The Impact of Third-Party Inks on Image Quality

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Abstract

While costs of inkjet printers have plummeted over the past few years, brand name consumable prices remain high. As a result, consumers have been drawn to third-party inks that offer the promise of comparable quality at a much lower price point.

In order to investigate the impact of third party inks on image quality, a combination of subjective and objective image quality measurements were applied to a set of samples printed under nearly identical circumstances on the same printer but by using different vendors' inks.

In this paper we will be presenting our assessment methods and the results of our study.

Introduction

Many customers boast great cost savings when using third party inks in new, remanufactured or refilled cartridges. Sometimes savings come with a cost: in this case, it may be accompanied by decreased image quality. For many users, the savings are worth it. Or, the type of printing that they are doing does not highlight the print quality shortfalls. However, as with print engine development, as price points converge, image quality will become an increasingly important product differentiator.

This study included three ink sets printed using the same printer. It is important to note that the quality differences that were measured and observed between these ink sets may not be indicative of an overall lack of quality in third party inks. However, it should be used to highlight the potential for image quality issues in ink development, and it illustrates the importance of image quality measurement in the ink development and verification process.

Test Parameters

Three new Canon S330 Color Bubble Jet printers were used as the marking engines for this test. The three inks included the original Canon BCI-24 black and tricolor ink cartridges, cartridges from third party vendors Carrot Ink and TopInkjet.com. These third party inks were chosen based on two criteria: The Canon printer was relatively new to the market and not many compatible third party inks were available, and the inks were chosen to reflect three different price points. The Canon cartridge is available for $26.98, Carrot Ink for $13.45, and the TopInkJet.com cartridge for $8.40.

Images were printed on two classes of substrates using each of the inks. The substrates included Canon's brand name glossy photo paper (Photo Paper Pro) and a 20lb multipurpose bright white paper by Paperline. Both customer-like and analytical images were printed using the manufacturers recommended settings for best quality for the particular substrate type. The analytical target used in this portion of the study was printed at 300dpi.

Image Quality Assessment

Test Target

The analytical test target was created in Microsoft Excel using the drawing package. As odd and unconventional as this choice may seem, Excel was chosen because we hoped to minimize the chances of on-board color management control impacting the color output. When drawing elements are considered to be "office" graphics, on-board color management does not appear to have the same impact as when "pictorial" content is printed. This type of color management is referred to as "on board" since it persists even when color management is turned off in the printer driver.

As a result of choosing Excel, the test target design was limited due to the capabilities of the drawing package. The full set of features that we would like to include in this type of comparison was not available. However, it became obvious upon beginning the analysis that the features that we had been able to create resulted in sufficient differences in quality to provide a basis for comparison.

Image Capture and Analysis

For the image quality analysis, a high magnification 3-CCD color camera (with 6 microns per pixel per color channel) was used to capture images of various image elements on the samples. The 3-CCD format allows for full resolution of each of the three color planes since there are three separate CCD arrays. The full arrays do not have the same limitations as the mosaic arrays that are commonly used in digital color cameras. ImageXpert software was used to analyze the image quality, and the data was imported into Microsoft Excel.

Measurements

For the purposes of this study, several measurements were performed to analyze the quality of various attributes. These measurements included dot and line quality and inter-color bleed.

Measurement Methods

Dot Quality

Dot quality (as impacted by ink/media interactions) is often measured by assessing the uniformity of dot size, shape and darkness of a group of dots. Different primaries require different color channels for maximum contrast. For example, yellow dots were imaged using the blue channel of the 3-CCD color camera.

Dot quality is impacted by the amount of ink mobility once it is in contact with the substrate surface. Wicking of ink along paper fibers can create very ragged dots and dots of different sizes.

Line Quality

As in the case of color dots, color lines often require imaging by different color channels to maximize the contrast of the image element. Line width and edge raggedness were measured for horizontal and vertical lines. In addition, both positive lines (lines printed on paper) and negative lines (lines printed in solid areas) were measured for this report.

Ink wicking (also called feathering) can impact positive line quality. Ink can be pulled along the paper fibers by capillary action. This can increase line width and edge raggedness.

Negative line quality is different for color lines and white lines in black backgrounds. White lines can be filled in if the black colorant is too mobile and the printed areas expand beyond their intended boundaries. Color lines can be impacted by inter-color bleed between the colorant of the line and the black colorant in the surround.

Inter-Color Bleed

Inter-color bleed is a measure of the amount of ink mobility between adjacent areas of different colorants. A stress case is to print a fine line of one color in a surround of another color.

When the width of a line printed in a colored area is compared with the width of the same line printed on paper, the difference can be an indicator of the magnitude of the inter-color bleed. Sometimes bleed manifests not only as differences in line width, but also as differences in edge raggedness.

Color

As the color characteristics of inks change, the color gamut of the printing system can be impacted.

Color of the third party inks was compared with the Canon ink set only on the Photo Paper. CMC Delta E measurements were made between the OEM and third part samples with an X-Rite Digital Swatchbook using D50 illumination and a 2 degree observer angle.

Photo Paper Results

Observations

In general, the three samples had remarkably similar performance. Black lines and single color lines (cyan, magenta and yellow) printed on paper were rendered with similar widths, and similar raggedness values. Single color dots were also quite similar in structure and variability was low as is usual with photo paper.

There were several differences that may impact customer satisfaction of one set of inks over another.

Negative Line Quality

Although black lines rendered similarly on all three samples, there was a difference in the quality of vertical white lines in black backgrounds. The Carrot Ink sample had a significant amount of splatter in the white line, which resulted in a darker-looking line with more ragged looking edges.

Figure 1. Canon line on left, Carrot Ink line on right

Black on Yellow Inter-Color Bleed

The measurement of black on yellow bleed was confounded by the fact that the black lines were printed as composites (CYMK). This is probably due to the photo paper setting in the driver for the printer. Although it results in a richer looking black, it is a challenge when it comes to making analytical measurements.

The magnitude of inter-color bleed between this composite black and the yellow background was similar for all three samples. Color halos were visible around the edges of the black lines adjacent to yellow on all samples. The OEM sample and the Carrot Ink sample showed a magenta halo, while the TopInkJet sample had a greenish halo.

Cyan on Yellow Inter-Color Bleed

The TopInkJet sample had a higher level of inter-color bleed between cyan lines and a yellow background than the other samples. It should be noted that the cyan colorant appeared to be much lighter than the colorant on the other samples, and the decreased contrast is visible in the following figure.

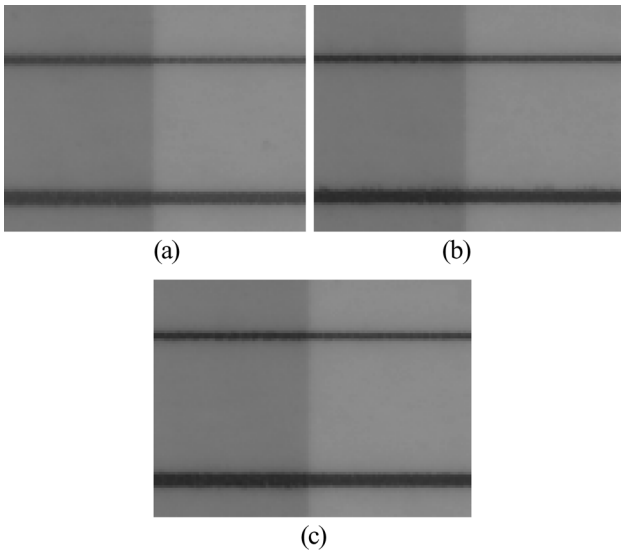

Figure 2. (a) TopInkJet, (b) Carrot Ink, (c) Canon

It can be seen in the previous figure that there is also some feathering on paper for the Carrot Ink sample as well as a bit more of a wispy or ragged bleed effect on the when compared with the Canon and TopInkJet samples.

Color Differences

Color differences were measured versus the Canon ink set. The high deltaE values, particularly those of the TopInkJet sample, indicate a large difference from the OEM ink. During the image quality testing, it was observed that the magenta, cyan and black inks appeared to be significantly different from the OEM. The measured values (shown in the following table) support this observation.

deltaE CMC
TopInkJet Carrot Ink
CYAN 11.4 1.9
MAGENTA 5.2 2
YELLOW 2.8 0.6
BLACK 22.5 6.6

Plain Paper Results

Observations

The image quality performance of the plain paper samples spanned a wide range. This was particularly true in the areas of inter-color bleed and wicking (feathering of line edges).

Overall, the OEM sample was the best by far, followed by the Carrot Ink sample, with the TopInkJet sample being the worst by a considerable amount in terms of most of the image quality attributes we measured. There are several exceptions to this (such as cyan on yellow color bleed) that will be addressed.

As in the case of the Photo Paper results, the TopInkJet sample had a significantly lighter cyan than the other samples. Magenta and black also seem lighter but not as visibly as the cyan.

Positive and Negative Lines

The three samples showed remarkable similarity for black lines on paper and white lines in black. Both line widths and line edge noise measurements were quite similar for horizontal and vertical lines-- although the black colorant in the TopInkJet sample was a little washed out so the contrast was not as high.

Positive Color Lines

Positive color lines (color lines on paper) on all samples showed some amount of wicking.

All three samples showed some level of cyan wicking. The Carrot Ink sample had the most pronounced wicking although both the OEM sample and the TopInkJet sample showed some amount as well. The TopInkJet sample looked a little blurry rather than ragged since the edge wicking was lower contrast due to the lower contrast cyan ink.

Magenta lines had the worst wicking on the Carrot Ink sample and the OEM sample, the best on the TopInkJet. The OEM sample had particularly "sharp" wicking which detracts considerably from the perceived quality of the line.

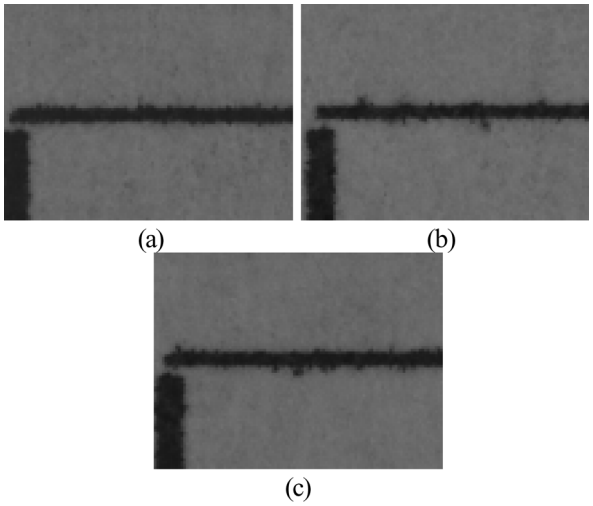

Figure 3. (a) TopInkJet, (b) Carrot Ink, (c) Canon

Yellow line quality was best in the OEM sample, the TopInkJet sample was second and the Carrot Ink sample was worst with the highest amount of wicking.

Negative Color Lines

The single color lines on black showed much larger quality differences. For all color lines on black, the OEM sample was markedly better, with the Carrot Ink sample

coming in a distant second with major quality problems. The negative color lines were virtually obliterated in the TopInkJet sample. Although this was true for all colors in both horizontal and vertical orientations, only horizontal yellow lines are shown here for comparison.

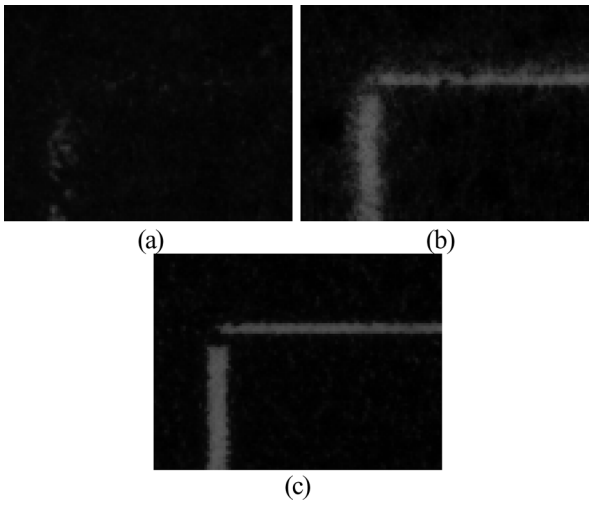

Figure 4. (a) TopInkJet, (b) Carrot Ink, (c) Canon

Dot Quality

Along with lines, dots are one of the fundamental building blocks of printed images. The ability of a printing system (engine, marking media and substrate) to render dots in a uniform fashion is important to overall image quality. For black and cyan, the dots were best rendered on the OEM sample, and worse on the samples printed with cartridges from Carrot Ink and TopInkJet.

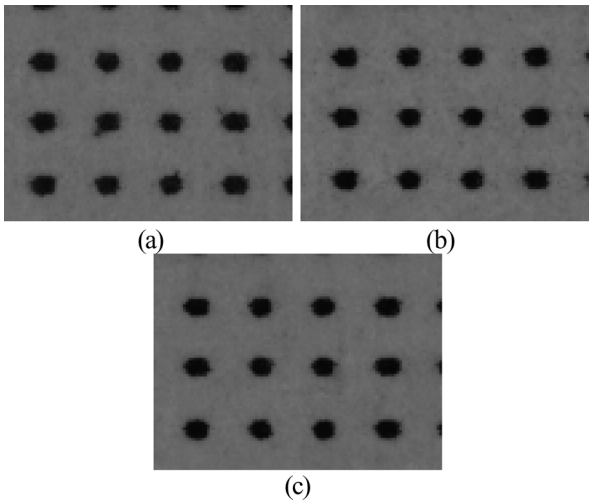

Figure 5. (a) TopInkJet, (b) Carrot Ink, (c) Canon

Magenta and yellow dots were more similar across all samples with visible non-uniformities caused by various amounts of wicking.

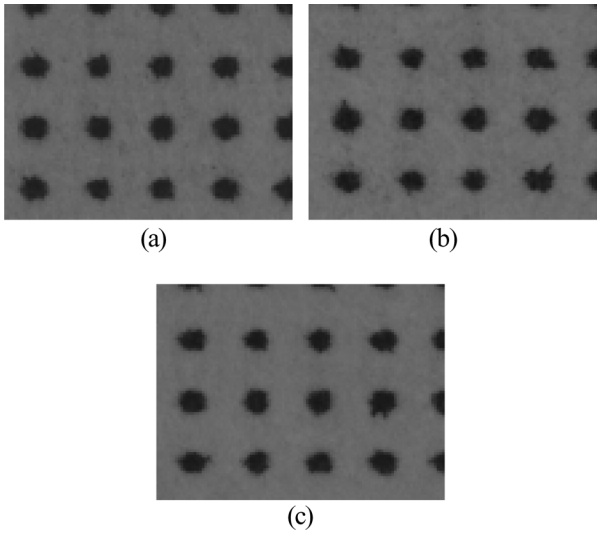

Figure 6. (a) TopInkJet, (b) Carrot Ink, (c) Canon

Black on Yellow Inter-Color Bleed

Black on yellow bleed showed very different quality levels.

In all cases- for wide and fine line widths, for horizontal and vertical lines--the OEM sample was the best by far. The Carrot Ink sample was second, and the TopInkJet sample had the worst performance with significant black to yellow inter-color bleed.

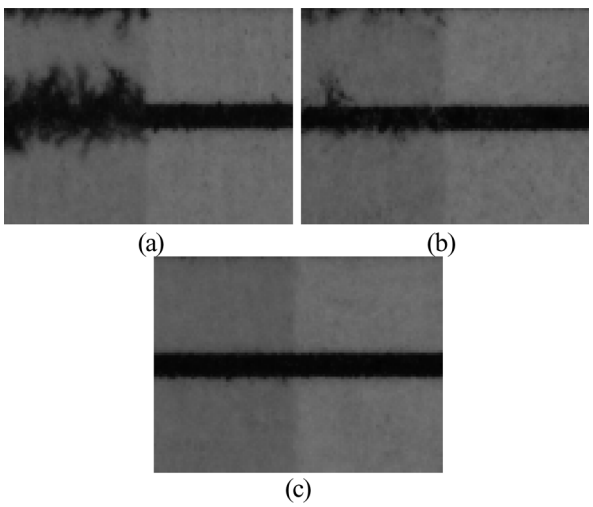

Figure 7. (a) TopInkJet, (b) Carrot Ink, (c) Canon

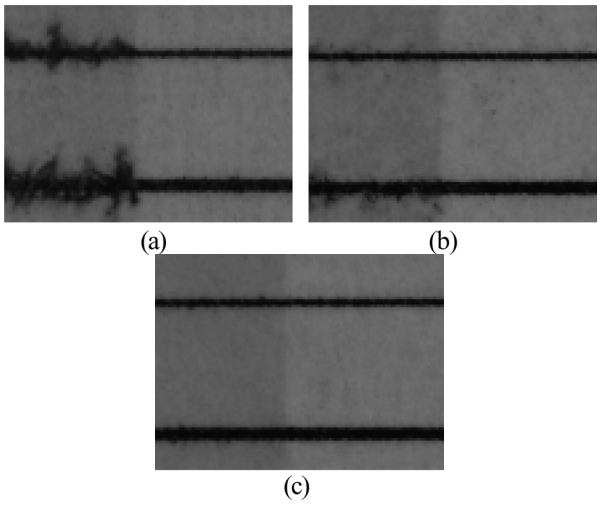

Figure 8. (a) TopInkJet, (b) Carrot Ink, (c) Canon

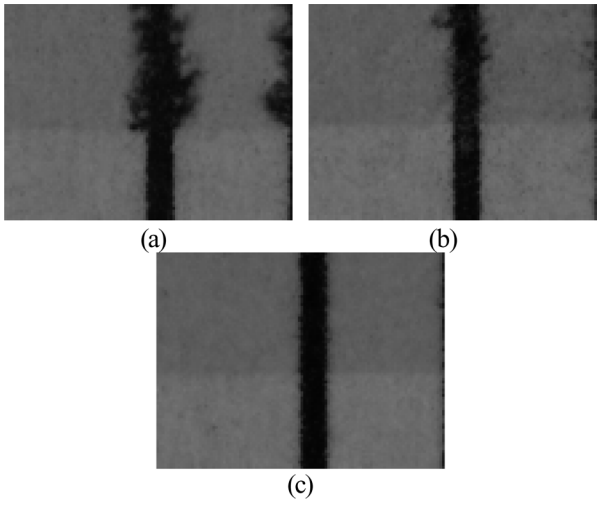

Figure 9. (a) TopInkJet, (b) Carrot Ink, (c) Canon

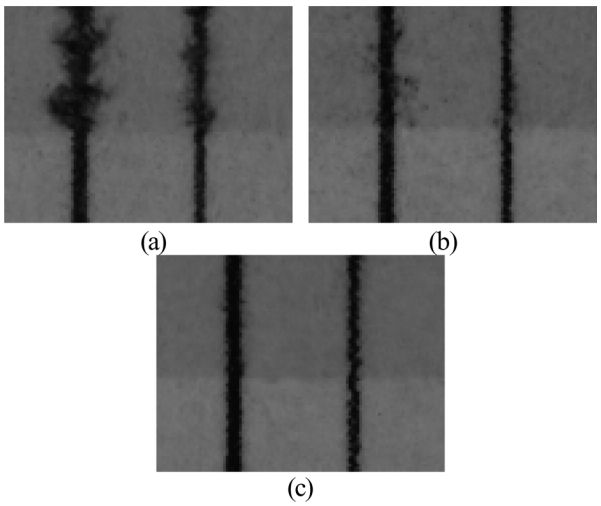

Figure 10. (a) TopInkJet, (b) Carrot Ink, (c) Canon

Cyan on Yellow Inter-Color Bleed

All samples showed considerable bleed between wide cyan lines and a yellow background, with the Carrot Ink sample having the highest magnitude of inter-color bleed, and the OEM sample and the TopInkJet sample being almost comparable.

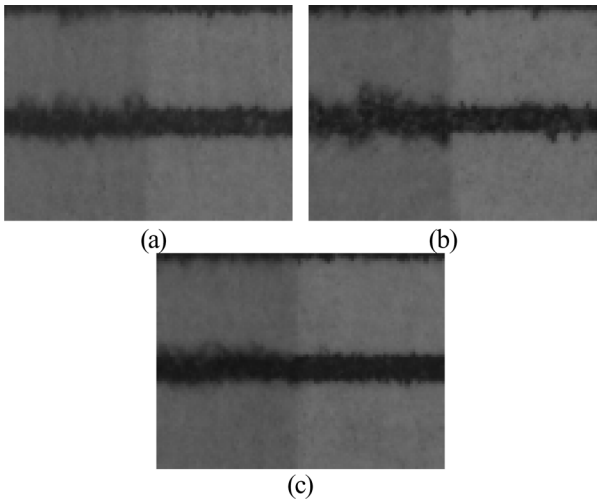

Figure 11. (a) TopInkJet, (b) Carrot Ink, (c) Canon

For the fine horizontal lines, the magnitude of cyan to yellow inter-color bleed was more comparable across the samples, but the Carrot Ink sample appeared to have more uneven bleed in the finest line, and the OEM sample appeared to have to most bleed in the slightly larger line.

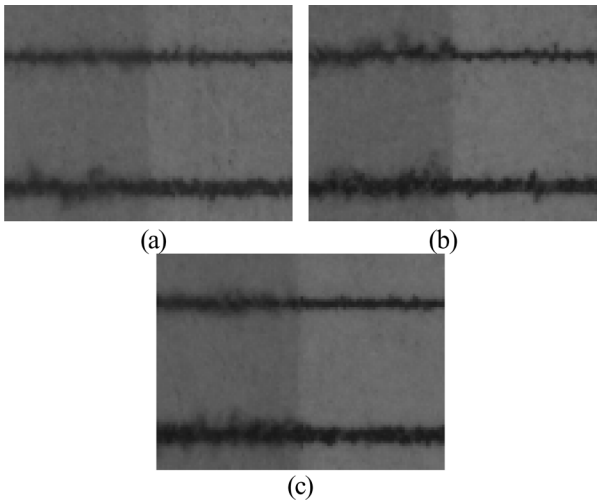

Figure 12. (a) TopInkJet, (b) Carrot Ink, (c) Canon

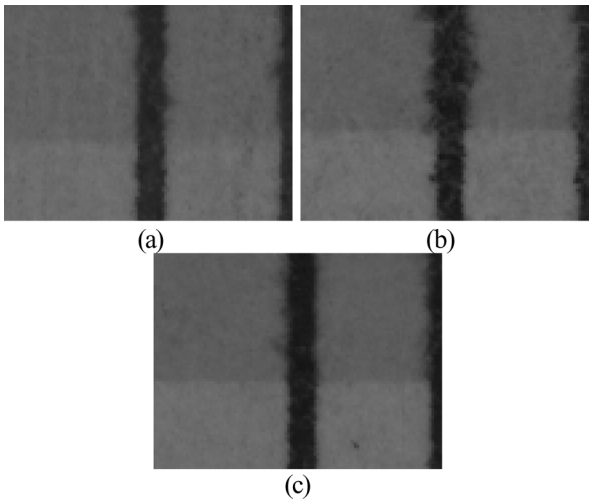

Figure 13. (a) TopInkJet, (b) Carrot Ink, (c) Canon

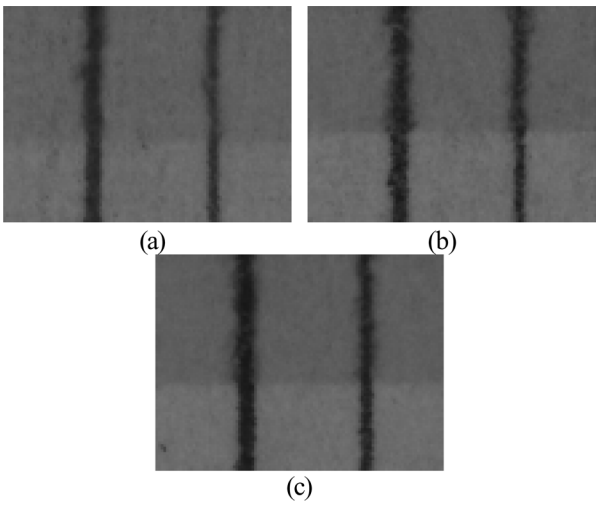

Figure 14. (a) TopInkJet, (b) Carrot Ink, (c) Canon

Vertical color bleed performance was consistent for both wide and fine lines. The Carrot Ink sample had the highest magnitude of inter-color bleed between cyan and yellow, the OEM sample and TopInkJet sample had slightly better performance.

Conclusion

Differences in performance were highlighted on the samples printed on multipurpose paper. The quality of black on yellow bleed and the color lines in black surrounds are significant differentiators for the quality of the images. Certainly, based on the analysis of the the TopInkJet sample, the considerable inter-color bleed and the obliteration of color lines in black background make the image quality versus cost tradeoff quite clear.

The higher quality paper, while not having the same magnitude of image quality detractors, did show a significant amount of color difference between the third party inks and the Canon ink set. The impact of color on image quality should be taken seriously.

Although third party inks might save money for the customer, sometimes saving money comes at a price. As this report shows, savings may be accompanied by significantly decreased image quality depending on the substrate and the print content. Third party ink developers should take notice. Both third party vendors included in this study claim to develop cartridges that meet or exceed the specifications of the OEM. It is clear, however, that even when performance specifications are met, quality might be an issue worth tracking. Equaling OEM quality but delivering it at a lower price point would be a compelling marketing statement.

Acknowledgement

The authors would like to thank Ray Cheydleur of X-Rite for performing the color difference measurements on the samples included in this report.

Biography

Glenn Menin joined PC Magazine in 2001 as Project Leader of the Peripherals Team. He had previously served as consultant for PC Magazine on many projects prior to that. Other endeavors have included graphic design and illustration. He has an Associates degree in Graphic Design from Pratt Institute.