MINIMAL MOTION EXAMINATIONS ON COMPUTER CONTROLLED CRT MONITOR

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1. INTRODUCTION

Color brightness matching measurements was first used to determine the relative visibility function (V(λ)). Since then four methods of comparing and checking the different color brightness have spread the direct matching, the minimally distinct border method, the flicker photometry and the minimal motion process [3,4,10].

The computer controlled color brightness matching is considered as a relatively new area. In our earlier monitor researches we transplanted the direct matching and the minimally distinct border methods to monitor use. However with the development of the PC's graphic parameters we tried to put the flicker photometry and the minimal motion methods into practice too.

The aim of our color brightness measurements on CRT monitors considering color vision examination is to develop tests with equal brightness, so that during their completion the color sensation (and not the brightness sensation) will be examined.

We developed for our researches an out of ordinary disc formed pattern instead of the railed one. This way the minimal motion brightness matching (MMBM) test became more solvable. Beside these checked measuring terms we tried to determine the red/green intensity proportion on the R and G monitor primaries full appearable luminance scale which belongs to the same measurable brightness sensation.

Keywords: Colour brightness matching, CRT monitor, minimal motion technique

2. MODIFIED MINIMAL MOTION TECHNIQUE

The apparent motion developed in the MMBM inquiry can be established with representing of the consecutively appearing colored gratings. We have to flare up four gratings following each other if we want to harmonize the red and green brightness sense with the MMBM method. The first grating is red-green, the second: light and dark yellow, the third and the fourth include the colors of the first and the second gratings vise-verse. The gratings are shifted ¼ cycle a step. The grating' flaring, mentioned above, produces one way motion. We can achieve the ceasing of the visual movement of the gratings if we make one of the bar intensity changeable. In this case the measured I_{Red} and I_{Green} intensity values can be considered as the same brightness.

We developed a disc form test pattern during our researches which also originates the apparent motion by the methods mentioned above (Figure 1.). During measuring the disc MMBM it apparently moves to the right or to the left by changing the intensity of one of the colors. The direction of the movement depends on which primary is brighter.

To increase the effectiveness of the test we changed the middle yellow gratings to achromatic (light and dark gray) ones, because only the brightness stimulus takes part in the development of the apparent motion, so we put the color stimulus aside.

The quality of the apparent motion representation also depends on the average luminance of the gray steps. During the test the average luminance of the red-green step is changing, so if we don't adjust the luminance of the gray step to the luminance of the red-green step, we can develop only hardly recognizable vibrating motion. For the compensation of this we generalized the luminance control of the two gray steps concerning the average luminance of the red-green steps, derived from the gamma function.

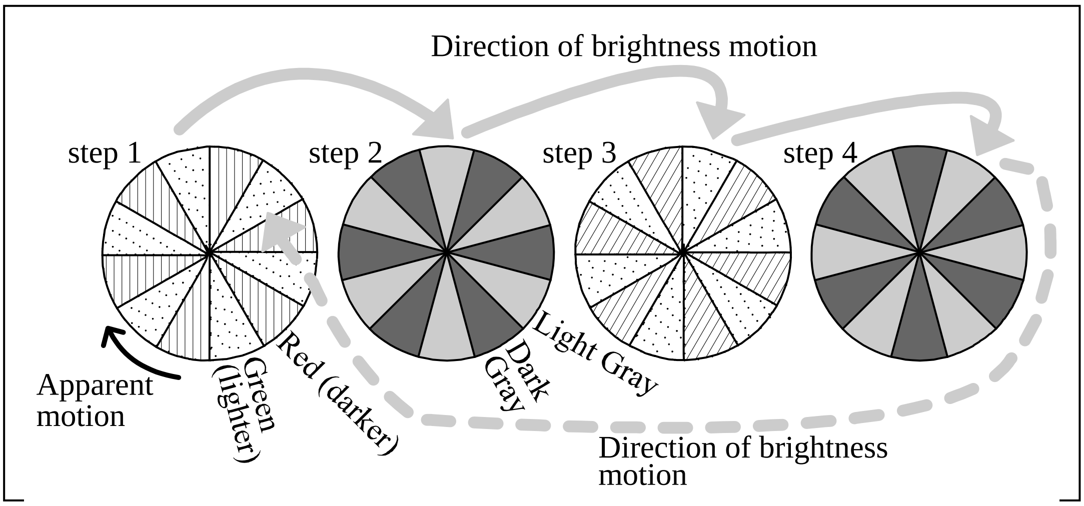

Figure 1.
The development of the apparent motion with the disc form test pattern

3. METHODS

The observers' taste was to set the I_{Red}/I_{Green} values for the primaries with different intensities and equal brightness. It denotes two series because we can put both I_{Red}/I_{Green} graphs to the red and to the green primary. The I_{Red}/I_{Green} values are calculated from the DAC values on the base of calibrated CRT monitor graphs ($I_{RGB}=f(DAC_{RGB})$).

In two series we checked the brightness equality on those red and green DAC intervals where the movement effect was enough strong (above 15 DAC) and so the red-green similar brightness could be developed. Applying the test to the anomalous color vision, we disregarded the adaptation field appearing on the monitor because of the CRT's lined red spectrum. So the given color temperature adaptation will happen on a lighted white paper.

4. MEASUREMENTS

The measurements took place in a dark room. (The measurement's set up can be seen on Figure 2.).

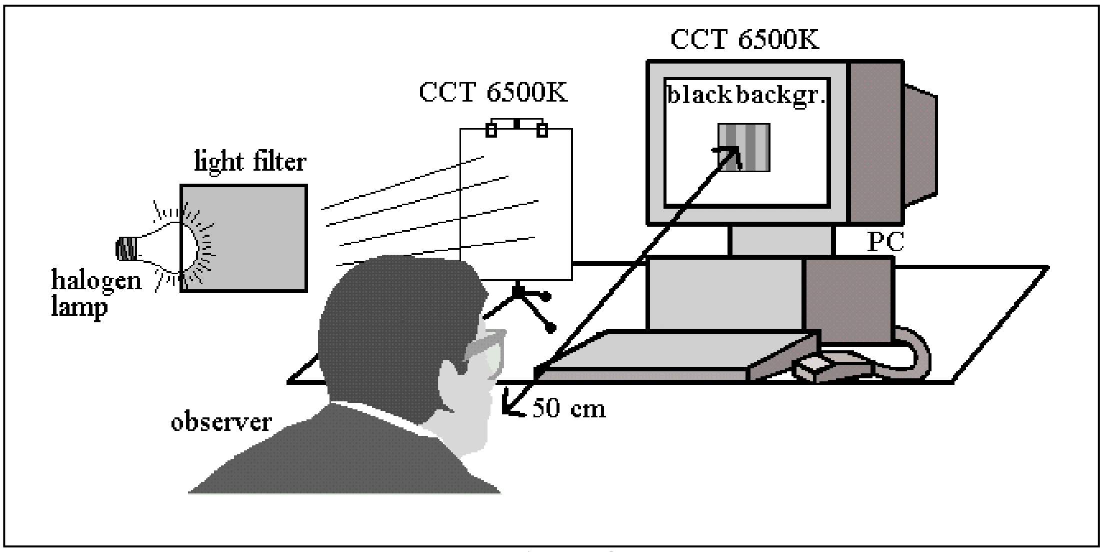

Figure 2.
The measurement's set up

The adaptation field is a white technical paper lighted by a halogen lamp. The luminance of the paper is 80 cd/m^2, the color temperature is 6500 K (CCT). We have adjusted the calibrated monitor's color temperature at the maximal DAC value of the RGB primaries to 6500 K (CCT) so that the monitor's luminance was 80 cd/m^2 too [18,11]. The observation distance is 50 cm both from the monitor and from the adaptation field.

10 normal color vision people age 22-27 were chosen among from university students with the help of the Velhagen pseudoisochromatic plates. The measurements were made with the help of red and green DAC scales. For the determination of the I_{Red}/I_{Green} proportion we took the 10 measurement points out of 20 steps between 15-195 DAC for the red primary and 7 measurement points between 15-105 DAC for the green one. The observer between each measure step was adapted to the lighted paper in 30 s period.

The target software on an Intel Celeron 633 machine (256Mb memory) runs with the Intel 810 graphic hardware, on an "LG 15" monitor, with 800x600 resolution, 75 Hz vertical refresh and 24 bit colors. Both test figures appeared in a 3º visual angle. The animation speed was 7,5 Hz, the spatial frequency at the gratings was 16 pixel/cycle and 30 º/cycle at the disc. These parameters were optimized to achieve the best motion effects.

We measured the completion time of the four series and at the end of the research the measuring person had to make a statement about which test, the disc or the railed one could have been done more easily. We made a repeated test on one test person to find out the reliability of the test.

5. RESULTS

The I_{Red}/I_{Green} equal brightness in function of relative intensity (I_{Red}) was taken three times from the 6th person on the disc form picture (Figure 3.). The correlation coefficients of the samples were under 0,95 so the I_{Red}/I_{Green} measurements in the

DAC domain are behaving as linear. Because of this the $I_{Red}/I_{Green}=f(I_{Red})$ and the $I_{Red}/I_{Green}=f(I_{Green})$ functions can be written down as follows:

$$\frac{I_{\mathrm{Re}\,d}}{I_{Green}} = a_R + b_R \cdot I_{\mathrm{Re}\,d} \quad ; \quad \frac{I_{\mathrm{Re}\,d}}{I_{Green}} = a_G + b_G \cdot I_{Green} \qquad (1)$$

, where the a_R , b_R , a_G , b_G are the linear coefficients applied to the calibrated monitor measurements in the 15 DAC_{Red} 195 and 15 DAC_{Green} 105 DAC intervals.

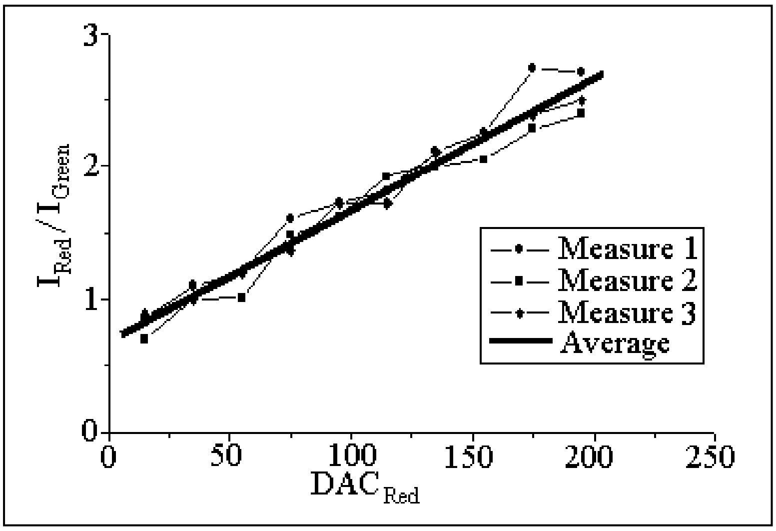

Figure 3.
Repeated tests on the 6th test person

Further results of the repeated test can be seen in Table 1. We couldn't show the significant difference between the a and b coefficient which pertains to the same type.

Table 1.
The repeat ability a and b coefficient in four measured patterns.

repeat	Red scale (15-195 DAC)				Green scale (15-195 DAC)			
	Grating		Disc		Grating		Disc	
	a_R	**b_R**	**a_R**	**b_R**	**a_G**	**b_G**	**a_G**	**b_G**
1	3,46	1,25	3,45	1,30	13,88	1,27	11,44	1,39
2	3,54	1,30	2,96	1,22	8,63	1,67	9,89	1,25
3	2,78	1,40	3,08	1,27	10,03	1,54	8,29	1,51
average	**3,26**	**1,31**	**3,16**	**1,26**	**10,85**	**1,50**	**9,87**	**1,38**
st.dev.	**0,42**	**0,08**	**0,26**	**0,04**	**2,72**	**0,20**	**1,57**	**0,13**

We represent the a and b coefficients of the four I_{Red}/I_{Green} functions in Table 2. The difference between the coefficients achieved on the red intensity scale is minimal, and neither did we get significant difference on the green intensity scale.

The I_{Red}/I_{Green} rates (Figure 4.) in function of the combined green and red primaries' relative intensities (measured with 2 methods) show difference, which has been already expected on the base of the visibility function and the RGB channels' different emissions.

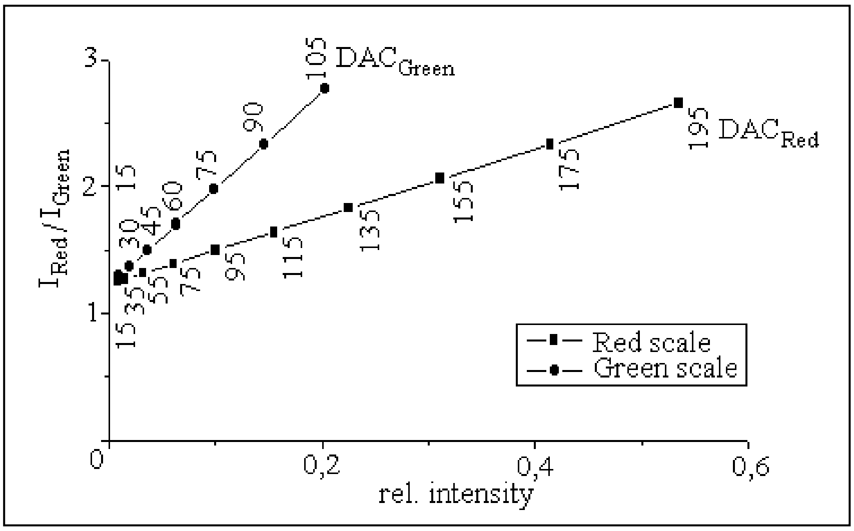

Figure 4.
Combined relative intensity rates concerning the green and red (with equal brightness)

Table 2.
Green and red I_{Red}/I_{Green} characteristics' linear coefficients measured with railed and disc test pattern.

observer	Red scale (15-195 DAC)				Green scale (15-195 DAC)			
	Grating		Disc		Grating		Disc	
	a_R	**b_R**	**a_R**	**b_R**	**a_G**	**b_G**	**a_G**	**b_G**
1	3,32	1,05	2,19	1,26	6,08	1,31	6,98	1,20
2	2,31	1,26	2,18	1,15	5,70	1,33	4,77	1,30
3	3,21	1,14	1,67	1,11	7,97	1,14	6,00	1,24
4	2,88	1,23	2,58	1,24	6,92	1,50	5,46	1,26
5	2,07	1,40	2,07	1,38	7,94	1,84	5,13	1,40
6	3,46	1,25	3,45	1,30	13,88	1,27	11,44	1,39
7	3,40	1,23	3,37	1,42	8,82	1,20	7,77	1,73
8	2,17	1,37	2,75	1,12	7,24	1,11	5,59	1,08
9	2,12	0,92	1,82	0,82	6,65	1,25	6,32	1,16
10	3,22	1,35	2,94	1,61	11,89	1,64	9,69	1,92
average	**2,82**	**1,22**	**2,50**	**1,24**	**8,31**	**1,36**	**6,91**	**1,37**
st.dev.	**0,58**	**0,15**	**0,62**	**0,21**	**2,62**	**0,23**	**2,15**	**0,26**

To the question that with the help of which test pattern is the test easier to do 9 of the 10 person have chosen the one with the disc form. This fact is also supported by the completion time of each series (Figure 5.).

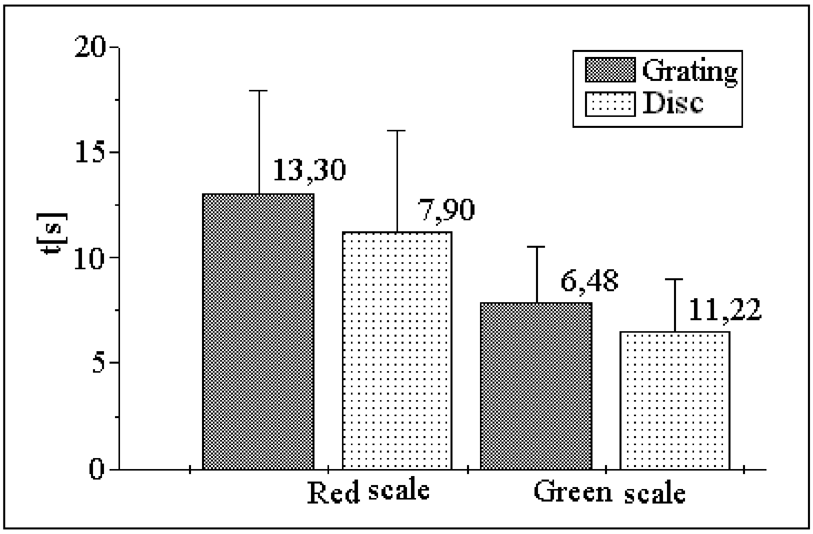

Figure 5.
The average time of the test

6. CONCLUSION

On the base of the 10 person MMBM test we found close linear connection on the measured red and green intensity domain between the intensities of the monitor primers and the red/green intensity. Despite the different test patterns the measured red and green functions proved to be the same. With the help of the disc form test pattern on the base of the tested persons' answers the MMBM test was easier to do then the grating test, but the grating test took less time and provided the same results.

So the developed disc form MMBM test and software can be reliably used to measure the $I_{Red}/I_{Green}=f(_{IRed})$ and the $I_{Red}/I_{Green}=f(I_{Green})$ functions, and these functions can be safely and effectively used in such color vision CRT monitor tests where we want to eliminate the color brightness discrimination.

7. ACNOWLEDGEMENTS

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