

# DETERMINATION OF THE INFLUENCE OF MEDIA ON THE NEON COLOUR SPREADING

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Original scientific paper

This paper represents a continuation of investigation of the influence of various parameters in the process of graphic reproduction on the intensity of the neon colour spreading effect. Influence of different media (printing substrates, and a LCD monitor) was examined, with certain combinations of the inserted segment colour and surround colour of the primary stimulus. The study was conducted on the Ehrenstein figure, with D65 CIE standard illuminants. The intensity of the effect is calculated using the colour difference variable, which represents the deviation in manifestation of neon colour spreading effect in relation to the colour of the graphic reproduction medium. Statistical analysis of results was conducted by using appropriate non parametric tests. It indicates that there is a statistically significant difference in the evaluation of the intensity of the investigated effect in most cases of printing substrates compared to the LCD monitor as a medium. The higher intensity of the effect on the LCD monitor than on the printing substrates was confirmed.

**Keywords:** *graphic reproduction, intensity, medium, neon colour spreading*

## Određivanje utjecaja medija na neonsko proširivanje boje

Izvorni znanstveni članak

Ovaj rad predstavlja nastavak istraživanja utjecaja određenih parametara unutar procesa grafičke reprodukcije na intenzitet efekta neonskog proširivanja boje. Istraženo je djelovanje različitih medija (tiskovne podloge i zaslon računala), uz određene kombinacije boje umetnutog segmenta i pozadinske boje primarnog stimulusa. Istraživanje je provedeno na testnim uzorcima baziranima na tzv. Ehrensteinovom modelu, uz standardni D65 CIE izvor svjetla. Intenzitet efekta prikazan je izračunanim kolorimetrijskim razlikama boja koje predstavljaju odstupanje manifestirane boje u efektu neonskog proširivanja boje u odnosu na boju medija grafičke reprodukcije. Statistička analiza rezultata istraživanja provedena je primjenom odgovarajućih neparametarskih testova. Ona ukazuje kako postoji statistički značajna razlika u vrednovanju intenziteta istraživanog efekta u većini slučajeva korištenja tiskovnih podloga kao medija u odnosu na zaslon računala kao medij. Potvrđen je veći intenzitet efekta na zaslonu računala nego na tiskovnim podlogama.

**Ključne riječi:** *grafička reprodukcija, intenzitet, medij, neonsko proširivanje boje*

## 1 Introduction

The area of graphic and multimedia communications is passing through almost daily changes. Image files with the same colour information are reproduced on different media in the process of graphic reproduction. Every new medium creates a new environment in which it is necessary to provide a correct perception of coloured samples. Contemporary models of processing and presentation of colour information in different media within the process of graphic reproduction that we use every day (imprints, computer screens, mobile devices, TV, projectors, etc.) base their work on the classical colorimetric colour models (first of all CIELAB i CIEXYZ). Besides the mentioned colorimetric colour models, there are also intuitive colour models, colour models of device and colour appearance models. Building objective models of human perceived colour will allow better understanding of the relationship of trichromatic values coloured stimulus and all relevant parameters influencing the system of the multimedia communications [1]. To achieve uniformity of colour (correct colour appearance) through all phases of the process of graphic reproduction is doubtful in conditions of appearance of various psychophysical visual effects [2, 3, 4, 5].

Quantitative and qualitative analysis of individual psychophysical visual effects contributes to creating an environment in which the forecasting process excludes all objective and subjective conditions of observation influencing significant deviations in the perception of graphic reproduction [6, 7, 8].

Previous studies of the neon colour spreading effect did not give a complete picture of the influence of various parameters in the process of graphic reproduction on the

intensity of the effect. The intensity of the manifestation of the neon colour spreading effect with respect to its known characteristics is determined by various parameters [9, 10, 11, 12]: standard illuminants, coloured stimuli characteristics, geometric characteristics of stimulus, types of media in the reproduction system of graphic product design.

In the mentioned experiments, the influence of various parameters on the manifestation of the neon colour spreading effect in the process of graphic reproduction was investigated. Papers were published, Vusić et al. *"The neon colour spreading effect in various surround ambient conditions"* and Vusić et al. *"The influence of the primary colour stimuli selection on the neon colour spreading"*, in which a level of the influence of particular standard illuminants on the neon colour spreading effect in the process of graphic reproduction and the influence of the selection of primary colours of additive and subtractive synthesis when designing test patterns (stimulus) based on Ehrenstein figure, was determined. The research results clearly demonstrated that the influence of the selection of inserted segment colour and surround colour on the primary stimulus of Ehrenstein figure was more important for the manifestation of the effect than the change of the illuminants.

This paper will investigate the influence of the various media on the manifestation of the neon colour spreading effect in the process of graphic reproduction. Determination of the quantitative value of the effect intensity provides the use of colorimetric and psychophysical research. The test samples based on Ehrenstein figure (Fig. 1) were created, where the influence of application of the various media in the

process of graphic reproduction on the neon colour spreading was investigated. Deviations in the colour perception due to manifestation of psychophysical visual effect of neon colour spreading under the influence of the media are shown by colorimetric colour difference [13].

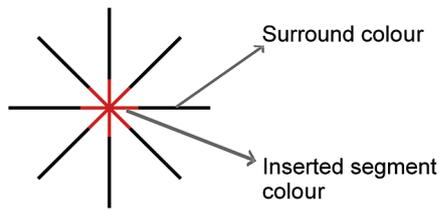


Figure 1 The Ehrenstein figure

## 2 Experimental part

The experimental part of this paper includes investigation of the intensity of the neon colour spreading effect depending on the media - different printing substrates and LCD monitor.

### 2.1 Research description

For investigation, twelve test samples were created (Tab. 1) by using Adobe Illustrator. The basis of test patterns is the Ehrenstein figure – specific geometric structure consisting of sets of orthogonal lines formed by combining various colour combinations of the primary stimulus.

Table 1 Colour combinations of test samples

Tests samples	Inserted segment colour	Surround colour
1	red	"black"
2	green	"black"
3	blue	"black"
4	cyan	"black"
5	magenta	"black"
6	yellow	"black"
7	red	cyan
8	green	magenta
9	blue	yellow
10	cyan	red
11	magenta	green
12	yellow	blue

Tab. 1 shows the colour combinations of primary stimulus. The line colour in each test sample is combined with primary colours of additive (red, green, blue) and subtractive synthesis (cyan, magenta and yellow) like the inserted segment of the primary stimulus. As a surround colour of the primary stimulus "black" is used in one case (Fig. 2) and the colours that are complementary to the colour of the inserted segment of primary stimulus in the second case (Fig. 3). The surround of the primary stimulus is "white" colour of the media, size A4. The size of test samples was defined according to standard ambient conditions of observation (ISO 3664:2009 standard, which specifies the observation conditions for graphic technology and professional photography) at the viewing angle of 10° and the distance of subjects of 50 cm.

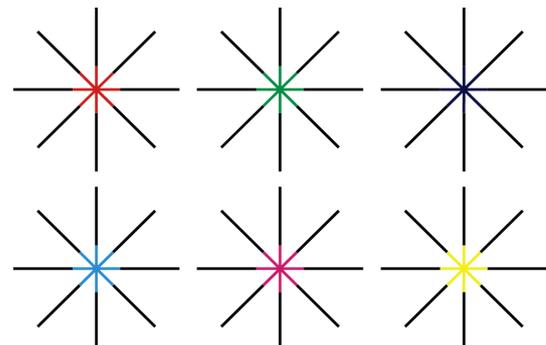


Figure 2 Test samples by black surround colour

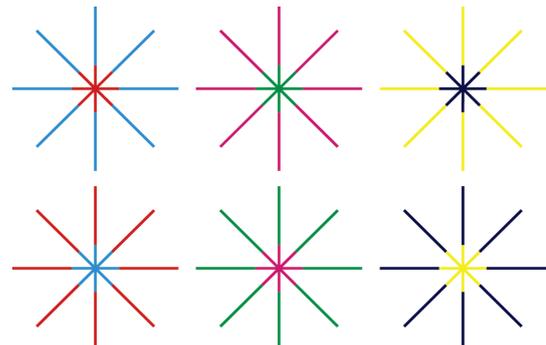


Figure 3 Test samples by complementary colour surround

When creating test samples, CMYK colour space was used. As a file format bit map (\*.psd) format is used. The printing of test samples was performed on calibrated digital printing machine - "Epson StylusPro 7900 HDR" on the principle of liquid toner cartridges (Epson UltraChrome HDR ink). Screening and printing were done by "GMG ColorProof" application using the absolute colorimetric ICC rendering method. The accuracy of reproduction of tristimuli colour characteristics with the selected print resolution of 720×720 dpi is <math><0,5 \Delta E^\*</math> of the total colour space.

As the main parameter of research were used three different media of the graphic reproduction: two printing substrates - "GMG ProofMedia - Proof paper Glossy and Proof paper SemiMatte", and LCD monitor HP DreamColor LP2480zx. Multiple coated printing papers for art printing - "GMG ProofMedia - Proof paper Glossy", grammage 250 g/m<sup>2</sup>, high whiteness (expressed in CIE  $L^*a^*b^*$  values:  $L^* = 94,1$ ,  $a^* = -0,6$  and  $b^* = -0,3$ ) and "GMG ProofMedia - Proof paper SemiMatte", grammage 250 g/m<sup>2</sup>, high whiteness (expressed in CIE  $L^*a^*b^*$  values:  $L^* = 93,6$ ,  $a^* = -0,6$  and  $b^* = -0,4$ ) was used as the printing substrate. Before printing, the printing substrate itself was placed in the identical room conditioned in the time period of 48 hours to the prescribed standard ambient conditions (the temperature of 23 °C and relative humidity of 55 %). The characteristics of the referent display the following: diagonal 24" (61 cm), display resolution 1920×1200, bandwidth of colour space in the internal processing is within min 10 bits to max 12 bits, IPS panel, RGB LED backlighting, while the volume of colour space for display is about 133 % NTSC.

For the purpose of visual evaluation of the test samples using the *constant stimuli method*, six reference colour atlases were created with the primary colours of additive and subtractive synthesis by using Adobe

Photoshop. The colour atlases are based on the change of perceptual attributes of colour within the HSB colour model in a way that the tone value ( $H$ ) and brightness ( $B$ ) is constant, and reference fields are formed in steps of 1 % of the value change of colour saturation ( $S$ ), ranging from 0 ÷ 30 % of the saturation values (Fig. 4). As a file format bitmap (\*.psd) ile format is used in the CIELAB colour space. The colour atlases are printed on identical printing substrates and in identical printing conditions like the test samples.

Determination of the intensity of manifestation of the neon colour spreading colour is enabled by the application of colorimetric and psychophysical studies. Together they form methodology for determining the physical values of visual perception of coloured stimulus due to manifestation of psychophysical visual effects. The colorimetric part of the study presents a spectrophotometric measurement which was used with formed reference fields on the printed colour atlas to determine the corresponding CIE  $L^*a^*b^*$  values and colorimetric difference colour values of each field in relation to the printing substrate [13]. Visual evaluation was based on the use of simultaneous binocular technique of harmonization through the visual discrimination of stimulus [14].

The experimental and selected parameters (physical values) are designed on the basis of method of constant stimuli. While conducting a visual evaluation, the subjects had the task to separate and join from the colour atlas a test field of the atlas, which is identical or most similar to values of the observed manifestation of the neon colour spreading effect of the test sample tested. The intensity of the neon colour spreading effect in dependence on the graphic reproduction media selection, at the standard D65 CIE illuminant, will be displayed graphically using the calculated colorimetric colour differences  $\Delta E^*_{94}$ . The colorimetric colour difference  $\Delta E^*_{94}$  is calculated using the equation [15, 16]:

$$\Delta E^*_{94} = \sqrt{\left[ \left( \frac{\Delta L^*}{k_L S_L} \right)^2 + \left( \frac{\Delta C^*_{ab}}{k_C S_C} \right)^2 + \left( \frac{\Delta H^*_{ab}}{k_H S_H} \right)^2 \right]}, \quad (1)$$

$k_L = k_C = k_H = 1$  for reference conditions,  
 $S_L = 1$ ,  $S_C = 1 + 0,045C^*_{ab}$ ,  $S_H = 1 + 0,015C^*_{ab}$ ,

where  $k_L$ ,  $k_C$  and  $k_H$  are parameters that are used to adjust the relative values of brightness, saturation and tone in conditions of observation, which are different from those defined by the CIE Commission [17]. Factors  $S_L$ ,  $S_C$  and  $S_H$  represent positional function, whose role is to correct the perceptual non-uniformity of CIELAB colour space.

In the printed colour atlases, the corresponding CIE  $L^*a^*b^*$  values of individual reference fields were measured. The measurement was carried out with "GretagMacbeth Eye-One" reflective spectrophotometer, choosing standard CIE illuminant – "daylight" D65, at the viewing angle of  $10^\circ$ . The accuracy of the device is  $\Delta E^*_{94} = 0,4$  for the D50 standard illuminant and viewing angle of  $2^\circ$ . With spectrophotometric measurements of reference fields of colour atlases the corresponding colorimetric values were expressed in CIE  $L^*a^*b^*$  values.

Based on these values the colorimetric colour differences  $\Delta E^*_{94}$  were calculated - the deviation in relation to colorimetric values of media colour.

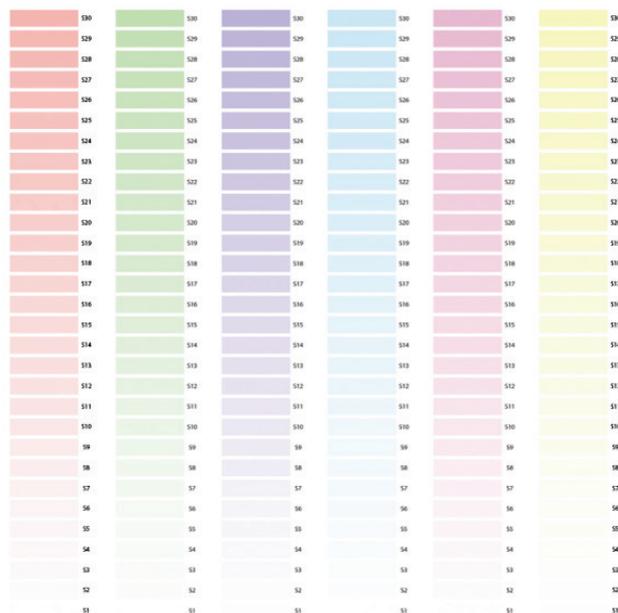


Figure 4 The colour atlas

Visual evaluation of the test samples was conducted on a sample of 30 subjects (mixed female-male population, average age 21 years). Before the evaluation process, the subjects successfully met the criteria of the Ishihara test (24 plates) for the detection of potential sight deficiencies. The visual field to conduct the experiment in controlled standard ambient conditions is configured in accordance with the guidelines of ISO 3664:2009 standard – viewing angle of  $10^\circ$ , the distance of the subject of 50 cm, neutral matte gray colour ambient, dimmed area. For this purpose, a stationary cabox for the observation of the test patterns, "The Judge II-S" was used (Fig. 5). In accordance with the preset experiment, the examined test samples and the corresponding colour atlases were evaluated under standard D65 CIE illuminants (6500 K– "daylight").



Figure 5 A stationary box for the observation of the test patterns "The Judge II-S"

The procedure of visual evaluation was performed using the *simultaneous binocular adjustment technique* – the colour atlas and the test sample were placed simultaneously in an integrated visual field, side by side

[18]. Each subject had a task to separate the reference field in the colour atlas which is of identical or most similar value of the observed manifestation of the neon colour spreading effect of the examined test sample by using visual discrimination and according to his personal judgment. The duration of assessment of individual subjects was not restricted. The described method is the method of constant stimuli – the subjects were randomly presented with a set of stimuli with various preset fixed physical values. Physical stimuli values (reference fields in the colour atlas) were selected in a manner that the entire potential threshold area of perception was covered. The minimum physical value of the reference field is very slightly below the expected threshold of perception, and the highest is above the expected threshold of perception.

## 2.2 Results and discussion

The statistical analysis of the results of visual evaluation and discussion of research results was related to the determination of intensity size of neon colour spreading effect under the influence of the media as a parameter of graphic reproduction.

Distribution data obtained by research statistically significantly deviates from the normal distribution (tested Kolmogorov-Smirnov test). For this reason, the calculation of statistically significant differences between the samples is done using a nonparametric Kruskal - Wallis test. This test is designed to test three or more samples that do not follow a normal distribution, which are independent and which are not of equal length.

For a graphical presentation of the data distribution is used the box and the whisker plot. Thicker black line marks the median (a positional mean value) – an indicator of the mean value data. Within some of the boxes and the whisker plot are rectangles that represent the values of the mean 50 % of the data (interquartile range between 25 % and 75 %). Those at nonparametric tests have a role of scattering data indicators. Horizontal black lines represent the minimum and maximum value of the data obtained within each sample that is not the so called outlier (marked with a red cross). Outliers are extreme data values that leave out the test algorithm to calculate statistically significant differences between samples.

Statistical analysis tested the null hypothesis of no statistically significant differences between samples. Statistically significant differences in the analysis are considered confirmed at the level of  $p < 0,05$ .

In the cases of statistically significant differences between samples, by multiple comparisons test was determined which samples are statistically significantly different.

There is a statistically significant difference between the samples in the intensity of the effect due to the three media of the process of graphic reproduction determined (Glossy paper, Semi matte paper and LCD monitor), for particular inserted segment colour (red, green, blue, cyan, magenta, yellow), D65 illuminant, by "black" or complementary surround colour. Figs. 6 ÷ 11 give a graphical presentation of the data distribution.

The results of the Kruskal-Wallis tests are summarized in Tabs. 2 ÷ 7. They are relating to the intensity effect depending on the type of media, for

particular inserted segment colour, D65 illuminant, by "black" or complementary surround colour.

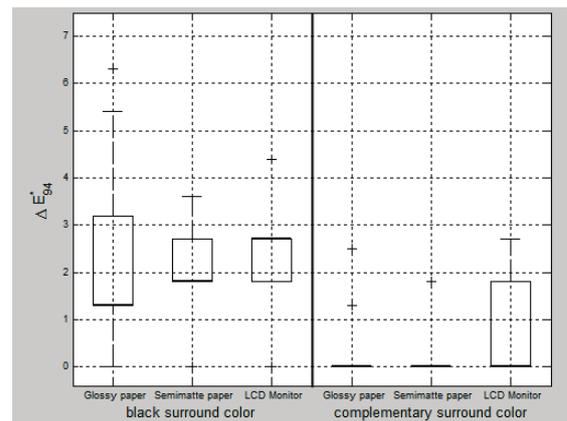


Figure 6 The intensity of the effect depending on the media, for the red inserted segment colour, D65 illuminant, and "black" or complementary colour surround

Fig. 6 gives a graphical presentation of the data distribution of intensity of the neon colour spreading effect in dependence of media, for the red inserted segment colour, D65 illuminant, and "black" or complementary surround colour. The same minimum median value (0) in all media can be noticed for complementary surround colour. The highest median value (2,7) has a LCD monitor at the "black" surround colour. Except for the Glossy and Semimatte paper for complementary surround colour where data are concentrated around the median value, in other cases the data are scattered.

It is evident from Tab. 2 that there is no statistically significant difference in the intensity of the effect between the samples due to the media for the red inserted segment colour, D65 illuminant, and "black" surround colour ( $p = 0,2186$ ), while on the complementary background there is a significant difference between samples ( $p = 0,0036$ ), and that between the samples 7D65-G and 7D65-Z, 7D65-S and 7D65-Z.

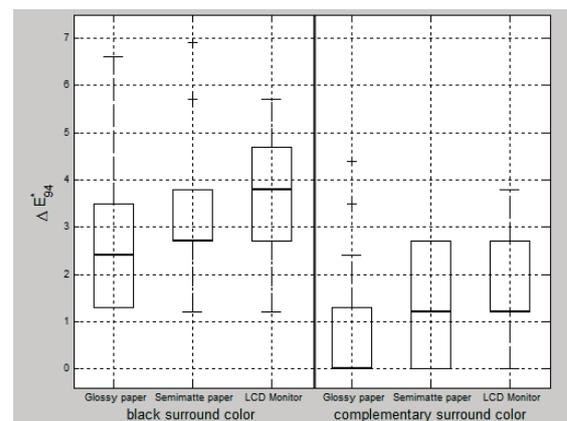
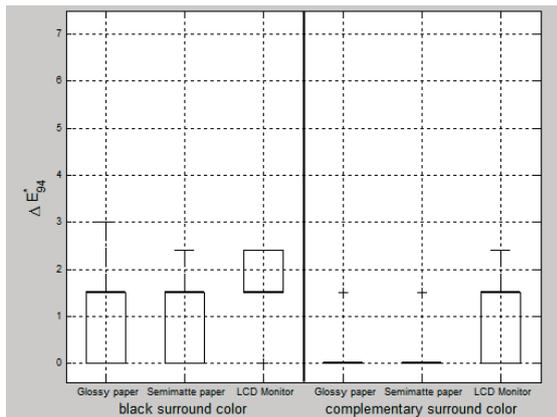


Figure 7 The intensity of the effect depending on the media, for the green inserted segment colour, D65 illuminant, and "black" or complementary colour surround

Graphical presentation of the data distribution of intensity of the neon colour spreading effect in dependence on media, for the green inserted segment colour, D65 illuminant, and "black" or complementary surround colour in Fig. 7 shows that the highest median

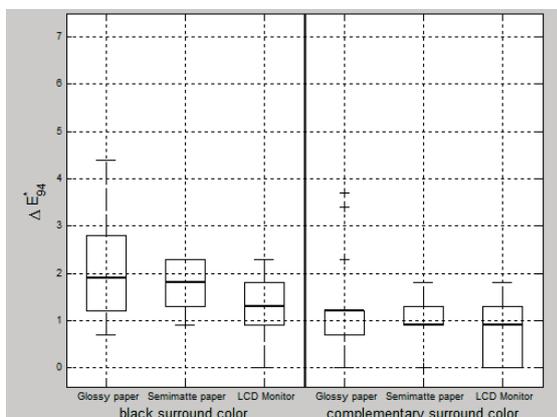
value is obtained at the LCD monitor for a "black" surround colour in the amount of 3,8. On a complementary surround and Glossy paper as a media is recorded the lowest median 0. Ranges in the middle 50 % of the data indicate data scattering.

There is a statistically significant difference in the intensity of the effect between the samples due to the media for the green inserted segment colour, D65 illuminant, and "black" surround colour ( $p = 0,0069$ ). Different samples are 2D-G and 2D-Z. At the complementary surround there is also a significant difference between samples ( $p = 0,0150$ ), and that between the samples 8D-G and 8D-Z, 8D-S and 8D-Z (Tab. 3).



**Figure 8** The intensity of the effect depending on the media, for the blue inserted segment colour, D65 illuminant, and "black" or complementary colour surround

The data analysis of intensity of the neon colour spreading effect in dependence on the media, for the blue inserted segment colour, D65 illuminant, and "black" or complementary surround colour in Fig. 8 refers to the same median value (1,5) in all researched media for "black" surround colour and the complementary surround colour for the LCD monitor. At printing substrates and complementary surround colour a positional mean value is equal to 0. For the median value 0 data are not dispersed, while in other situations dispersion of data is present.



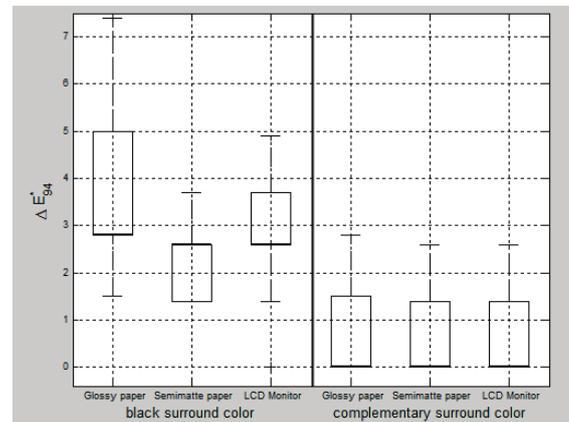
**Figure 9** The intensity of the effect depending on the media, for the cyan inserted segment colour, D65 illuminant, and "black" or complementary colour surround

According to the data from Tab. 4 there is a statistically significant difference in the intensity of the

effect between the samples due to the media for the blue inserted segment colour, D65 illuminant, and "black" surround colour ( $p = 0,0240$ ) and complementary surround colour ( $p = 0,0000$ ). Different samples are 3D-S and 3D-Z, 9D-G and 9D-Z, 9D-S and 9D-Z.

Maximum of the positional mean value of the neon colour spreading effect in dependence on the media, for the cyan inserted segment colour, D65 illuminant, and "black" or complementary surround colour comes to 1,9 on Glossy paper for the "black" surround colour. The lowest median value can be noticed for complementary surround colour Ehrenstein figure on the Semimatte paper and LCD monitor 0,9. The data are scattered in all cases - the value of the scattering is average as inter quartile ranges shown in Fig. 9.

The data from Tab. 5 indicate that there is a statistically significant difference in the intensity of the effect between the samples due to the media for the cyan inserted segment colour, D65 illuminant, and "black" surround colour ( $p = 0,0000$ ), while the complementary surround colour does not exist ( $p = 0,8457$ ). Different samples are 4D-G and 4D-Z.



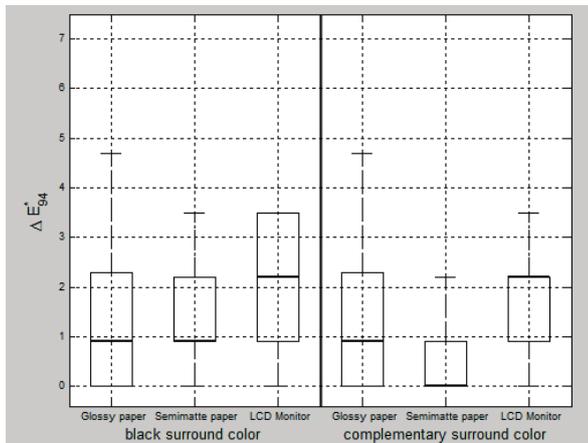
**Figure 10** The intensity of the effect depending on the media, for the magenta inserted segment colour, D65 illuminant, and "black" or complementary colour surround

Fig. 10 graphically shows the data distribution of intensity of the neon colour spreading effect in dependence on the media, for the magenta inserted segment colour, D65 illuminant, and "black" or complementary surround colour. The same minimum median value (0) can be noticed in all media for complementary surround colour. The highest median value (2,8) has a Glossy paper for a "black" surround colour. Values of distributed data are dispersed in all cases.

A statistically significant difference in the intensity of the effect between the samples due to the media exists for the magenta inserted segment colour, D65 illuminant, and "black" surround colour ( $p = 0,0000$ ). Different samples are 5D-G and 5D-S, 5D-G and 5D-Z, 5D-S and 5D-Z. On the complementary surround colour there is no significant difference ( $p = 0,9790$ ) (Tab. 6).

In the box and the whisker plot in Fig. 11, the analysis of positional mean values of colorimetric colour difference as a measure of the intensity of the neon colour spreading effect in dependence on media, for the yellow inserted segment colour, D65 illuminant, and "black" or complementary surround colour shows that the maximum

resulting positional mean value is 2,2 at the LCD monitor for each surround colour. On the other side, the minimum obtained positional mean value was noticed in Semimatte paper for complementary surround colour. Values of distributed data show scattering in all cases.



**Figure 11** The intensity of the effect depending on the media, for the yellow inserted segment colour, D65 illuminant, and "black" or complementary colour surround

There is a statistically significant difference in the intensity of the effect between samples due to media for the yellow inserted segment colour, D65 illuminant, and "black" surround colour ( $p = 0,0481$ ). Also, here is a statistically significant difference in the intensity of the effect between samples due to media for the yellow inserted segment colour, D65 illuminant, and complementary surround colour ( $p = 0,0073$ ). Different samples are 6D-G and 6D-Z, 12D-S and 12D-Z. (Tab. 7)

**Legend (tables):**

*H* – result of the Kruskal-Wallis test

*p* – *p* value, represents the significance level or probability of rejecting the true null hypothesis

1D-G – mark of the test sample; where the number "1" represents a combination of selection of the colour of the primary stimulus (Tab. 1); the letter "D" represents the parameter D65 illuminant, while the letter "G" represents the media type (Glossy paper, SemiMatte paper, LCD monitor).

**Table 2** The results of the Kruskal-Wallis test relating to the intensity of the effect depending on the media, for the red inserted segment colour, illuminant D65, and "black" or complementary colour surround

TEST SAMPLES	Media	Inserted segment colour	Illuminant	Surround colour	Kruskal-Wallis test	
					<i>H</i>	<i>p</i>
1D-G 1D-S 1D-Z	Glossy paper Semimatte paper LCD monitor	red	D65	"black"	3,0407	0,2186
7D-G 7D-S 7D-Z	Glossy paper Semimatte paper LCD monitor			complementary	11,2458	0,0036

**Table 3** The results of the Kruskal-Wallis test relating to the intensity of the effect depending on the media, for the green inserted segment colour, illuminant D65, and "black" or complementary colour surround

TEST SAMPLES	Media	Inserted segment colour	Illuminant	Surround colour	Kruskal-Wallis test	
					<i>H</i>	<i>p</i>
2D-G 2D-S 2D-Z	Glossy paper Semimatte paper LCD monitor	green	D65	"black"	9,9563	0,0069
8D-G 8D-S 8D-Z	Glossy paper Semimatte paper LCD monitor			complementary	8,3963	0,0150

**Table 4** The results of the Kruskal-Wallis test relating to the intensity of the effect depending on the media, for the blue inserted segment colour, illuminant D65, and "black" or complementary colour surround

TEST SAMPLES	Media	Inserted segment colour	Illuminant	Surround colour	Kruskal-Wallis test	
					<i>H</i>	<i>p</i>
3D-G 3D-S 3D-Z	Glossy paper Semimatte paper LCD monitor	blue	D65	"black"	7,4614	0,0240
9D-G 9D-S 9D-Z	Glossy paper Semimatte paper LCD monitor			complementary	26,6001	0,0000

**Table 5** The results of the Kruskal-Wallis test relating to the intensity of the effect depending on the media, for the cyan inserted segment colour, illuminant D65, and "black" or complementary colour surround

TEST SAMPLES	Media	Inserted segment colour	Illuminant	Surround colour	Kruskal-Wallis test	
					<i>H</i>	<i>p</i>
4D-G 4D-S 4D-Z	Glossy paper Semimatte paper LCD monitor	cyan	D65	"black"	14,0592	0,0000
10D-G 10D-S 10D-Z	Glossy paper Semimatte paper LCD monitor			complementary	0,3353	0,8457

**Table 6** The results of the Kruskal-Wallis test relating to the intensity of the effect depending on the media, for the magenta inserted segment colour, illuminant D65, and "black" or complementary colour surround

TEST SAMPLES	Media	Inserted segment colour	Illuminant	Surround colour	Kruskal-Wallis test	
					<i>H</i>	<i>p</i>
5D-G 5D-S 5D-Z	Glossy paper Semimatte paper LCD monitor	magenta	D65	"black"	26,3386	0,0000
11D-G 11D-S 11D-Z	Glossy paper Semimatte paper LCD monitor			complementary	0,0425	0,9790

**Table 7** The results of the Kruskal-Wallis test relating to the intensity of the effect depending on the media, for the yellow inserted segment colour, illuminant D65, and "black" or complementary colour surround

TEST SAMPLES	Media	Inserted segment colour	Illuminant	Surround colour	Kruskal-Wallis test	
					<i>H</i>	<i>p</i>
6D-G 6D-S 6D-Z	Glossy paper Semimatte paper LCD monitor	yellow	D65	"black"	6,0672	0,0481
12D-G 12D-S 12D-Z	Glossy paper Semimatte paper LCD monitor			complementary	9,8458	0,0073

The results of this research confirmed that the intensity of the effect of neon colour spreading effect on media with additive synthesis of colour (LCD monitor) was higher than is the case when investigating the effect on the media with subtractive synthesis of colour (printing substrate). The explanation of these results can be found in the fact that the media with additive synthesis of colour are in fact emission media. Such types of media during the perception are not coming to the subtraction of particular areas of wave lengths of visible light and selective absorption. Therefore the losses of colour information are less. The research results does not indicate the possible statistically significant difference in the manifestation of neon colour spreading effect on the investigated printing substrates - Glossy and Semimatte paper.

Regularities of media influence were noticed as a parameter for particular inserted segment colour on Ehrenstein figure regardless of the background colour. Research results showed that for all media green and magenta inserted segment colour induced the greatest effect, while the minimum value of the intensity of the effect is noted at blue inserted segment colour. More noticeable deviation is observed in green inserted segment colour at the complementary surround colour, where positional mean values show that the effect is not manifested. There was no strong link by which could be explained such derogation from the observed regularities.

### 3 Conclusion

The research activities under the proposed topic of this work focused on determination of influence of the media as a parameter in the process of graphic reproduction on the intensity of the neon colour spreading effect. The study shows that there is a statistically significant difference in the evaluation of the intensity of the investigated neon colour spreading effect in most cases at the media with subtractive synthesis of colour (Glossy and Semimate paper) compared to the media with additive synthesis of colour (LCD monitor).

Transformation of colour information from the digital colour space (LCD monitor) to the analog space (the

printing substrate) results in reduced colour gamuts and leads to the loss of colour information by different parameters. The research conducted in this paper confirms this hypothesis based on the fact that the intensity of the neon colour spreading effect is more pronounced on a LCD monitor than on the printing substrates. The reason is that the losses of colour information led to less unwanted colour spreading in the researched effect of the Ehrenstein figure.

It is evident that there is certain traceability and predictability in the manifestation of neon colour spreading effect in the process of graphic reproduction, as determined in almost all tested samples. Based on them, it is possible to predict the influence of the investigated parameters and thereby avoid the application of various parameters. Therefore, it is important to harmonize the colour combination of choice of primary stimuli (colour inserted segment colour and surround colour), and the correct definition of the geometric structure of stimuli during graphic design solutions provides a lower level of errors in the perception of colour information to the media with additive synthesis of colours within the process of graphic reproduction.

The questions that arise are: Can additional finishing operations of surface processing of print substrates in the process of graphic reproduction result in changes in colour perception attributes due to manifestation of the neon colour spreading effect? How much influence can they have on the the intensity of the effect? The answer should be sought in the new research, which will analyze the neon colour spreading effect influenced by refinishing, powder coating and other procedures of surface processing printing substrates.

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