About the Center

Rochester Institute of Technology (RIT) was selected by the Alfred P. Sloan Foundation in 2001 to join the family of Sloan Industry Centers located at prestigious universities across the U.S. The Printing Industry Center at RIT is a joint program of the School of Print Media and RIT's College of Business, emphasizing Sloan's long-standing tradition of applying a broad multidisciplinary approach to industry investigations and findings.

Dedicated to the study of major business environment influences in the printing industry brought on by new technologies and societal changes, the Printing Industry Center at RIT addresses the concerns of the printing industry through educational outreach, research initiatives, and print evaluation services. The Center creates a forum for printing companies and associations worldwide to access a neutral platform for the dissemination of knowledge that can be trusted by the industry, to share ideas, and to build the partnerships needed to sustain growth and profitability in a rapidly changing market.

With the support of RIT, the Alfred P. Sloan Foundation, and our Industry Partners, it is our mission to continue to develop and articulate the knowledge necessary for the long-term economic health of the printing industry.

More information on the Printing Industry Center at RIT and its research activities can be found online at http://print.rit.edu.

Industry Partners

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For Affiliates of the Printing Industry Center at RIT

Further Investigation into the Image Quality Differences Between Digital and Offset Printing

The primary goal of this research report, *Further Investigation into the Image Quality Differences Between Digital Print Technologies and Traditional Offset Lithography* (PICRM-2009-04), by Susan Farnand, was to follow-up on research conducted in 2007 into the image quality gap between digital print technologies and offset lithography. The 2007 results suggested that, for some of the images tested, the prints provided by digital printers on uncoated cover stock were valued as highly or even more highly than those printed using offset lithography. The dependence on the media of the comparative difference in image quality was one that required further exploration.

Additionally, in the 2007 experimentation the test images contained unintended color shifts that observers were asked to disregard in making their image quality assessments. In discussions of the experimental results, concerns were expressed regarding the observers' ability to disregard color. In these discussions, questions were also raised regarding the impact of designing images with consideration of the limitations and strengths of the specific output device and the effect of the level of skill of the survey participants.

Therefore, the main objective of this follow-on project was to further evaluate the image quality gap between digital print technologies and offset lithography, including the questions raised in the discussions, and to verify trends suggested by the initial study, with particular

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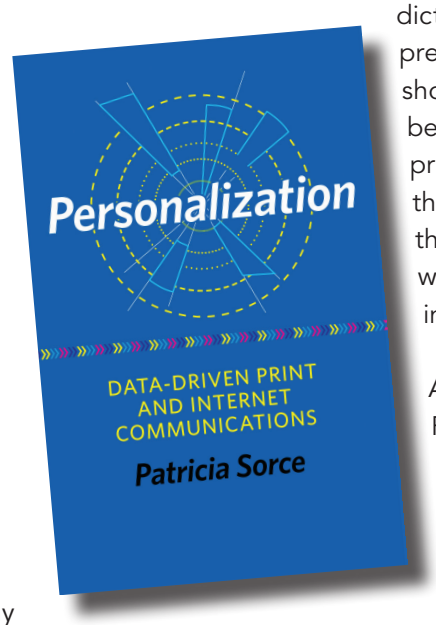
R·I·T Printing Industry Center

inside

New RIT Publication Focuses on Personalized Communications

Two-way consumer communication has evolved through the use of technology—but to maximize the benefits—it still must be tailor-made to meet customer needs and interests.

Author Patricia Sorce discusses the latest trends on custom communications techniques in her new book, *Personalization: Data-Driven Print and Internet Communications*, published by the Cary Graphic Arts Press at Rochester Institute of Technology. *Personalization* is the fourth volume in the Printing Industry Center Series.



"This is a follow-up to my first book, *Data-Driven Print* (2006), an updated perspective on using insights about the people you are communicating with to craft the message," says Sorce, who is administrative chair of the School of Print Media in RIT's College of Imaging Arts and Sciences and co-director of the RIT Printing Industry Center. "It focuses on the one-to-one marketing strategy to create two-way communication with customers to make sure they receive information that is relevant and of interest to them.

"Most people think the Internet is the only medium where personalization can be done effectively," Sorce explains. "An example is when you log onto Amazon and it brings up a set of recommendations on your past purchase history; there's an algorithm that does that. Personalized print is also a very powerful medium but it does not have the immediacy of the Internet. However, printed marketing communications can generate a lot of attention particularly when the personalized messages are based on past buying behavior and predictive analytics. The book presents case studies that show how to utilize the best of both media—print and Internet—so that each can work with the other in a synergistic way to maximize marketing outcomes."

According to Lem Richards at Digital Marketing and Print Solutions based in Dallas. "As a printer trying to assess the strategy in the variable data market, this book was a superb reference in helping our group understand key concepts."

Sorce says Personalization is aimed at the practitioner—printing professionals, media planners, sales and corporate communicators—and identifies the best practices, best prospects and associated business models for delivering top value to printing clients. In addition, several case studies provide real-world examples of this evolving industry.

Personalization is available for purchase for $18 by calling RIT's Cary Graphic Arts Press at (585) 475-6766 or visiting http://carypress.rit.edu.

More information is available at: http://print.rit.edu/publications

RIT School of Print Media's *Test Targets 9.0* Now Available!

The scholarship of current and emerging print technologies is the theme of the latest edition of *Test Targets 9.0*, published by Rochester Institute of Technology.

RIT students, faculty and staff from RIT's School of Print Media submit research papers for the annual publication. Topics covered in *Test Targets 9.0* include color management, process control, color measurement and dimensional printing.

In collaboration with Eastman Kodak Co., there is a special insert, "Gallery of Visual Interest," featuring an article "Benchmarking Color Image Quality Between Inkjet and Offset." Kodak was the vendor that agreed to incorporate the actual targets printed on its inkjet solution. *Test Targets 9.0* contains the first widely available Kodak Prosper 5000XL press with Stream Inkjet Technology samples.

Using color measurement and visual comparisons, RIT researchers determined the Kodak Prosper 5000XL press, a high-speed color inkjet press, produces pleasing offset print quality by honoring the gray balance of a standard offset printing while having higher chroma as seen in various hues. The article also demonstrates how the Kodak Prosper 5000XL press can closely match a standard offset printing condition by using a device link ICC profile.

In addition to research and content creation, collaborators also perform pre-media, prepress and printing tasks using facilities at the School of Print Media and RIT's Printing Applications Laboratory. The production of the publication was sponsored by the Printing Industry Center at RIT as part of its 2009-2010 research agenda. Copies of *Test Targets 9.0* were distributed to its industry partners at the annual Printing Industry Center Symposium and Planning Meeting held Nov. 19 and 20 in Rochester.

Test Targets 9.0 is available as a PDF free of charge at:
http://cias.rit.edu/~gravure/tt/

Hard copies of the publication may be purchased for $24.95 from RIT Cary Graphic Arts Press by calling RIT's Cary Graphic Arts Press at (585) 475-6766 or visiting http://carypress.rit.edu. Profits from the sale of the publication are donated to RIT's School of Print Media scholarship fund.

For more on *Test Targets*, visit
http://cias.rit.edu/~gravure/tt/

Image Quality Differences *continued*

attention to the media used. This was accomplished through two sets of experiments: Experiments I and II.

Experimental Method

Experiment I

This experiment was essentially a repetition of the experiment conducted in 2007. It used the same image set, but the prints were significantly closer in color balance than those used in 2007.

The image set used in the 2007 experimentation, which included six images entitled "China", "Print Gallery", "Sarah", "Text", "Train", and "Village Sports", was used in the present study (the images may be seen in Appendix A of the full monograph). The images represent the categories included in the 2006 Printing Industry Center research monograph *Permanence of Toner on Paper—Based on the Lifecycle of Documents* (Frey, Christensen, & Disantis, 2006): direct mail, marketing and promotional materials, business communications, and photo books.

The experiment was conducted under D50 lighting conditions in D50 viewing booths at the ImagineRIT Innovation Festival in May 2008 and in the Psychophysics Lab in the Color Science building at RIT. Twenty-one people having a variety of backgrounds participated. Eight females participated along with thirteen males. The age range of the participants was 15-64.

Experiment II

The image set was expanded in this experiment. Images lacking the known stressors, namely, uniform areas for the digital printers, were chosen to supplement the image set. Ten test images were used, including five of the images used in the first experiment; "Print Gallery", "Sarah", "Text", "Train", and "Village Sports". The "China" image was replaced with two other photo book images, "Munich" and "Cars". Another marketing document "Shaving", which included a significant proportion of text, and which was, like the "Train" image, created as part of the Technology Practicum course at RIT in 2007, was used. Finally, an additional category of Photos for Display was included and represented by two detailed images: "Rose" and "Flowers" (these additional images can be seen in Appendix B of the full monograph).

With the image set selected, prints were made on a sheetfed offset lithographic press in the Printing Applications Lab at RIT. These images were, as in Experiment I, used as guide prints in generating the images on the digital equipment. Prints were then made of each image on three different high-end digital presses at RIT. Three substrates were used on each device, one coated (Titan 80# gloss text) and two uncoated (80# Accent Opaque and 60# Accent Opaque). These were lighter weight papers than were used in the previous experimentation.

The psychophysical experimentation conducted followed the same general protocol* as that in the previous experimentation. However, in this experiment, the print sets included all of the prints of a given image on all media as well as on all printers. Again, at the start of the evaluation of each set, the participant was told the purpose of the document.

The experiment was conducted under D50 lighting conditions in the Psychophysics Lab in the Color Science building at RIT. Twenty-seven people having varied backgrounds participated, including twenty from an undergraduate psychology course. In total, there were fifteen participants in the "Skilled" category. The remaining twelve participants comprised the naïve

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Image Quality Differences *continued*

participant category. Fifteen females participated along with twelve males. At least one participant had a color vision anomaly; this was self-reported, so others may have been present. The age range of the participants was approximately 18-50, with the vast majority being around 20.

* For each set, the print made on the offset press on the coated paper was selected to be the reference print. As in Experiment I, when the participants were shown the reference print, they were told that they paid a dollar for this page. They were then presented with the set of comparison prints, one at a time. The participants were given the following instructions: for each of the comparison prints, if the quality was sufficiently higher than the reference to justify paying more for the document, specify how much more you would be willing to pay. If the quality was sufficiently worse than the reference, tell how much less you feel it is worth. If you think the quality is essentially comparable (even if the prints looked quite different), state that it has the same value as the reference. With this explanation, the first comparison print of the first set was presented, and each participant proceeded through the document sets in random order.

Results & Discussion

Experiment I

For both studies, the data indicate that the offset press produced prints on coated paper that had comparable or higher perceived value (see Figures 1 and 2). This result holds up for all of the images included in the studies, on average (see Figures 3 and 5). The results for the prints made on the coated paper in the two studies are remarkably similar.

The differences were not so subtle, however, on uncoated paper. In the 2007 experimentation, it was found that some of the prints from two of the digital printers, especially of the photo book pages and marketing materials, were found to be of higher value than the counterparts made using offset lithography (see Figure 6). Printer 1 or Printer 3—and often both together—yielded prints that were rated more highly than the offset prints for every image tested with the exception of the "Print Gallery" image.

However, the results of the current study were markedly different. Looking at Figure 1, it is evident that the prints made on the offset press were superior on uncoated paper as well as coated. Examining the results by image (as shown in Figure 4), there were few instances where the digital print was rated of greater value than the offset print. For the most part, however, the results on uncoated paper looked much more like the results from the current study on coated paper, with prints produced by the offset press being rated as having higher perceived value relative to the digital prints, than the results of the 2007 experimentation for uncoated paper.

How did this occur? There were several differences between the two experiments, including different sets of observers and different physical viewing environments, although both experiments took place in D50 viewing booths. However, probably the most important difference between the two was that the digital prints were different. Recall that for the present study, the offset print on each media was used as a "guide print" for the digital print runs to remove the impact of color balance shifts in the print value assessments. Making the digital prints look like the offset prints had important consequences. For one thing, it reduced the variability in the assessed values. In the 2007 experimentation it was found that, as the difference from the reference print increased, so did the variability in how the participants valued those prints. With the digital prints used in the current study much more closely resembling the reference print, the resultant variability in assessed value

Figure 1. Mean assigned values for the images on coated and uncoated media for each printing device, 2008 study

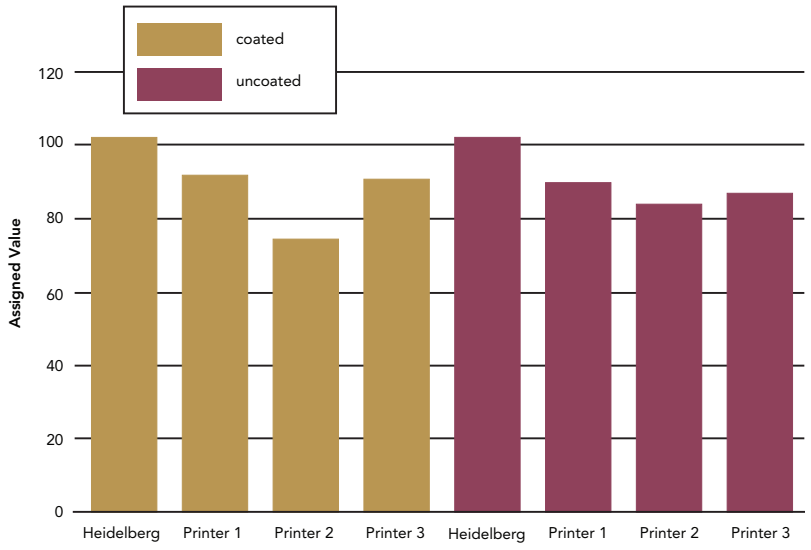
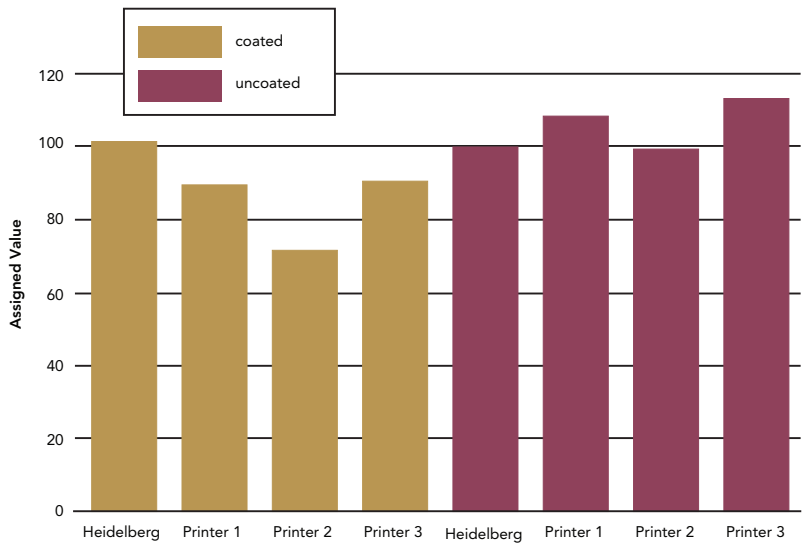


Figure 2. Mean assigned values for the images on coated and uncoated media for each printing device, 2007 study



was significantly lower.

Another, perhaps more important, consequence of using the offset prints as guide prints is that this may have impacted the advantages seen by the digital presses. In the 2007 study, the offset prints were generally preferred over the digital prints on the coated paper. Using the offset print as a "guide print" then entailed little risk. However, for the uncoated media, the offset print was not always the most preferred. The contrast and overall gloss level of the digital prints were cited as the image attributes that led many participants to rate the digital prints more highly than the offset prints. Although the intent of using the offset print as a "guide print" was to verify the color balance, the contrast and gloss seem to have been affected as well. By making these aspects of the digital prints more like the offset prints, any advantage that they may have provided was lost. The differences that remained were the uniformity issues and reduced quality text and line reproduction on the digital prints. The comments made

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Image Quality Differences *continued*

Figure 3. Average assigned value for each image on coated media, 2008 study

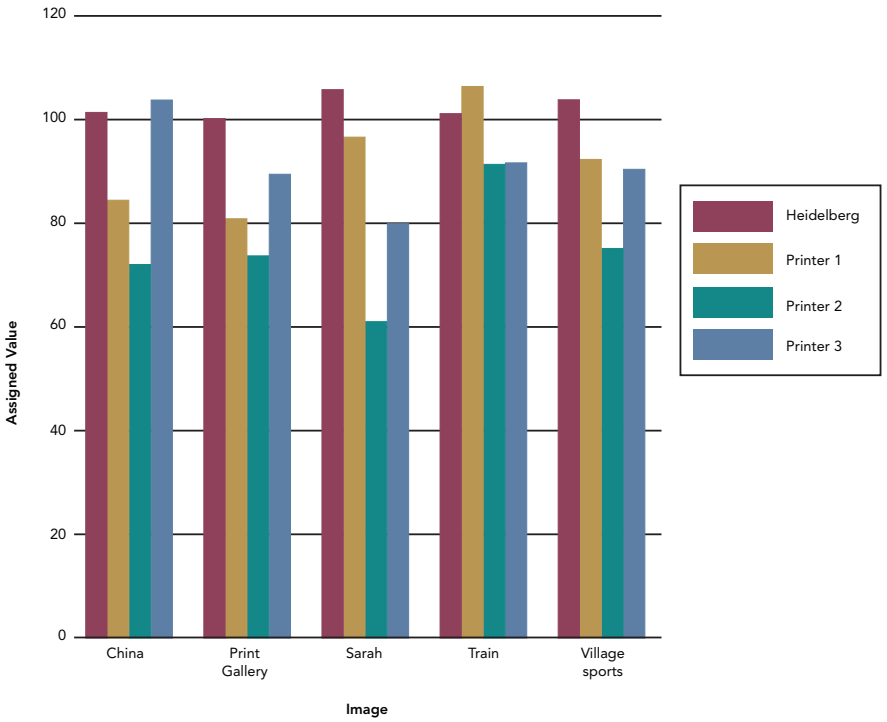
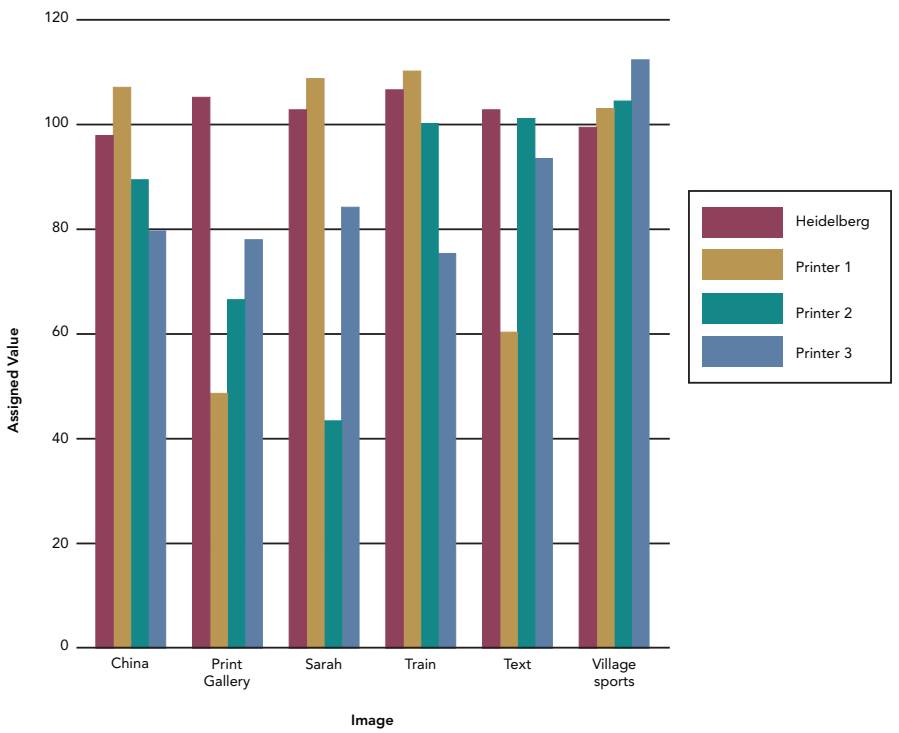


Figure 4. Average assigned value for each image on uncoated media, 2008 study



by the participants as they made their assessments support this assertion.

The original question under investigation in Experiment I was what the effect of the unintended color shifts present in the images in the experimentation conducted in 2007 had on the results obtained. Looking at only the coated results, we see that the impact of the color shift on the experimental results was minimal, though the variability in the data was reduced. The uncoated results, however, illustrate the importance of contrast and gloss on perceived image value. The changes in these attributes makes it difficult to know what impact the color shift alone had on relative perceived quality of the uncoated prints.

It is fortunate, perhaps, that the experiments were conducted in the order they were, because the effect of the paper, which was a key result in the experimentation conducted in 2007, was not obvious in Experiment I of the current study. However, as Experiment II will show, this factor is indeed relevant and important to consider.

Figure 5. Average assigned value for each image on coated media, 2007 study

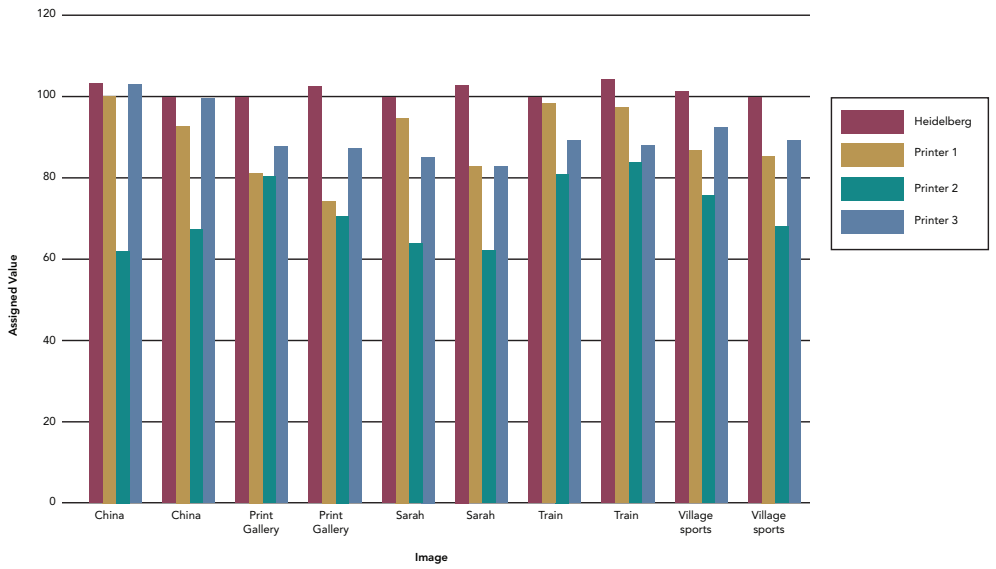
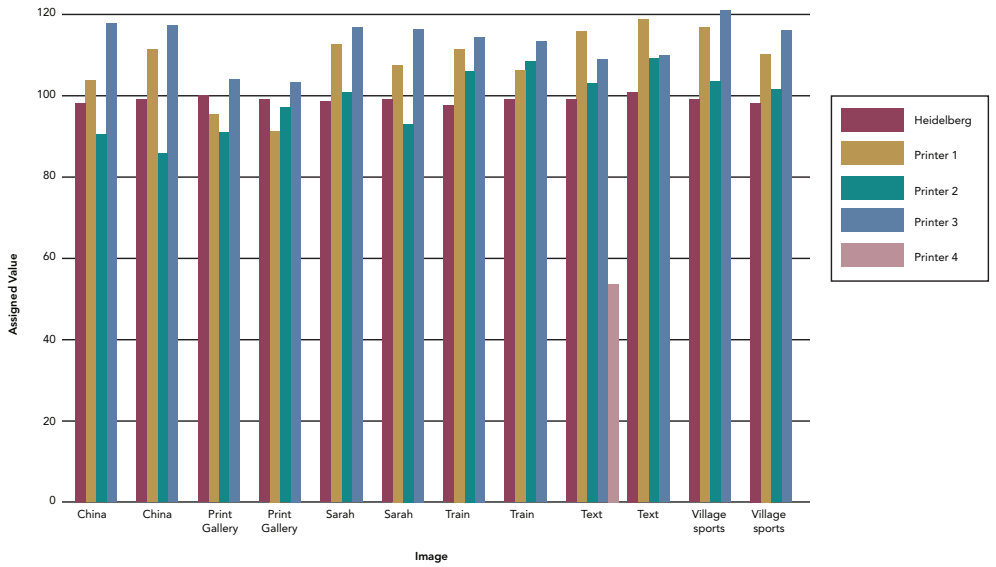


Figure 6. Average assigned value for each image on uncoated media, 2007 study



Experiment II

A key difference between this experiment and the previous studies is that, in this experiment, the image on coated paper was used as the reference print for all renditions of that image on all of the three media. Interestingly, there are several prints from Printers 1 and 3 on coated paper (as shown in

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Image Quality Differences *continued*

Figure 7) that were rated more highly than the offset reference and many that were rated equivalently to the offset reference. This is somewhat surprising, given the results from the 2007 experimentation and Experiment I. One difference between the studies was that the present work used a lighter weight coated paper than was used in the previous experimentation.

In contrast to this, almost none of the prints on uncoated media were rated higher than the reference print, which was on coated stock.

Clearly, there is a significant difference in the perceived quality of the prints on coated media relative to uncoated media. The mean assigned value for each image is shown in Figure 8 for each paper on the offset press and averaged over the digital presses. For all of the photo images, the ratings on coated paper were significantly higher than those on uncoated media. Even the "Print Gallery" image, which includes a picture of a young girl, shows a substantial difference between the coated and uncoated media. Only the "Text" image (the only image with no photo content at all), shows a larger difference between print technologies than between media. The response data are shown averaged over all of the images by media and by printer in

Figure 7. Average assigned value for each image on coated media by printing device

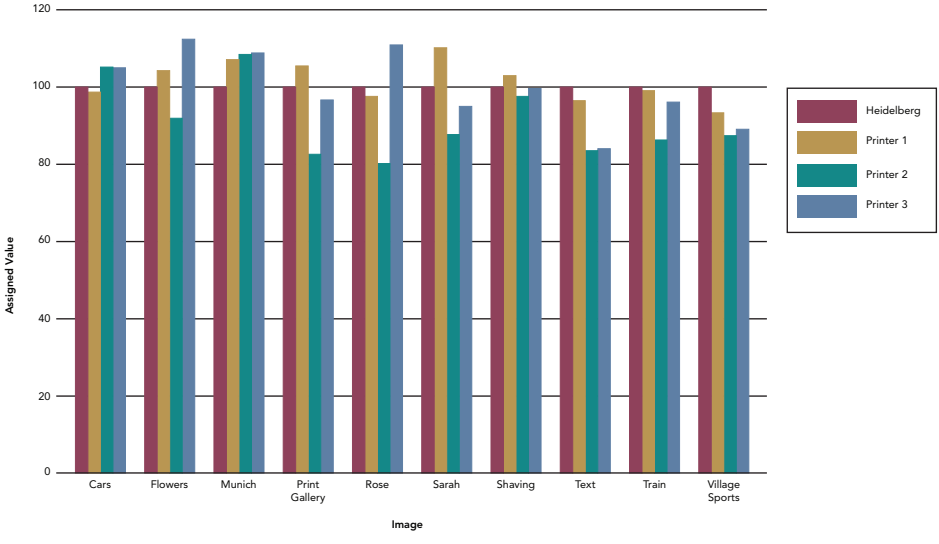
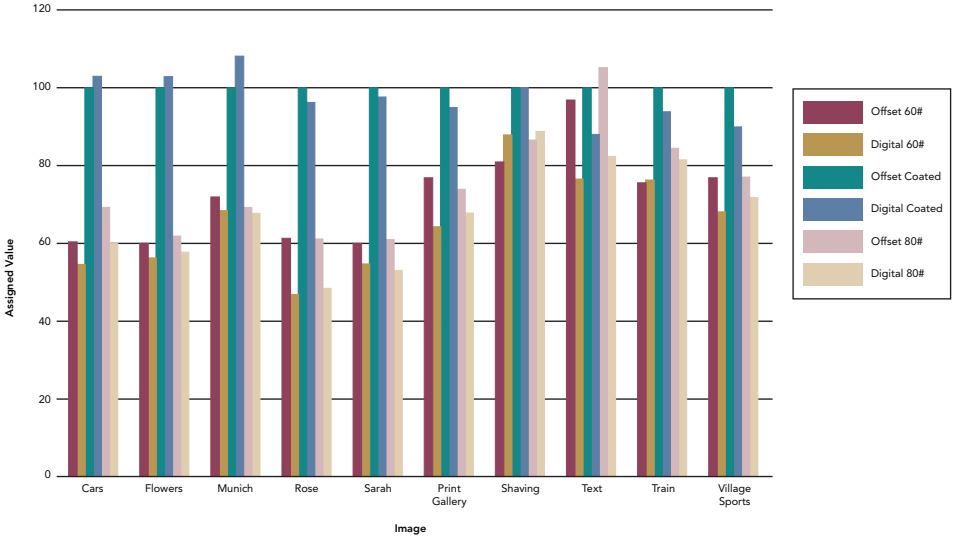


Figure 8. Average assigned value for each image by media



2009 Symposium & Planning Meeting

The annual meeting of the Printing Industry Center was held November 19-20, 2009. Nearly 60 participants—representatives from Industry Partner companies, RIT faculty and staff, and RIT graduate students—came together to learn about the research that was conducted over the past year.

Research topics in 2009 included: printing industry demographics, typographic expressiveness, a distribution center model for print service providers, future high value news media audiences, print energy usage measurement, consumer photography preferences (print vs. screen), and the Open Publishing Guide.

On the second day of the event, RIT researchers presented their proposed research plans for the coming year, and Industry Partner companies had the opportunity to provide feedback. This collaboration in developing the research agenda results in rich and relevant inquiries into the printing industry.

Based on these discussions, a Center plan of work for 2010 will be released to the community in January. Descriptions of the research and the principal investigators involved will be posted on the Center web site.

More on Center research is available at http://print.rit.edu/research/

Image 1. Frank Romano's presentation
Frank Romano, Professor Emeritus in the RIT School of Print Media, during his presentation on printing industry demographics.

Image 2. Franziska Frey's breakout session
Franziska Frey, Ph.D., McGhee Distinguished Professor in the RIT School of Print Media, presenting her research on consumer photograph consumption preferences during a breakout session on the first day.

Image Quality Differences *continued*

Figure 9. From this graph, it is evident that the media had a far greater effect on perceived value than the print technology, on average.

The results were also examined as a function of the skill of the participants. The people participating in the experiment included several graphic arts students, faculty, and staff; photography students, and imaging science students and staff with printing experience. These were grouped into the skilled category. All others were grouped into the naïve category. The average assigned value for each image for each group of participants was determined. The results for the two groups were highly correlated, and the relationship was highly linear with a slope slightly greater than 1 and an offset of about 29, indicating a systematic difference between values given by skilled and naïve participants. This difference was then calculated (naïve – skilled). All the differences are positive, indicating that the skilled

Figure 9. Average assigned value for each media and printer, averaged over all images

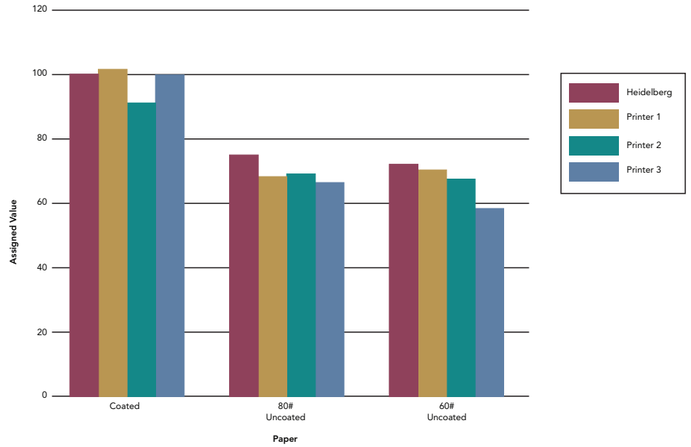
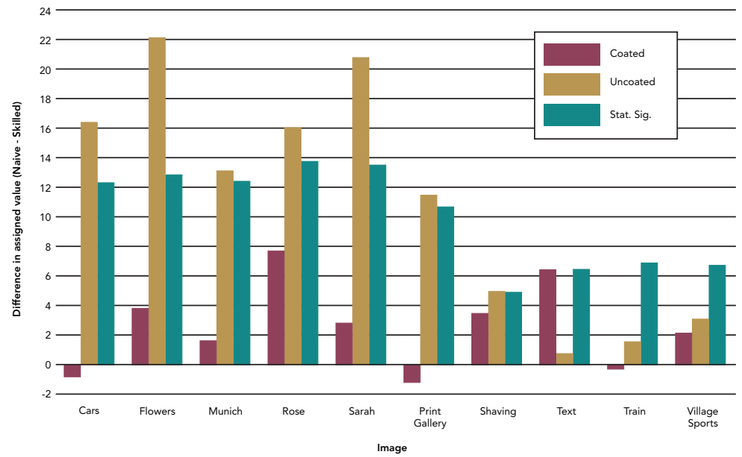


Figure 10. Difference in the average values assigned by skilled versus naïve participants for each image on coated and uncoated paper**



** The statistically significant bar shows the level needed for the difference to be statistically significant.

observers were more critical in general than the naïve participants, which is to be expected.

When the results are examined by paper, however (see Figure 10), significant differences are seen for almost all of the images. There are significant differences for all of the photo images and the Shaving image on uncoated paper and for the text image on coated paper. The only images that do not have a statistically significant difference between skilled and naïve observers are Train and Village Sports.

In Experiment I, the attribute most frequently mentioned as important in assessing the quality of the images was uniformity. In this experiment, uniformity was much less frequently mentioned. For Experiment II, the most common attribute mentioned as important in quality decisions was contrast. Other relevant attributes in this experiment were saturation, gloss, paper quality, sharpness, and text and line quality.

Conclusion

As was stated in 2007, it is important to remember that prints were made on only one offset press and only one machine for each of three different high-end digital printer vendors. Different results may be obtained using different equipment or even the same equipment run by different people or on different days. Drawing conclusions from this work must be done with a fair bit of caution. What we are really looking for is a better understanding of existing trends. In Experiment I, it was found that the offset press produced prints on coated and uncoated paper that had comparable or higher perceived value for the images tested. This is a different result from that obtained in 2007, when, on uncoated media, some of the prints from two of the digital printers, especially of the photo book pages and marketing materials, were found to be of higher value. As in 2007, participants generally liked the uniformity and high quality lines and text of the offset prints. However the higher contrast of the digital prints that they tended to prefer on the uncoated paper, at least for some applications, was missing from the prints made on uncoated paper for this experiment. The digital prints on uncoated paper went from being comparably rated or slightly preferred in 2007 to receiving lower ratings in the present testing.

While the results on uncoated paper were dramatically different between the experiment conducted in 2007 and Experiment I of the present study, the results on coated paper were nearly equivalent year to year. This may serve as evidence that the observers in the earlier experimentation were able to ignore the unintended color balance shifts, since this was the main difference between the prints used in the two experiments.

In Experiment I, the overall results on uncoated paper were similar to those on coated stock. The effect of media was not obvious as it was in the 2007 experiment. The effect of media was, however, quite obvious in Experiment II. In this experimentation, the impact of the media was much greater than the impact of the printing technology, overall. The prints made using offset lithography and those made on the digital printers, on average, were comparable in image quality on both coated and uncoated papers.

References

Frey, F., Christensen, H., & Disantis, N. (2006). *Permanence of toner on paper—Based on the lifecycle of documents* (PICRM-2006-05). Rochester, NY: Printing Industry Center at RIT.