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Influence of Light on Typographic and Colorimetric Properties of Ink Jet Prints

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Abstract. *The purpose of this study is to examine the influence of light on the changes in typographic and colorimetric properties of ink jet prints in order to establish an appropriate typeface style and type size for business correspondence to ensure information permanence. The prints were made with six ink jet printers from different manufacturers on four different office papers. Four different, widely used typefaces (one old-style, one transitional, and two sans-serif) in five different sizes (6, 8, 10, 12, and 16 pt) were tested. The resistance of printed business correspondence to light was evaluated according to the ISO 12040 standard. The color differences were determined spectrophotometrically. The differences in typographic tonal density and wicking of typefaces were measured with image analysis. After the exposure to light, the biggest difference in typographic tonal density was observed at type sizes 6 and 8 pt, and at one of the sans-serif typefaces. © 2010 Society for Imaging Science and Technology.*
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INTRODUCTION

Ink jet technology has recently become important and widely used in many different areas, not only for home application but also for printing documents. For the latter, fastness of prints can present a problem. Under the influence of external factors, i.e., light, heat, and humidity, the appearance on an ink jet print can change significantly.[1] Since the inks used for ink jet printing often comprise of dyes rather than pigments,[2] the problem of fading becomes even more evident. The application of pigments ensures better fastness, however, it is connected with more complex ink formulation.[3,4] Light fastness of dyes is influenced not only by their structure, but also by the substrate structure.[4–6] As it is known, the paper quality has an important influence on the quality of ink jet prints.[7–12]

According to the large number of studies on legibility,[13] a number of typographic characteristics is to be observed to make the text more legible, i.e., distinctive character features (counter shape), x-height, ascender, descender, serifs, contrast (stroke weight), set width, type size, leading (i.e., space between lines) etc.[13–16]—The white space enclosed by a letterform is called counter. It can be completely enclosed (e.g., as in *d* or *o*) or partly (e.g., as in *c* or *m*). X-height is the distance between the baseline and the midline of an alphabet, which is normally the height of the unextended lowercase letters (e.g., *a*, *c*, *m*, *r*, *u*, *x*). Ascender is the distance between the midline and the cap line or ascender line (e.g., upper parts of the letters *b*, *d*, *h*, *k* are in ascender). Descender is the distance between the baseline and the descender line (e.g., lower parts of the letters *p*, *q*, *y* are in descender). A small stroke added to the beginning or end of the main stroke of a letter is called serif. Serifs at different styles of typefaces are different according to the shape and size. The contrast depends on the difference between thick and thin strokes of a given letter. Set width defines the width of a letter (e.g., the same typeface style and the same size can have different width of letters).[17,18]

For a normal reading distance, the optimum type size for continuous text is usually between 9 and 11 points,[14] or even between 8 and 12 points.[13] The precise size depends on the x-height of the typeface—typefaces with larger but moderate x-heights are generally more legible at small sizes. An increased x-height gives an impression of increased legibility of the next larger type size.[13,15,16,19] The classification of typefaces for Latin script, which reconcile historical and technical characteristics of typefaces, subdivides them into nine groups as follows: old-style (humanist and garald), transitional, didone (or modern), slab serif, lineal (or sans-serif), incised (or glyphic), script and manual.[20,21] In typography design, it is also useful to be familiar with typographic tonal density (or typographic tonality) of different typographic elements, which refers to the relative blackness or shades of gray of type on a page. Typographic tonal density can be expressed as the relative amount of ink per square centimeter, pica, or inch.[22] The changes in various type features can create variations in typographic tonal density. Such type features include typeface (style of letterform—stroke width, set width, counter size, x-height), caps, italic, bold, compressed, and extended (and all variations in weight and width), type size, letter and word spacing, leading etc.[13,14,23] Typefaces with large counters, trap a larger amount of white space in the enclosed spaces of letters such as *o*, *a*, *g*, and *p*. The cumulative effect decreases typographic tonal density. A thicker stroke width creates more ink per area.[17,18,23] Most sans-serif typefaces therefore need more ink per area. The reason is in their design, for the contrast between the strokes of characters is limited and the sans-serif typefaces have little or no difference between thick and thin strokes.[17,18]

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Thus, the purpose of this study was to examine the influence of light on the changes in typographic and colorimetric properties of ink jet prints in order to establish an appropriate typeface style and type size for business correspondence to ensure information permanence. Since there is no recommendation or standard yet about the preservation of different typeface styles and type sizes, we studied the influence of light with a numerical evaluation of changes in the typefaces.

EXPERIMENTAL

Paper Properties

The prints included in the study were made with six ink jet printers from three different manufacturers on four different office papers. Prior to printing, the basic, surface and optical properties of paper were measured. The paper grammage was measured according to the ISO 536[24] standard, while the paper thickness was measured according to the ISO 534[25] standard. The specific volume or density is related to porosity, rigidity, hardness, and strength and it influences several physical and optical properties of the paper. The measurements were made according to the ISO 534[25] standard. The measurement of roughness of the paper was conducted with the Bendtsen method in accordance with the ISO 8791/2[26] standard. The paper roughness is described from the amount of airflow, which goes through the test sample clamped between the land and circular gasket. The measurement of the airflow was used to describe the porosity of paper, which is tested according to the Bendtsen method with regard to the ISO 5636/3[27] standard. The water absorption of paper was measured with the Cobb method in accordance with the ISO 535[28] standard, where the time of the test was 60 s ($Cobb_{60}$). Gloss refers to the degree of light reflected from the paper surface at a selected angle and depends on the surface smoothness. The measurement was conducted on the Lehmann equipment in accordance with the TAPPI 480[29] standard. Brightness refers to the degree of blue light reflected from the paper surface at the wavelength 457 nanometers, when the paper yellowing is most easily gauged. The measurement of brightness was made according to the ISO 2470[30] standard. Opacity describes the amount of light transmitted through paper, and was measured with regard to the ISO 2471[31] standard. The measured properties of the felt side of the four papers (S1–S4) are presented in Table I. Paper 3 (S3) has a recycled paper declaration.

Table I. Properties of tested papers (S1–S4).

Properties	S1	S2	S3	S4
Grammage (g/m^2)	79.13	78.71	79.75	78.88
Thickness (mm)	0.098	0.100	0.100	0.103
Specific volume (cm^3/g)	1.23	1.26	1.26	1.30
Roughness (ml/min)	160	71	175	205
Porosity (ml/min)	959	992	646	875
Water absorption (g/m^2)	32.30	35.00	30.90	37.60
Gloss (%)	3.80	5.60	4.30	3.50
ISO Brightness (%)	98.30	97.93	78.15	102.02
Opacity (%)	94.85	96.07	94.70	93.40

Typographic and Colorimetric Properties of Prints

Black and color prints were made with six ink jet printers, i.e., Canon Pixma IP 4200 (P1), HP OfficeJet 5610 (P2), Epson Stylus DX 8450 (P3), HP DeskJet 5150 (P4), HP DeskJet 710 C (P5), and HP DeskJet 5740 (P6). The printer Epson Stylus DX 8450 (P3) uses ink comprised of pigments. Four different, widely used typefaces were tested, namely two sans-serif (Arial and Verdana),[17,21] one old-style (Palatino)[17,21] and one transitional typeface (Times),[17,21] each in five different sizes (i.e., 6 pt for footnote, 8, 10, and 12 pt for body text, and 16 pt for titles). On each of the four papers, two field intensities were printed, i.e., of 100% (K100) and 50% (K50). Color prints with two field intensities were printed in red (R100, R50), green (G100, G50) and blue (B100, B50).

Light Fastness of Prints

The resistance of printed business correspondence to light was evaluated according to the ISO 12040[32] standard using the Xenotest Alpha (Atlas, USA) with a xenon arc lamp. The color temperature was between 5500 and 6500 K at a constant temperature of 35 °C and constant relative humidity of 35%. The samples were exposed to xenon light for 72 h.

The CIE $L^*a^*b^*$ parameters of the illuminated parts of prints were measured with the spectrophotometer EFI/ES—1000 (Gretag Macbeth) in accordance with the ISO 13655[33] standard using the D50 standard illumination, 2° standard observer, black backing and instrument geometry 45/0. The color difference between the nonexposed and exposed samples was calculated according to the CIE $L^*a^*b^*$ equation for color differences,

$$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}. \tag{1}$$

The differences in typographic tonal density and wicking[34,35] or circularity[36] of nonexposed and exposed typefaces were measured with an image analysis (IMAGE J).[34–36] The value of wicking is between 0 and 1, where the calculation is made according to the following equation:

$$\text{wicking (or circularity)} = 4\pi \frac{\text{area}}{\text{perimeter}^2}. \tag{2}$$

The value 1.0 indicates a perfect circle; in consequence, the edges or obliqueness of letter strokes are perfectly smooth. As the value approaches 0.0, it indicates an increasingly elongated polygon and consequently, the edges of letter strokes are no longer smooth.[34–36] All the measured samples were of the same size, i.e., 2100×360 pixels.

RESULTS AND DISCUSSION

Influence of Light on Colorimetric Properties

Tables II and III show CIE $L^*a^*b^*$ parameters of black prints with 100% and 50% intensity printed with different ink jet

Table II. CIE L*a*b* parameters of black prints with 100% intensity printed with different printers (P1–P6) on different papers (S1–S4).

		P1	P2	P3	P4	P5	P6
	L*	26.56	34.78	30.71	47.51	31.56	32.88
S1	a*	1.48	−1.50	0.63	−3.29	1.94	1.69
	b*	1.24	0.05	0.27	−3.72	−2.57	−0.99
	L*	24.99	36.06	31.36	51.05	30.67	32.86
S2	a*	1.23	−1.29	0.58	−3.69	2.05	1.71
	b*	0.15	−0.55	−0.55	−4.49	−2.42	−0.96
	L*	25.73	37.07	30.71	51.48	29.30	34.61
S3	a*	1.45	−1.79	0.63	−3.89	1.66	1.71
	b*	0.24	−0.10	0.27	−2.44	−1.75	−0.49
	L*	25.91	33.03	30.84	31.16	31.56	36.68
S4	a*	1.42	−0.03	0.69	−0.13	1.94	0.67
	b*	1.20	1.2	−0.13	−0.27	−2.57	−1.50

Table III. CIE L*a*b* parameters of black prints with 50% intensity printed with different printers (P1–P6) on different papers (S1–S4).

		P1	P2	P3	P4	P5	P6
	L*	59.25	66.06	64.82	65.42	63.24	67.46
S1	a*	1.30	−3.55	−0.25	−2.73	−2.29	−1.92
	b*	−8.06	−5.27	−13.45	−6.33	−7.27	−10.05
	L*	60.23	67.02	65.55	67.06	63.90	70.17
S2	a*	2.03	−3.23	0.62	−2.07	−1.30	−0.89
	b*	−9.13	−5.60	−13.72	−5.61	−7.07	−10.30
	L*	59.63	66.27	64.32	65.95	63.67	68.59
S3	a*	1.82	−3.96	−1.11	−2.79	−2.51	−2.11
	b*	−5.36	−1.11	−8.09	−1.56	−3.94	−4.47
	L*	61.00	70.14	67.54	67.95	66.32	68.45
S4	a*	3.08	−2.06	1.27	−1.25	−0.84	−1.46
	b*	−9.54	−6.19	−13.29	−7.05	−7.72	−7.67

printers. The results obtained show that there are only minor differences among the samples. Sample 2 with the highest gloss (Table I) gave the best prints, while Sample 4 gave the least satisfactory results, all the results of printed inks from different printers being quite homogenous. Furthermore, Sample 4 had the highest ISO brightness and the lowest gloss among all samples. The results show a difference in quality among the tested printers. According to the value of lightness of black prints with 100% intensity, it was noticed that the least satisfactory prints were obtained with Printer 4, which gave prints with highest values of lightness and a relatively high chromatic component. The best results were obtained with Printer 1. For black prints with 50% intensity, the differences in lightness among the samples were even smaller. The black prints on Sample 3 were only slightly darker than on other samples. Sample 3 had the lowest ISO brightness among the chosen papers. If the quality of prints is measured according to lightness (L^*), the best characteristics were seen at Printer 1 at both print intensities (100% and 50%). The smallest chroma was noted on black prints printed with Printers 3 (100% intensity) and 6 (50% intensity). Higher chroma is often a consequence of a higher negative value b^*, which was higher on black prints with a bluish cast with 50% intensity.

After the color differences (ΔE) on samples printed with black ink after the exposure to xenon light were calculated (Figures 1 and 2), it became evident that the prints with 50% intensity tend to fade much more than the prints with 100% intensity. Moreover, as it was expected, the smallest color difference was noticed on black prints printed with Printer 3, which uses ink comprised of pigments. Among the printers which use ink comprised of dyes (i.e., Printers 1, 2, 4, 5, and

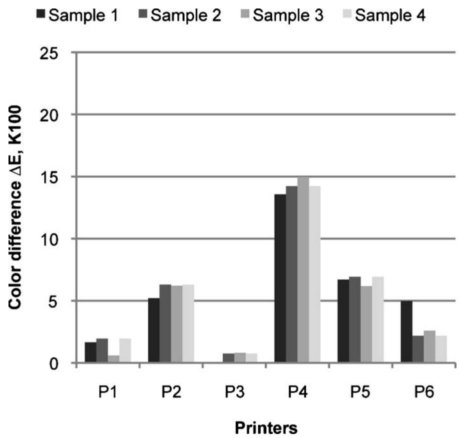

Figure 1. Light fastness of black prints with 100% intensity printed with different printers exposed to xenon light according to measurement of color difference (ΔE).

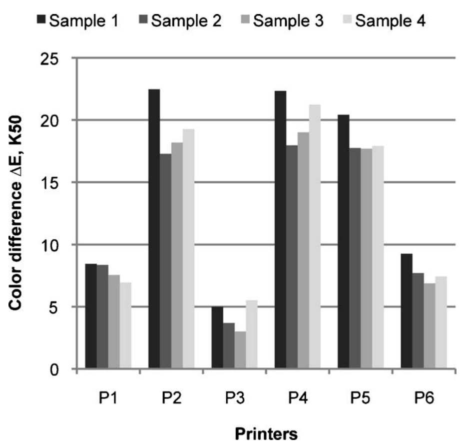

Figure 2. Light fastness of black prints with 50% intensity printed with different printers exposed to xenon light according to measurement of color difference (ΔE).

6), the smallest color differences were measured on black prints printed with Printers 1 and 6, while the highest color differences were measured on black prints printed with Printer 4. For black prints with 100% intensity, it could be seen that the smallest color differences after the exposure to light appeared on Samples 1 and 3. Black prints with 50% intensity showed the smallest color difference on Samples 2 and 3, while the biggest color difference appeared on Sample 1.

A comparison of fading black prints and colored (RGB) prints was conducted, since it was expected that black prints would be more resistant to light. Table IV shows the average values of color differences after the illumination for all tested printed samples (Papers S1–S4, Printers P1–P6). It is evident that black prints (K100) give the best results, as the color difference in this case is much smaller ($\Delta E = 5.34$) comparing to the values obtained for colored samples [where ΔE ranges from 10.32 (G) to 18.22 (R)]. For the 50% intensity, surprisingly good results were obtained for green prints (G50), which on average performed even better than black prints (K50).

Table IV. Average color difference (ΔE) on prints after exposure to xenon light.

Intensity (%)	ΔE K	ΔE R	ΔE G	ΔE B
50	12.82	14.51	9.39	18.49
100	5.34	18.22	10.32	14.35
Average	*9.08*	*17.87*	*9.86*	*16.42*

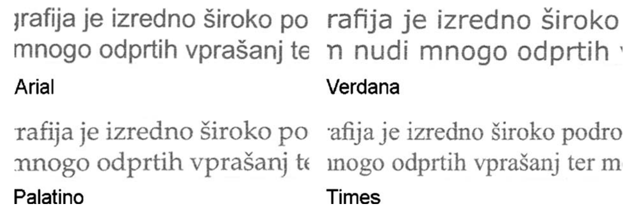

Figure 3. Sample of exposed typefaces, 10 pt in size (P4, S1).

Influence of Light on Typographic Properties

The typographic tonal density of each typeface, each in different size, was measured on nonexposed and exposed black prints. The samples of the studied typeface, 10 pt in size, after the exposure are presented in Figure 3. The black prints with the highest and the lowest typographic density and their differences in typographic density after the exposure are presented in Tables V–VII and Figures 4–6. The results show that sans-serif typefaces have higher typographic tonal density (Fig. 4, Table V), which was expected due to smaller differences in letter stroke width. Due to wider letters, bigger counters and highest x-height, a slightly lower typographic tonal density was observed with the sans-serif typeface Verdana than with the sans-serif typeface Arial. The lowest typographic tonal density was observed with the old-style typeface Palatino. Palatino letters have big counter size, the difference between thick and thin strokes is not very significant, and the thick strokes are not very wide. After the exposure to light, the most noticeable difference in typographic tonal density occurred with Verdana (sans-serif) typeface (Fig. 4, Tables V and VI). Between the typefaces with differences in stroke width (i.e., Times and Palatino), bigger differences were mostly noticed with Palatino typeface after the exposure to light. The smallest difference in typographic tonal density of the nonexposed and exposed samples was seen mostly with the transitional typeface Times, which has a smaller counter size and wider thick strokes than the old-style typefaces. Obviously, the old-style typefaces, where the thick strokes are not very wide and serifs are smaller, are not resistant enough to the influence of light. The results obtained show the biggest differences at typefaces used in sizes 6 and 8 pt (Table VII). The typographic tonal density at smaller sizes of typeface is usually higher due to the smaller counter size of letters and leading (Figures 7 and 8). Furthermore, the differences were more evident after the exposure to light. At typefaces with lower typographic tonal density, due to the thin strokes, wider

Table V. Average value of typographic tonal density (TTD) of tested typefaces before and after exposure for black prints on different papers (S1–S4).

	TTD (%)				
Typefaces	S1	S2	S3	S4	Average
Arial—nonexposed	23.04	22.50	22.77	22.23	22.62
Arial—exposed	21.76	21.08	21.60	21.66	21.53
Difference					*1.09*
Verdana—nonexposed	21.62	21.17	21.15	20.77	21.18
Verdana—exposed	20.06	19.68	19.92	20.08	19.94
Difference					*1.24*
Palatino—nonexposed	19.23	18.66	18.50	18.39	18.70
Palatino—exposed	18.08	17.19	17.58	17.84	17.67
Difference					*1.03*
Times—nonexposed	19.75	18.76	19.24	18.90	19.16
Times—exposed	18.79	17.97	18.32	18.39	18.37
Difference					*0.79*

Table VI. Differences in typographic tonal density (TTD) of tested typefaces according to type size.

Type size (pt)	Biggest differences in TTD on average	Smallest differences in TTD on average
6	Verdana, 1.11	Times, 0.89
8	Verdana, 1.46	Times, 1.08
10	Verdana, 0.88	Times, 0.51
12	Verdana, 1.71	Palatino, 0.99
16	Verdana, 0.99	Palatino, 0.73

Table VII. Differences in typographic tonal density (TTD) in type size according to used printers (P1–P6).

Printers	Biggest differences in TTD on average at type sizes after exposure
P1	6 pt, 1.50; 8 pt, 1.82
P2	8 pt, 1.16
P3	6 pt, 0.52
P4	6 pt, 1.73; 8 pt, 1.54
P5	6 pt, 2.07; 8 pt, 1.90
P6	12 pt, 1.12

counter, lower x-height, small and thin serifs (e.g., old-style typefaces), the difference in typographic tonal density after the exposure to light has more influence on legibility as it has at typefaces with wider strokes (e.g., sans-serif typefaces, Figure 9).

While comparing the printing quality of printers used in this study, the smallest changes in typographic tonal density were, as expected, obtained on black samples printed

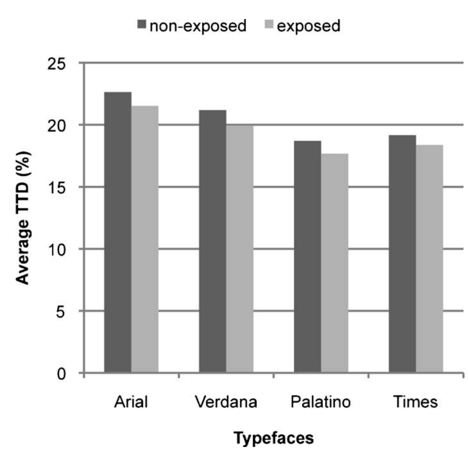

Figure 4. Average value of typographic tonal density (TTD) of tested typefaces before and after exposure.

with Printer 3 (Fig. 6, Table VIII). Moreover, the black prints printed with this printer had almost the highest typographic tonal density. The most evident differences in typographic tonal density were observed on black prints printed with Printers 1, 4, and 5. Among the black printed samples, the most noticeable differences appeared above all on Sample 1 and the least noticeable on Sample 4 (Fig. 5, Table IX), where on average, the lowest typographic tonal density before the illumination was measured. On Sample 3 (i.e., recycled paper, Table I), a relatively high typographic tonal density was measured. This paper exhibits the smallest porosity, which can influence the distribution of ink during the printing process and affect the amount of ink bonded on the surface.

By employing image analysis, wicking of the nonexposed and exposed small letter *a* was measured. Results of the wicking values are presented in Figures 10–12. The average changes in wicking of the nonexposed and ex-

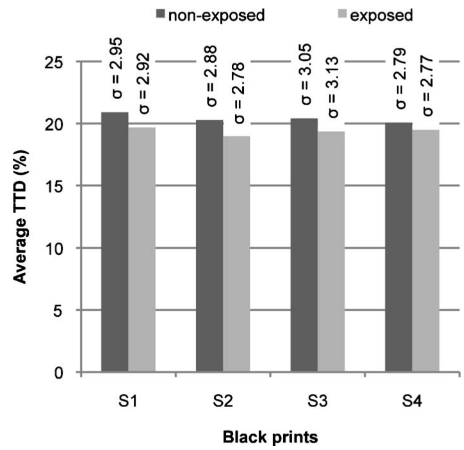

Figure 5. Average values of typographic tonal density (TTD) for black prints on different papers (S1–S4) before and after exposure.

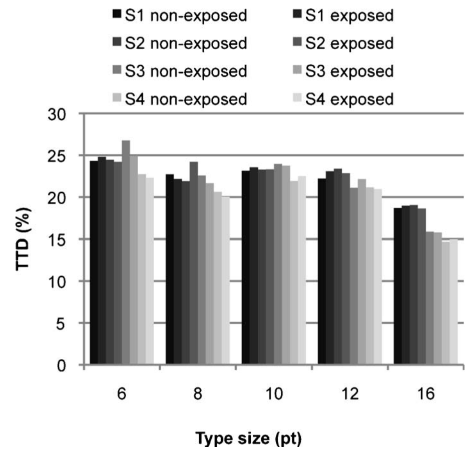

Figure 8. Typographic tonal density (TTD) of Verdana typeface measured on nonexposed and exposed black printed samples (S1–S4) printed with P3.

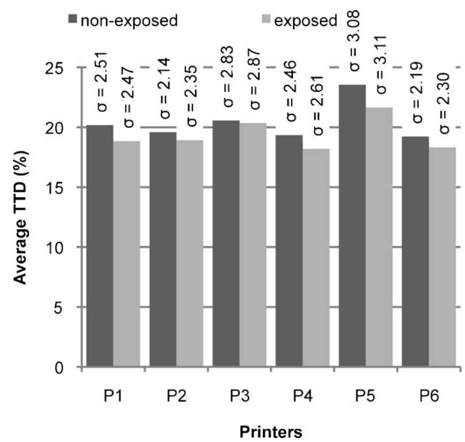

Figure 6. Average values of typographic tonal density (TTD) before and after exposure for black prints printed on different printers (P1–P6).

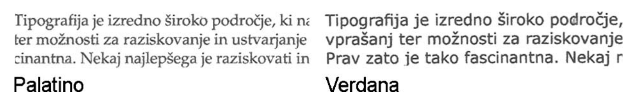

Figure 9. Sample of exposed typefaces Palatino (old-style) with difference in typographic tonal density 0.22, and Verdana (sans-serif) with difference in typographic tonal density 0.40, 6 pt in size (P2, S4).

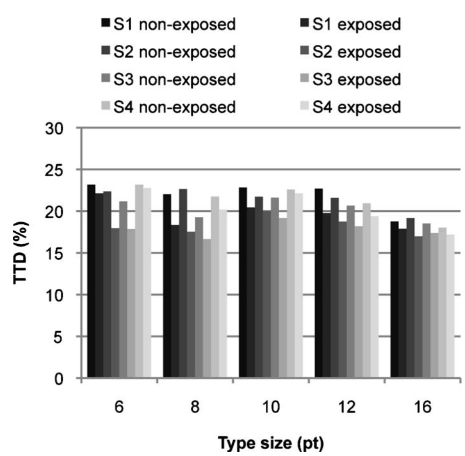

Figure 7. Typographic tonal density (TTD) of Verdana typeface measured on nonexposed and exposed black printed samples (S1–S4) printed with P1.

posed typefaces can be seen in Fig. 10. After the illumination of letters, wicking usually had lower numerical value. If the obliqueness of letter strokes is no longer smooth, the wicking value is lower; it approaches to 0. In some rare cases, it was noticed that the wicking value was even slightly higher (Fig. 12). Nevertheless, it was observed that typographic tonal density decreased after the exposure to light, since some parts of letter strokes disappeared under the influence of light. This was most frequently noticed at small sizes of typefaces. The values of wicking may not be valid for very small parts, where they could be even higher than 1.[37] It is suspected that a very small size of typefaces could cause the measured value of stroke smoothness being higher after the exposure to light. In some cases, after the illumination, a letter divided into numerous small fragments and the wicking could not be measured. The latter was noticed at the smallest size (i.e., 6 pt) of the used old-style and transitional typefaces, due to the differences in stroke width and smaller serifs, printed with Printer 4 (Figure 13). The best smoothness of letter strokes is seen with the typeface Verdana, where after the exposure, the smallest difference in wicking was noticed (Fig. 10). The highest wicking appeared at letters printed on Samples 2 and 4, where after the exposure, the highest decrease in the numerical value of wicking is demonstrated (Fig. 11). Very small changes in wicking were noticed on black samples printed with Printer 3 (Fig. 12). The smallest wicking value was measured on samples printed with Printer 4, which generally gave the least satisfactory results.

CONCLUSIONS

The results of the study show that it is necessary to consider the chosen typeface style and its size to ensure information permanence. Typefaces with thin strokes and big counter size are therefore not recommended. Special attention is required when a very small type size is chosen. The strokes of

Table VIII. Differences in typographic tonal density (TTD) and its changes after exposure for black prints made with printers (P1–P6) according to used type sizes.

	Type size (pt)				
	6	8	10	12	16
Highest TTD (%) on Average	P5, 25.42	P5, 23.54	P5, 24.89	P5, 23.88	P5, 20.20
	P3, 23.40	P3, 19.99	P3, 21.66	P3, 21.16	P3, 17.64
Lowest TTD (%) on average	P4, 18.47	P4, 19.08	P6, 20.57	P6, 20.32	P6, 16.62
	P6, 19.57	P6, 19.12	P4, 20.83		P1, 17.36
Biggest differences in TTD on average after exposure	P5, 2.07	P5, 1.90	P5, 1.40	P5, 1.81	P5, 1.19
	P4, 1.73	P1, 1.82	P1, 1.17	P4, 1.00	P1, 1.04
Smallest differences in TTD on average after exposure	P2, 0.49	P3, 0.20	P6, 0.24	P3, 0.23	P3, 0.23
		P6, 0.84	P3, 0.25	P2, 0.61	P2, 0.38

Table IX. Differences in typographic tonal density (TTD) and its changes after exposure for black prints on different papers (S1–S4) according to used printers (P1–P6).

	P1	P2	P3	P4	P5	P6
Highest TTD (%) on average	S1, 21.16	S3, 19.98	S3, 21.26	S1, 19.78	S1, 24.30	S3, 19.70
				S2, 19.73		S1, 19.57
Lowest TTD (%) on average	S3, 19.33	S2, 18.90	S4, 19.06	S3, 18.78	S4, 22.12	S2, 18.72
		S4, 19.81		S4, 19.08		S4, 18.87
Biggest differences in TTD on average after exposure	S2, 2.16	S1, 1.07	S3, 0.28	S1, 1.39	S2, 2.25	S1, 1.02
				S2, 1.09	S3, 1.71	
Smallest differences in TTD on average after exposure	S4, 0.38	S3, 0.23	S1, 0.09	S4, 0.54	S4, 0.97	S4, 0.54
		S4, 0.49	S2, 0.17			

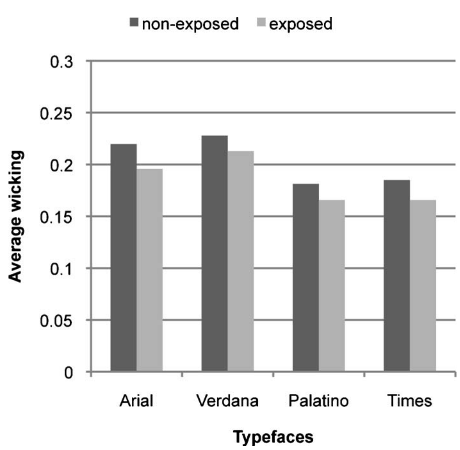

Figure 10. Average wicking of nonexposed and exposed typefaces.

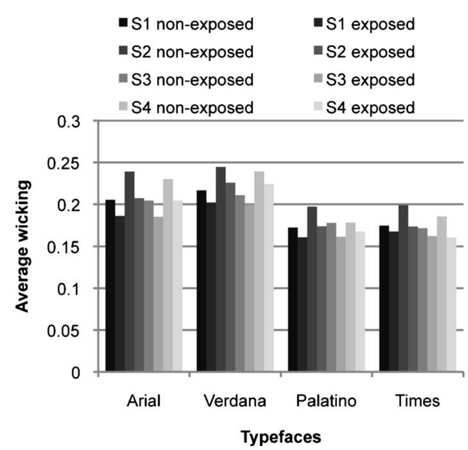

Figure 11. Average wicking of nonexposed and exposed typefaces printed in black on different papers (S1–S4).

smaller typefaces should be thick enough, e.g., sans-serif or at least transitional typefaces. The obtained results reveal that small differences in paper quality are not of great significance for the resistance of prints to light, e.g., despite being recycled, Sample 3 showed good printability properties. In contrast, the selection of a printer and of inks comprising of dyes or pigments is far more important. The results show that the smallest differences in color properties and frequently in typographic tonal density of the nonexposed and exposed samples are provided by ink jet inks comprised of pigments. Furthermore, the edges of letters printed with such a printer have higher smoothness and the difference in the wicking value is smaller after the exposure to light. It was also established that black prints are on

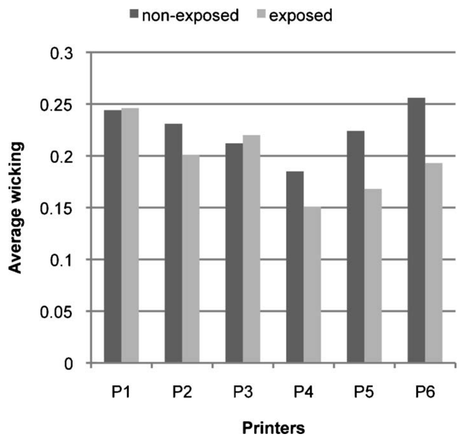

Figure 12. Average wicking of nonexposed and exposed typefaces printed in black with different printers (P1–P6).

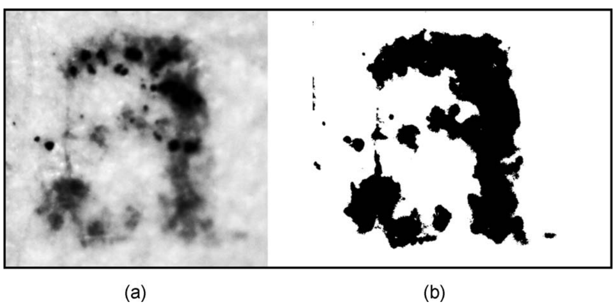

Figure 13. Letter divided into numerous small fragments after exposure (a), i.e., Palatino typeface at 6 pt (P4, S3), microscope photo is enlarged 25-times; letter changed into binary picture (b), which is base for image analysis, e.g., for measuring TTD and wicking.

average more resistant to light than colored prints, and that the prints with lower intensity (i.e., 50%) tend to fade much more than the prints with higher intensity (i.e., 100%). Fading is more obvious with poor quality prints, e.g., samples printed with Printer 4 on Sample 4.

In order to ensure information permanence, attention should be paid at least to the selection of proper typeface styles and suitable type sizes unless using ink jet printers with ink comprised of pigments rather than dyes. Since sans-serif typefaces or typefaces with moderate letter strokes were more resistant to light, it is concluded that such typefaces are better for permanent documents.

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