Influence of Light on Typographic and Colorimetric Properties of Inkjet Prints

Klementina Možina[1], Tanja Medved[1], Blaž Rat[1], Urška Bogataj[2], Sabina Bračko[1]; [1]University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Textiles; Ljubljana, Slovenia; [2]Valkarton, Production of corrugated board and packaging d.d., Logatec, Slovenia

Abstract

The purpose of this study was to examine the influence of light on changes in typographic and colorimetric properties of inkjet 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 inkjet 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 by means of Xenotest Alpha (Atlas). The differences in CIELAB values and the total colour difference were determined spectrophotometrically. The differences in typographic tonal density and wicking of typefaces were measured numerically with image analysis. The obtained results show the smallest typographic tonal density at the old-style typeface. After the exposure to light, the biggest difference in typographic tonal density was observed at one of the sans-serif typefaces. The most noticeable difference in typographic tonal density occurred at type sizes 6 and 8 pt.

Introduction

Inkjet 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, e.g. light, heat and humidity, the appearance on an inkjet print can change significantly. Since the majority of inks used for inkjet printing comprise of dyes rather than pigments [1], the problem of fading becomes even more evident.

Therefore, the purpose of this study was to examine the influence of light on changes in typographic and colorimetric properties of inkjet prints with the aim of establishing appropriate typeface style and type size for business correspondence to ensure information permanence.

Experimental part

Paper properties

The prints included in the study were made with six inkjet printers from three different manufacturers on four different office papers. Prior to printing, their basic, surface and optical properties were measured. The paper grammage was measured according to the ISO 536 standard [2], while thickness, and specific volume or density, respectively, of the paper were measured according to the ISO 534 standard [3]. The gloss measurement was conducted on the Lehmann equipment in accordance with the TAPPI 480 standard [4] and paper brightness in accordance with the ISO 2470 standard [5]. The opacity of paper was measured with regard to the ISO 2471 standard [6]. The measured properties of the felt side of the paper are presented in Table 1. Paper 3 (S3), respectively, has a recycled paper declaration.

Table 1: 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
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 prints (S1–S4) were made with six inkjet printers: Canon Pixma IP 4200 (P1), HP OfficeJet 5610 (P2), Epson Stylus DX 8450 (P3), HP DeskJet 5150 (P4), HP DeskJet 710 C (P5), 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) [7, 8], one old-style (Palatino) [7, 8] and one transitional typeface (Times) [7, 8], each in five different sizes (i.e. 6, 8, 10, 12, and 16 pt). On each of the four papers, two field intensities were printed, i.e. of 100% (K100) and 50% (K50).

Light fastness of prints

The resistance of printed business correspondence to light was evaluated according to the ISO 12040 standard [9] using Xenotest Alpha (Atlas), with a xenon arc lamp. The colour 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 hours.

The CIE L*a*b* parameters of the illuminated parts of prints were measured with the spectrophotometer EFI/ES – 1000 (Gretach Macbeth) in accordance with the ISO 13655 standard [10]. The colour difference between the non-exposed and exposed samples was calculated according to the CIE L*a*b* equation for colour differences:

$$\Delta E_{ab} = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2} \tag{1}$$

In typography design, it is useful to be familiar with typographic tonal density (or typographic tonality) of different typographic elements, which refers to the relative blackness or shades of grey of type on a page. Typographic tonal density can be expressed as the relative amount of ink per square centimetre, pica or inch [11]. The differences in typographic tonal density and wicking of non-exposed and exposed typefaces were measured numerically by means of image analysis (Image J) [12]. All the measured samples were of the same size, i.e. 2100 × 360 pixels.

Results and discussion

Influence of light on colorimetric properties

Tables 2 and 3 show CIE L*a*b* parameters of samples (i.e. prints on different papers) with 100% and 50% intensity printed with different inkjet printers. The obtained results show that there are only minor differences among the samples. Sample 2 with the highest gloss (cf. Table 1) gave the best prints, while Sample 4 gave the least satisfactory results, all the results of printed inks with 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 at samples 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 relatively high chromatic component. The best results were obtained with Printer 1. At samples with 50% intensity, the differences in lightness among the samples were even smaller. The 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 samples 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.

Table 2: CIE L*a*b* parameters of samples (S1–S4) with 100% intensity printed with different printers (P1–P6)

		P1	P2	P3	P4	P5	P6
S1	L*	26.56	34.78	30.71	47.51	31.56	32.88
	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
S2	L*	24.99	36.06	31.36	51.05	30.67	32.86
	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
S3	L*	25.73	37.07	30.71	51.48	29.30	34.61
	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
S4	L*	25.91	33.03	30.84	31.16	31.56	36.68
	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 3: CIE L*a*b* parameters of samples (S1–S4) with 50% intensity printed with different printers (P1–P6)

		P1	P2	P3	P4	P5	P6
S1	L*	59.25	66.06	64.82	65.42	63.24	67.46
	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
S2	L*	60.23	67.02	65.55	67.06	63.90	70.17
	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
S3	L*	59.63	66.27	64.32	65.95	63.67	68.59
	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
S4	L*	61.00	70.14	67.54	67.95	66.32	68.45
	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

After the colour differences (ΔE) on printed samples after the exposure to xenon light were calculated (Figure 1, 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 colour difference was seen on samples printed with Printer 3, which uses ink comprised of pigments. Among the printers which use ink comprised of dyes (i.e. Printer 1, 2, 4, 5, and 6), the smallest colour differences were measured on samples printed with Printers 1 and 6, while the highest colour differences were measured on samples printed with Printer 4. At prints with 100% intensity, it could be seen that the smallest colour differences after the exposure to light appeared on Samples 1 and 3. Prints with 50% intensity showed the smallest colour difference on Samples 2 and 3, while the biggest colour difference appeared on Sample 1.

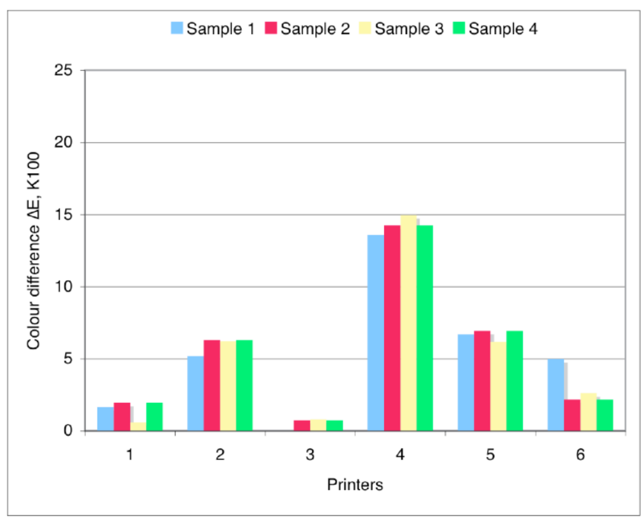

Figure 1: Light fastness of different samples with 100% intensity printed with different printers exposed to xenon light according to the measurement of colour difference (ΔE)

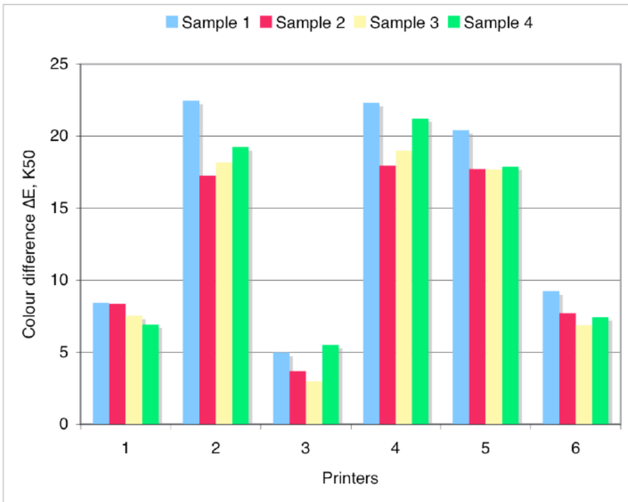

***Figure 2**: Light fastness of different samples with 50% intensity printed with different printers exposed to xenon light according to the measurement of colour difference (ΔE)*

Influence of light on typographic properties

Typographic tonal density of each typeface, each in different size, was measured on non-exposed and exposed samples. The samples with the biggest and the smallest typographic density and their differences in typographic density after the exposure are presented in Tables 4–6. The results show that sans-serif typefaces have bigger typographic tonal density, which was expected due to smaller differences in letter stroke width. The smallest typographic tonal density was observed at the old-style typeface Palatino. Palatino letters have big counter size, the difference between thick and thin strokes is not very significant, and thick strokes are not very wide. After the exposure to light, the most noticeable difference in typographic tonal density occurred at Verdana (sans-serif) typeface. The smallest difference in typographic tonal density of non-exposed and exposed samples was seen mostly at 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 thick strokes are not very wide and serifs are smaller, are not resistant enough to the influence of light. The obtained results show the biggest differences at typefaces used in sizes 6 and 8 pt (Table 4). Typographic tonal density at smaller sizes of typeface is usually bigger due to the smaller counter size of letters and leading (i.e. space between lines); furthermore, the differences were more evident after the exposure to light.

While comparing the printing quality of printers used in this study, the smallest changes in typographic tonal density were, as expected, obtained on samples printed with Printer 3. Moreover, samples printed with this printer had almost the biggest typographic tonal density. The biggest differences in typographic tonal density were noticed on samples printed with Printers 1, 4, and 5. Among the printed samples, most noticeable differences appeared above all on Sample 1 and the least noticeable on Sample 4, where on average, the smallest typographic tonal density before the illumination was measured. On Sample 3 (recycled paper), a relatively high typographic tonal density was measured.

Table 4: Differences in typographic tonal density (TTD) of printed samples (S1–S4) and type size according to the used printers (P1–P6)

	P1	P2	P3	P4	P5	P6
The biggest TTD	S1	S3	S3	S1, S2	S1	S3, S1
The smallest TTD	S3	S2, S4	S4	S4, S3	S4	S2, S4
The biggest differences in TTD after exposure	S2	S1	S3	S1, S2	S2, S3	S1
The smallest differences in TTD after exposure	S4	S3, S4	S1, S2	S4	S4	S4
The biggest differences in TTD at type sizes after exposure	6, 8 pt	8 pt	6 pt	6, 8 pt	6, 8 pt	12 pt

Table 5: Differences in typographic tonal density (TTD) given by used printers (P1–P6) according to the used type sizes

	Type size (pt)				
	6	8	10	12	16
The biggest TTD	P5, P3	P5, P3	P5, P3	P5, P3	P5, P3
The smallest TTD	P4, P6	P4, P6	P4, P6	P6	P6, P1
The biggest differences in TTD after exposure	P5, P4	P5, P1	P5, P1	P5, P4	P5, P1
The smallest differences in TTD after exposure	P2	P6, P2	P6, P3	P2, P3	P2, P3

Table 6: Differences in typographic tonal density (TTD) of used typefaces according to the used type sizes

Type size (pt)	The biggest differences in TTD	The smallest differences in TTD
6	Verdana	Times
8	Verdana	Times
10	Verdana	Times
12	Verdana	Palatino
16	Verdana	Palatino

By employing image analysis, wicking of the non-exposed and exposed small letter ‘a’ was measured. The average changes in wicking of non-exposed and exposed typefaces can be seen in Figure 3. After the illumination of the letters, wicking had sometimes a lower and sometimes a higher numerical value. If obliqueness of letter strokes is no longer smooth, the wicking value is higher. In some cases, it was also noticed that typographic tonal density decreased after the exposure to light, since some parts of letter strokes disappeared under the influence of light; nevertheless, the wicking value remained higher. In some cases, after the illumination, a letter divided into numerous small fragments and wicking could not be measured – this was noticed at old-style and transitional typefaces (due to the differences in stroke width and smaller serifs) in the smallest size used (i.e. 6 pt) printed with Printer 4. The smallest difference in wicking was noticed at typeface Verdana; however, the biggest difference at this typeface was noticed in typographic tonal density. After the exposure, the highest increase in wicking appeared at letters printed on Sample 4, which had the lowest gloss among all samples. One of the smallest changes in wicking was seen on samples printed with Printer 3.

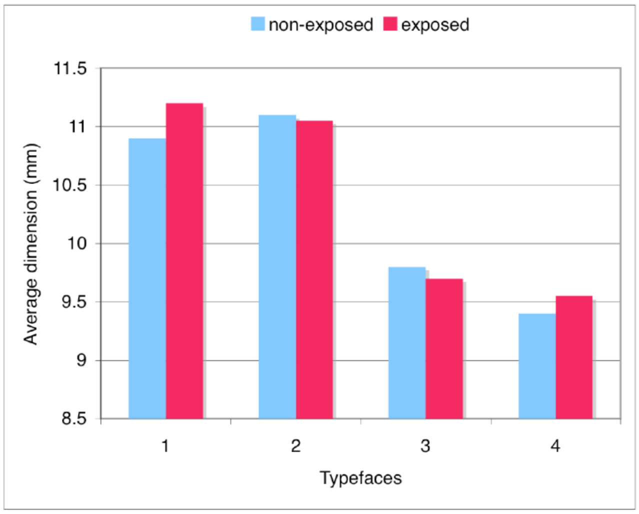

Figure 3*: Average changes in wicking of non-exposed and exposed typefaces: 1 – Arial, 2 – Verdana, 3 – Palatino, 4 – Times*

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 needs to be paid when very small type size is chosen. The strokes of 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. More important, on the other hand, is the selection of a printer, the inks of which comprise either of dyes or pigments. The results show that the smallest difference in colour properties, and frequently in typographic tonal density of non-exposed and exposed samples are given by inkjet inks comprised of pigments. Furthermore, these printers enable smoother obliqueness of printed letters; in consequence, wicking is smaller prior to and after the exposure to light. It was also established that prints with lower intensity (i.e. 50%) tend to fade much more than prints with higher intensity (i.e. 100%). Fading is more obvious at 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 inkjet printers with ink comprised of pigments rather than dyes.

References

[1] R. W. Kenyon, Ink Jet Printing In: Chemistry and Technology of Printing and Imaging Systems (Blackie Academic & Professional, London, 1996) pg. 113–138.

[2] ISO 536, Paper and board – Determination of grammage (ISO, Geneva, 1995).

[3] ISO 534, Paper and board – Determination of thickness and apparent bulk density or apparent sheet density (ISO, Geneva, 1997).

[4] TAPPI 480, Specular gloss of paper and paperboard at 75° degrees (TAPPI, Atlanta, 1999).

[5] ISO 2470, Paper, board and pulps – Measurement of diffuse blue reflectance factor (ISO brightness) (ISO, Geneva, 1999).

[6] ISO 2471, Paper and board – Determination of opacity (paper backing) – Diffuse reflectance method (ISO, Geneva, 1998).

[7] Ruari McLean, The Thames and Hudson Manual of Typography (Thames and Hudson, London, 1996) pg. 58–62.

[8] Klementina Možina, Knjižna tipografija (University of Ljubljana, Ljubljana, 2003) pg. 156–169, 184–191.

[9] ISO 12040, Graphic technology – Prints and printing inks – Assessment of light fastness using filtered xenon arc light (ISO, Geneva, 1997).

[10] ISO 13655, Graphic technology – Spectral measurement and colorimetric computation for graphic arts images (ISO, Geneva, 1996).

[11] E. Keyes, “Typography, color, and information structure,” Technical Communication, 4, 638–654 (1993).

[12] Image analysis (<http://www2.grafika.ntf.uni-lj.si/uploads/media/10_SlikovnaAnalizaTP108.pdf>, 26/11/2008).

Author Biography

Klementina Možina graduated from the Faculty of Graphic Arts in Zagreb, Croatia in 1993 and was awarded a PhD in 2001 at the Faculty of Arts in Ljubljana, Slovenia. As a part of the research for her PhD, she spent three months at the Department of Typography and Graphic Communication in Reading, Great Britain.

She worked five years at the Mladinska Knjiga publishing company, and since 1998, she has been working at the University of Ljubljana. Her main research interest is related to the usability of typography.