this time under conditions of visual stress [9].

3.2 Assessment procedure

All tests, both in normal mode and in visual stress mode, were supervised by an examiner, as a graduate of the Optometry specialization, so that there is no risk that, at some point, any of the people would no longer know what to he had to do. In addition, supervision was also useful to avoid certain fraud attempts (i.e. not keeping the distance from the laptop screen). In this idea, the distance imposed from the screen during testing was set at 0.8 meters, considered an intermediate viewing distance, and the screen was tilted at an angle of 10-15 degrees so that the visual axis of the subjects came perpendicular to screen.

The two stages, each, in turn, involved three sub-stages of evaluation, namely: reduced degree of difficulty, medium degree of difficulty and high difficulty (with the highest speed of displaying text messages). The procedure was followed, so that all subjects to be first tested one by one in the low difficulty level, then the testing was repeated in the same order for the medium difficulty and then for the high difficulty level. The reason for doing this was to not remember the order in which the text messages appear in a cycle to be identified. Obviously, the same procedure was applied identically for the 2nd stage of the assessment, under conditions of visual stress [9].

3.3 Presentation and comparative interpretation of the obtained results

Tables 1 and 2 show the results obtained after testing the 10 subjects in the 2 postures. It should be noted that the score awarded was considered between 0 and 180. For the tests the following abbreviations were made: LL - testing in the reduced level of difficulty; NL - medium difficulty test and HL - high difficulty test.

It should be specified that the subjects with myopia were evaluated without any correction of refractive errors (no glasses or contact lenses). The reason was to observe to what extent visual stress can affect more a subject with uncorrected or poorly corrected vision problems. This is because it is known that very often even if a person wears corrective glasses, they may no longer correspond to current needs [9].

Table 1. Testing the first 5 subjects, considered emmetropic

1st subject			2nd subject			3rd subject			4th subject			5th subject		
without visual stress														
LL	NL	HL	LL	NL	HL	LL	NL	HL	LL	NL	HL	LL	NL	HL
180	180	170	150	130	130	180	160	160	170	170	160	180	180	160
including visual stress														
170	150	130	130	120	120	150	140	120	150	130	110	150	140	130

Table 2 displays the results for the other tested persons (having myopia).

Table 2. Testing the last 5 subjects, having myopia

6th subject			7th subject			8th subject			9th subject			10th subject		
without visual stress														
LL	NL	HL	LL	NL	HL	LL	NL	HL	LL	NL	HL	LL	NL	HL
130	110	70	100	70	50	100	90	70	90	80	60	100	90	70
including visual stress														
120	70	50	90	60	40	70	70	50	80	70	50	90	80	60

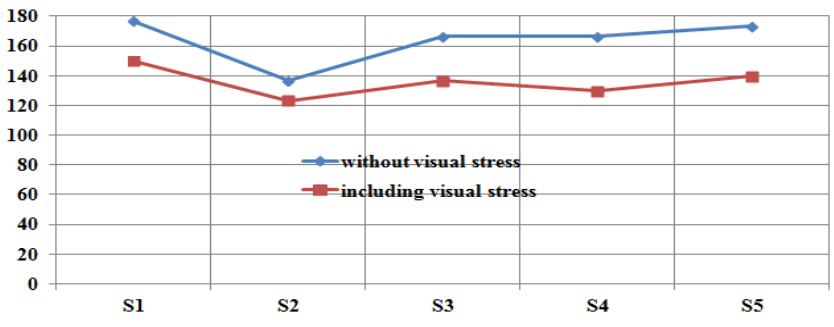


Fig. 11. Distribution of the values of the average scores of the first 5 men (emmetropics)

Figure 11 shows the distribution plots of the mean score values of the first 5 emmetropic subjects. Average scores mean the arithmetic mean of the scores obtained by a subject for all difficulty levels.
Figure 12 shows another distribution plot of the mean score values of the other 5 subjects (having myopia).

From this finding one could, by extrapolation, draw a conclusion, namely that a person with low vision could be more affected in the case of visual stress, but to a small extent, compared to a person without vision problems.

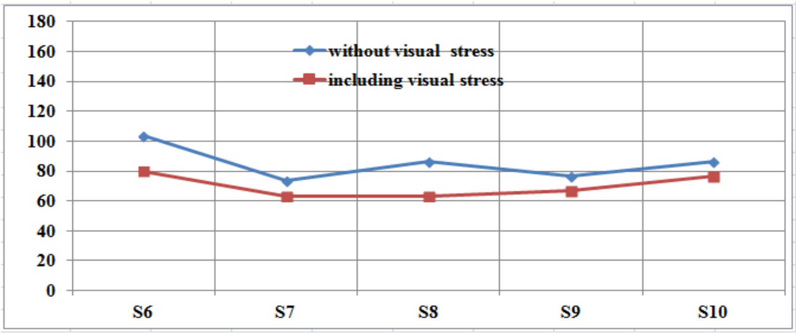


Fig. 12. Distribution of the values of the average scores of the last 5 persons (with myopia)

Obviously, a decrease in performance under conditions of visual stress could be observed, for both categories of people investigated. One of the aspects targeted was to observe which of the two categories would be more affected by the induction of visual stress. For this, starting from the data, as average values of the scores, for each category, the following could be found: For the first the decrease in performance as a result of the presence of visual stress it was about 17% compared to the case of no stress. For the second category the decrease in performance as a result of the presence of visual stress was approximately 18% compared to the case of the absence of stress.

4 Conclusion

The method proved to be effective and conclusive regarding the influence of visual stress on visual acuity and work performance. Although it was based only on the study of a single type of visual stress, it can be considered as a basis for further research, the expansion of assisted assessment methods of the influence of visual stress, the research can also be extended to prevent short- and long-term exposure to blue light and ultraviolet radiation. The main purpose was to raise concerns, through practical, objective and fast methods, in being able to prevent, as much as possible, the exposure of the eyes to as many forms of stress as possible. The main areas targeted would be occupational medicine optometry, military, occupational optometry and even sports optometry.

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