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Between Digital
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By
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A Research Monograph of the
Printing Industry Center at RIT

No. PICRM-2009-04

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PICRM-2009-04

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The research agenda of the Printing Industry Center at RIT and the publication of research findings are supported by the following organizations:



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Abstract

In recent years the differences in image quality of digital printers relative to offset lithographic presses have been becoming ever subtler. In 2007, experimentation was conducted within the Printing Industry Center at the Rochester Institute of Technology examining this difference. It was found that there were significant differences in the perceived value of prints made on digital versus offset printing equipment. Prints on coated media made on offset equipment were generally preferred, while the prints on uncoated media made on digital printers were frequently assigned higher values. The results of this experiment were possibly compromised by the reality that there were unintended shifts in the color balance of the prints made on some of the digital equipment relative to the offset reference prints that the participants in the study were asked to disregard. The present study was conducted to examine the effect, if any, of these unintended color shifts and to further probe the effect of the media on the perceived image quality differences between high-end digital presses and offset lithography. The impact of observer image evaluation skill on the perceived image quality differences was also examined. The experimental results suggested that the color balance shift had minimal impact on the perceived image quality differences, though contrast played a significant role. The media also had a strong effect on perceived quality. Unsurprisingly, skilled observers tended to rate images more critically than unskilled participants, though this effect was only statistically significant for photo-based images on uncoated paper.

Introduction

In recent years digital “presses” have been introduced to the print production market, allowing short runs of customized documents in compressed time frames. While these printing capabilities are highly valued, there were questions regarding image quality when using devices with a heritage more closely associated with office copiers than commercial lithographic printing presses. But is this guilt by association fair? The general sentiment seems to be that the quality of the images being generated on digital printing equipment has essentially reached the realm of offset. Freedman of Technology Watch™ has conducted extensive work demonstrating that higher end digital printers such as the Kodak/NexPress 2100 and the Xerox DocuColor 8000 can be set up to produce image quality comparable to that of offset lithography (Freedman, 2004, 2006a, and 2006b).

In 2007, the Printing Industry Center sponsored an investigation into the image quality gap between digital print technologies and offset lithography. The results of this investigation suggest 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 an interesting result that we wished to explore further.

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.

The 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 attention to the media used. This was accomplished in two stages. First, the issue of unintended color shifts possibly confounding the results was addressed by essentially repeating the first experiment with images significantly closer in color and no longer asking observers to disregard color in making their assessments. Second, further testing was conducted examining additional images printed on “standard” weight media, as opposed to cover stock, which was used in the initial testing. The image set included some of the same images as used in the initial testing as well as images that were designed to be less stressful on the equipment being used. Participants with expertise in evaluating print images were recruited.

Background

Understanding and evaluating digital print quality has long been an area of interest for researchers in industry and academia (Swanson, 2000; Gast & Tse, 2001; Shaw, 1997; International Committee for Information Technology Standards, 2004; Chung & Rees, 2006c; Chung & Rees, 2006b; Xu & Kellogg, 2007). In these studies, typically four or five print attributes are cited as being of particular importance to the quality of the print; color rendition, uniformity, resolution, gloss, and artifacts (Swanson, 2000; International Committee for Information Technology Standards, 2004; Chung & Rees, 2006c). In their study on digital print quality, Chung and Rees (2006c) found that attributes of interest for digital print were generally also of interest for offset printing. Chung and Rees point out, however, that “[w]hile many of the attribute names are shared, the difference in the two technologies results in different visual appearances” (2006c, p. 15). It is this difference in the visual appearance that was of interest in the experimentation conducted for the Printing Industry Center in 2007, and it is this difference that remains of interest in this study. While efforts have been made to evaluate the measured differences in such things that pertain to print appearance as solid area density, dot gain, colorimetric values, and color gamut volume (Xu & Kellogg, 2007), it is the focus of this study to evaluate actual perceived differences in the quality of prints produced on high-end digital printing equipment relative to those printed via offset lithography.

Experimental Method

Experiment I

The experimentation conducted to evaluate the effective image quality differences between offset and digital was executed in two parts. The first 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 also used in the present study (the images may be seen in Appendix A). 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 “Sarah” and “China” images represent photo book documents. The latter image included vacation-type photos, Chinese text, and copyright text. For business communications, a text and graphics document, “Text,” and IS&T’s NIP23 Print Gallery document were used. In the marketing and promotional materials category, a brochure, entitled “Train”, created as part of the Technology Practicum printing course offered each spring at the Rochester Institute of Technology, and a mailer obtained from the Village Sports child care and sports center were used.

With the image set selected, prints were then made on the same printing equipment and the same substrates as the initial experimentation. The equipment included a Heidelberg Speedmaster 74 sheetfed lithographic press, an HP Indigo 5000, and a NexPress 2100, all located in the Printing Applications Lab at RIT, and a Xerox iGen3 located in the HUB Printing Center at RIT. The images made on the Speedmaster were used in generating the prints on the digital equipment, in essence representing a set of “guide” prints.

The same substrates used in the initial experimentation were used in this experiment. Two substrates were used on each device, one coated (Titan Plus Dull *digital* 100lb. cover) and one uncoated (HP Indigo printing paper 80 lb premium cover) cover stock. As in the 2007 experimentation, the “Text” image was only evaluated on uncoated stock. With prints of five images on four printers each on two papers and one image on four printers, the complete test set consisted of 44 prints.

With the print database generated, psychophysical experimentation was conducted that examined the impact of any apparent image differences on perceived quality or value. The participants were shown the prints in sets, where a set constituted all prints of a given image printed on a given medium. At the start of the evaluation of each set, the participant was told of the purpose of the document. For the photo book pages, the participants were told that the prints represented photo book pages of pictures that they may have taken on vacation and were for their personal use to share with family and friends. For the Village Sports brochure, each participant was told that he or she was the owner of Village Sports and that the document was a mailer that had been commissioned to send to prospective customers. For the Train brochure, each was told that they were the owner of Georgetown Loop Railroad and that the prints represented sales brochures used to generate business. For the text document and the Print Gallery page, the participants were told that these were business communications documents that would be circulated within an office environment, perhaps even sent to a supervisor, and, although the main purpose of the document was to convey information, the documents still needed to be presentable.

To address the question of impact, the observers were questioned regarding what they would be willing to pay for a given print. For each image on each paper, the print made on the Heidelberg Speedmaster 74 sheet-fed press served as the reference print. 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 (so that you would not want to pay as much for the document as you had for 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.

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 the second 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).

With the image set selected, prints were made on the Heidelberg Speedmaster 74 sheetfed 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 made on high-end digital equipment, including an HP Indigo 5500 and a NexPress 2100, both located in the Printing Applications Lab at RIT, and a Xerox iGen3 located in the HUB Printing Center at RIT.

For this second experiment, the effect of media on image quality was again of interest. In this experiment, 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. With prints of ten images on three papers made on four printers, the complete test set consisted of 120 prints.

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. For the Train brochure, the Print Gallery page, the Text document, and the Village Sports mailer, the participants were given the same document purpose explanations given in Experiment I. For the photo book pages, this time including the Munich and Cars documents as well as Sarah image, the participants were again told that the prints represented photo book pages to share with family and friends. For the “Photo for Display” image sets, the participants were told the prints were photos for display

such as posters or something that might be framed. For the Shaving document, the participants were told that this was an advertisement, maybe something handed out at the mall or available at fine salons.

For each set, the print made on the Heidelberg Speedmaster 74 sheet-fed 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 (so that you would not want to pay as much for the document as you had for 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.

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. Their majors ranged from Computer Science to Photography to Biotechnology. There was also a significant number of graphic design students from the class that participated in the experiment. These students were included in the expert observer category, which also included printing and imaging science graduate students and staff. The Imaging Science personnel were researchers who have worked in the area of printing. There were fifteen participants in the “Skilled” category. The remaining twelve participants comprised the naïve 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.

Results and Discussion

Experiment I

With the experiment complete and the data in hand, the next step was the data analysis, which began by calculating the mean assigned value for each of the comparison prints. The consistency of the participants' responses was then evaluated by calculating the correlation coefficients of the individual responses with the mean response for each of the comparison prints. These correlation coefficients averaged about 0.72, and varied from 0.57 to 0.90. This compares favorably with the results from the 2007 experimentation, in which the average correlation coefficient was 0.60 with a range of 0.24 to 0.80. All of the results collected were retained in the analysis.

The mean assigned values for the prints made on coated and uncoated paper averaged over all the image sets on each piece of printing equipment included in the experimentation are shown in Figure 1. The results are broken down by image in Figures 3 and 4 for the coated and uncoated papers, respectively. For comparison, the equivalent results for the Printing Industry Center research on the differences in digital and offset print quality conducted in 2007 are shown in Figures 2, 5 and 6. 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. For example, in Figures 3 and 5, the "China" print from Printer 3 and the "Train" print from Printer 1 were rated comparably to that from offset in both studies on coated paper. Over all the images and printers, the differences are quite subtle.

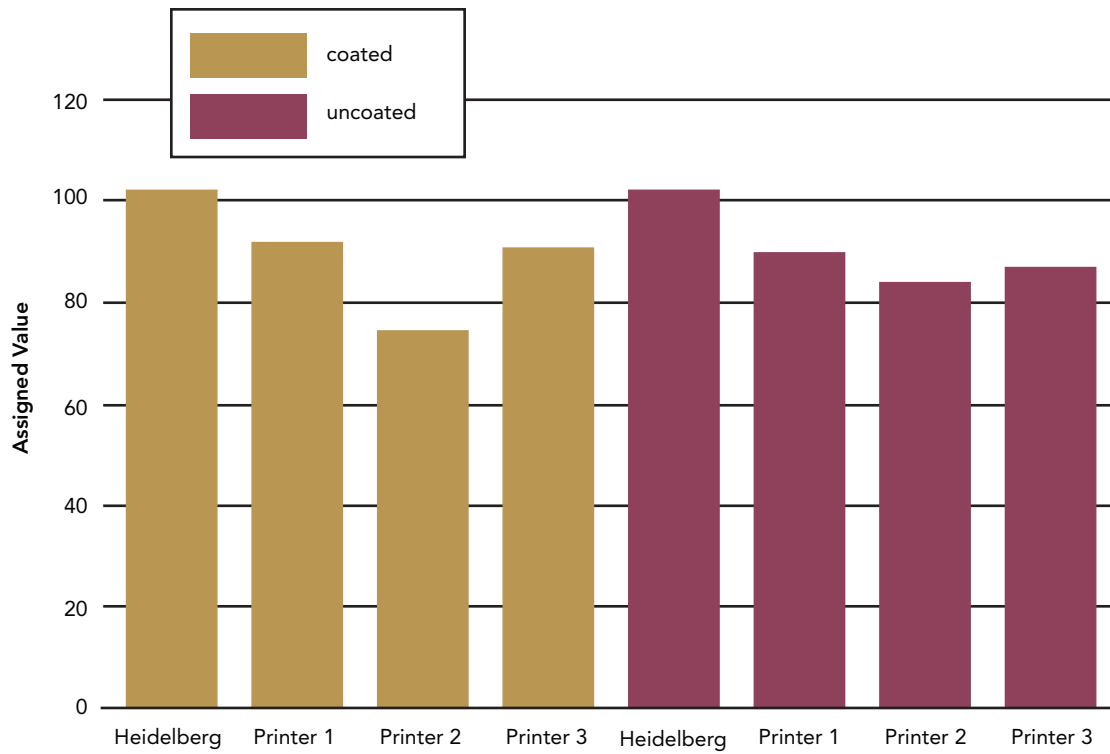


Figure 1. Mean assigned values for the images on coated and uncoated media for each printing device, 2008 study

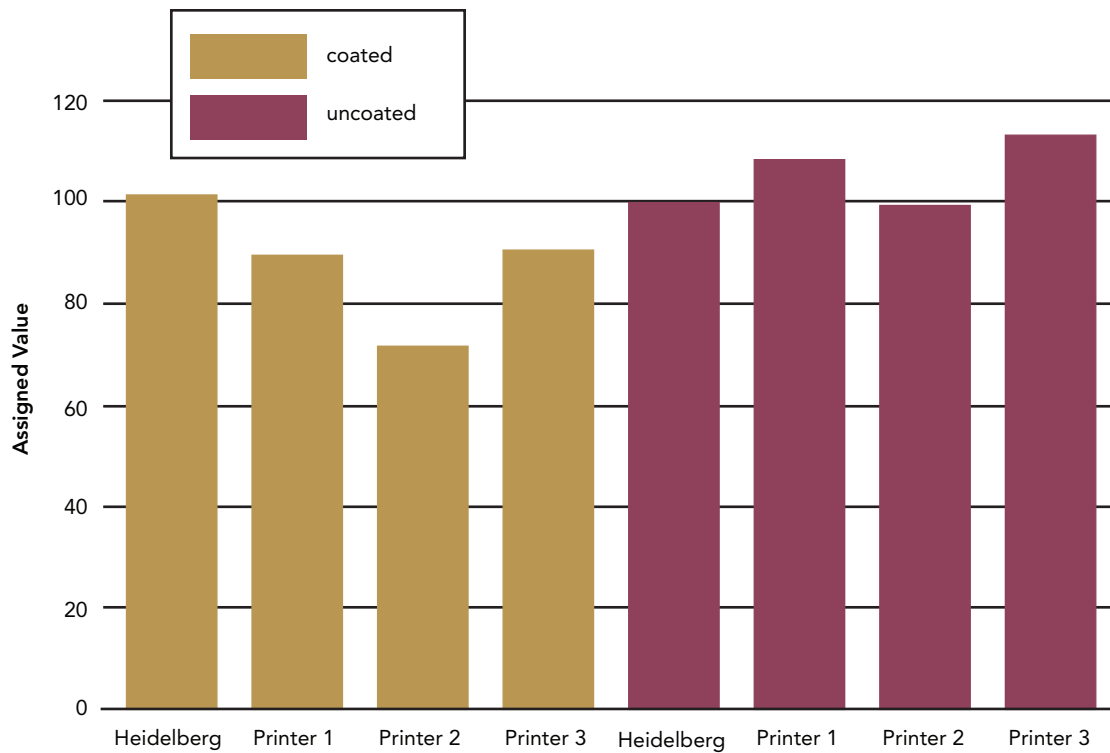


Figure 2. Mean assigned values for the images on coated and uncoated media for each printing device, 2007 study

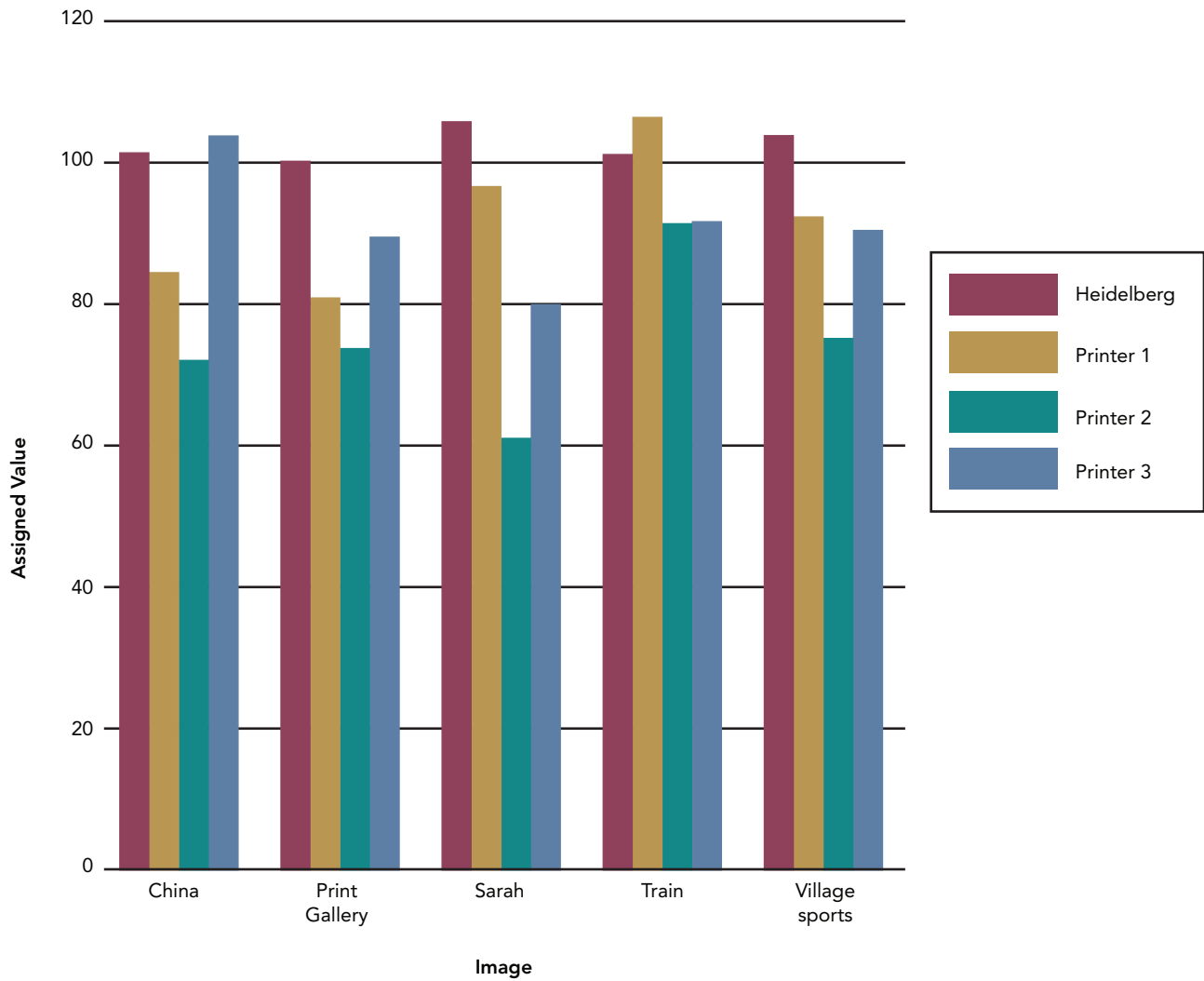


Figure 3. Average assigned value for each image on coated media, 2008 study

Results and Discussion

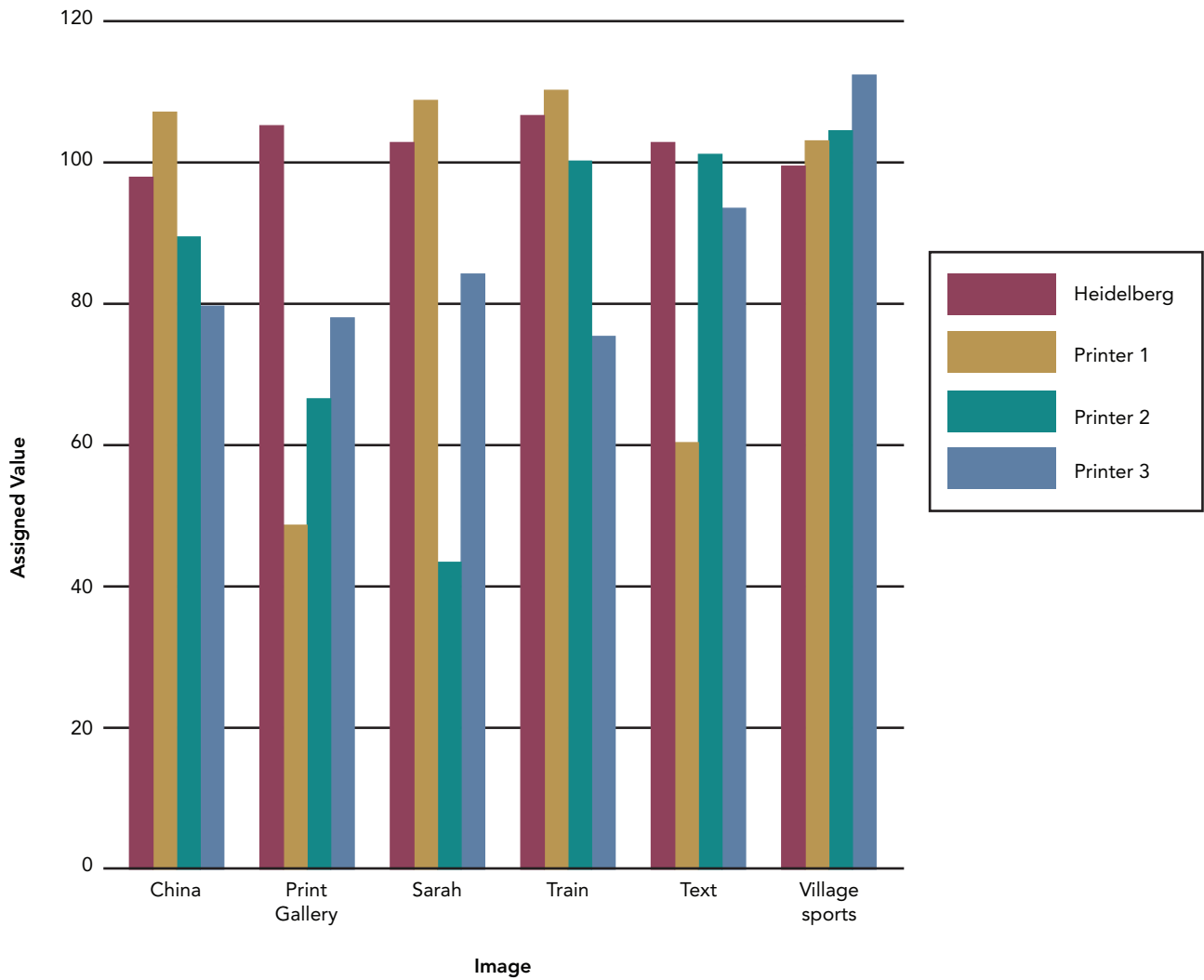


Figure 4. Average assigned value for each image on uncoated media, 2008 study

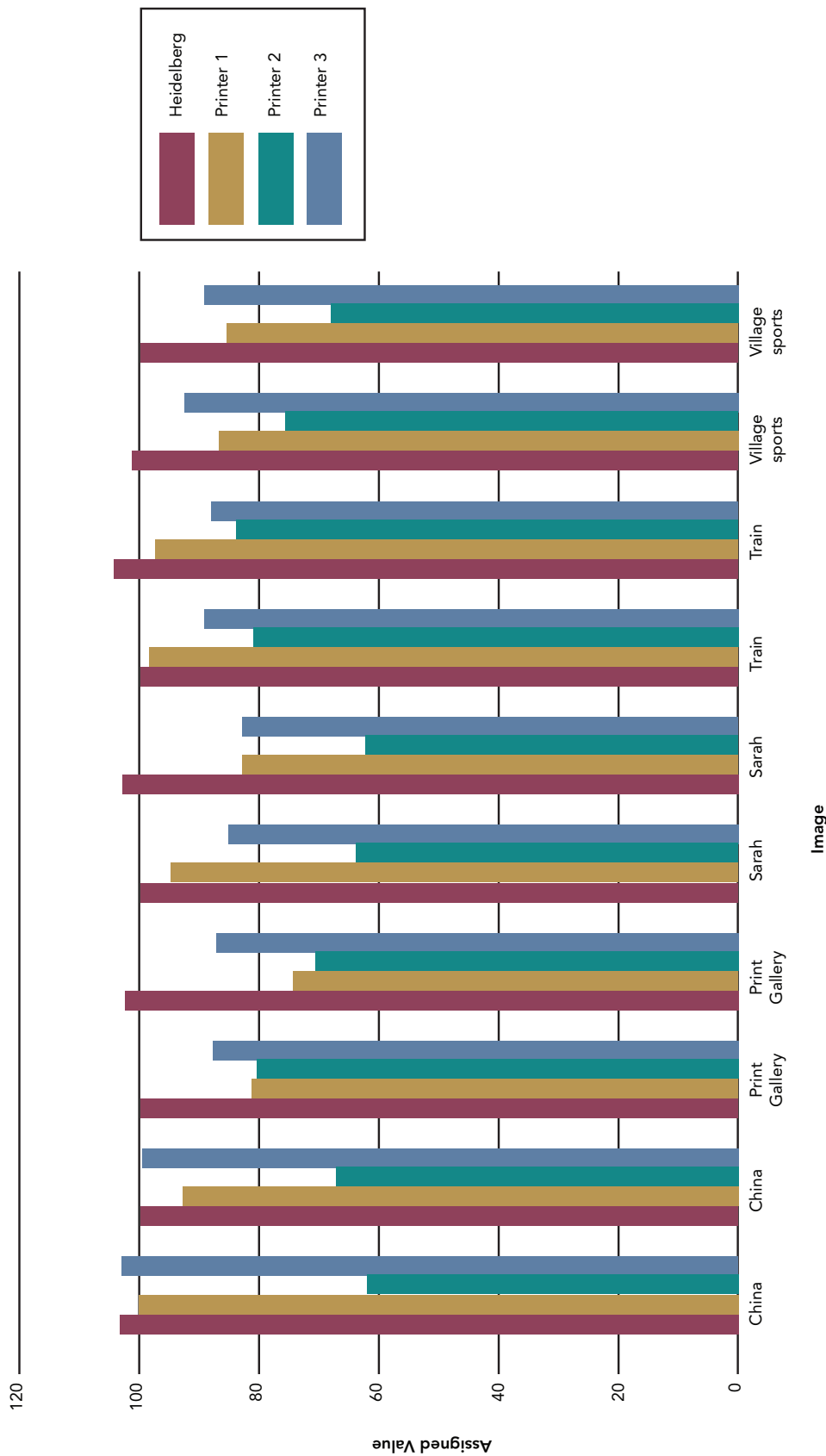


Figure 5. Average assigned value for each image on coated media, 2007 study

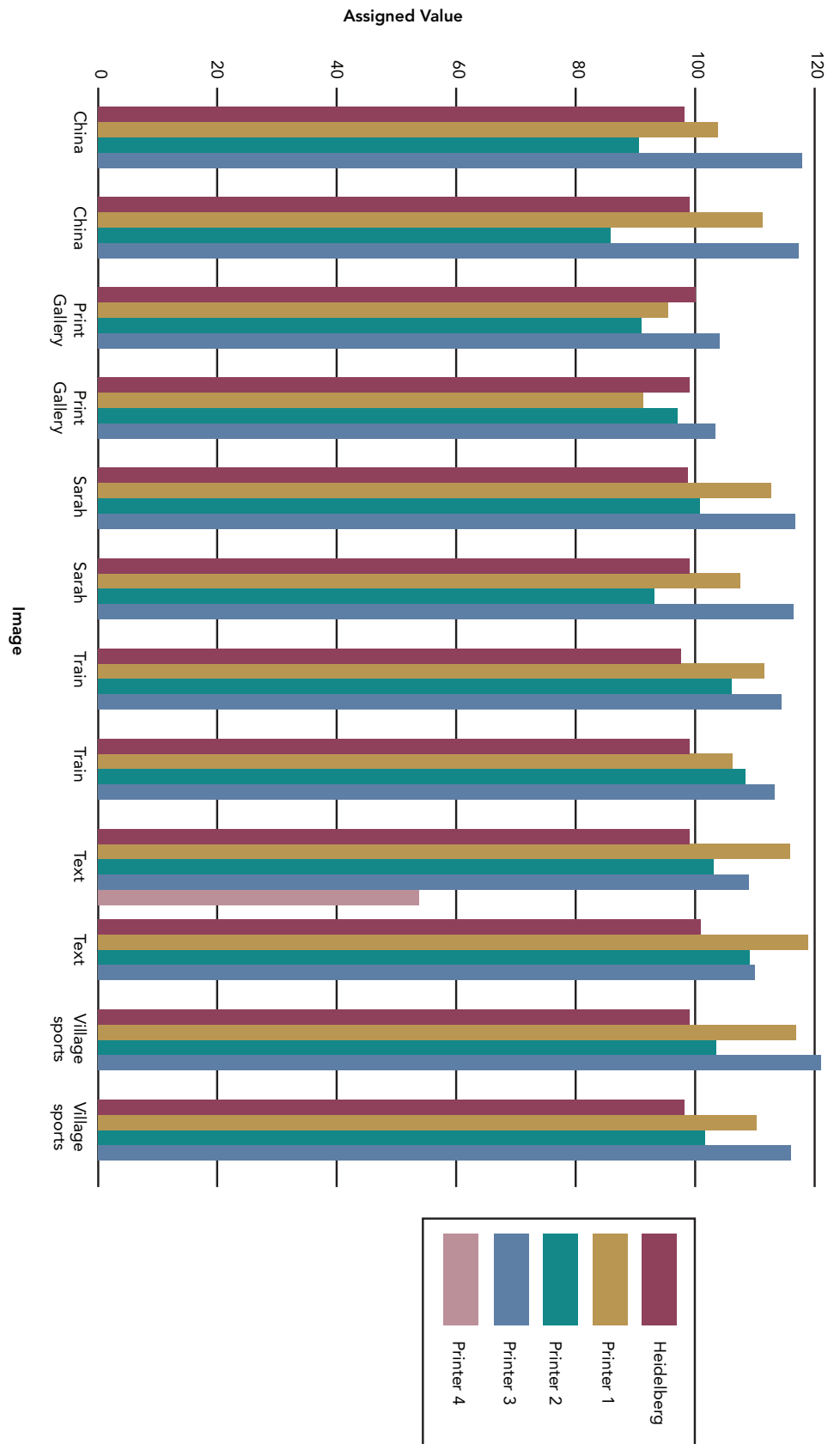


Figure 6. Average assigned value for each image on uncoated media, 2007 study

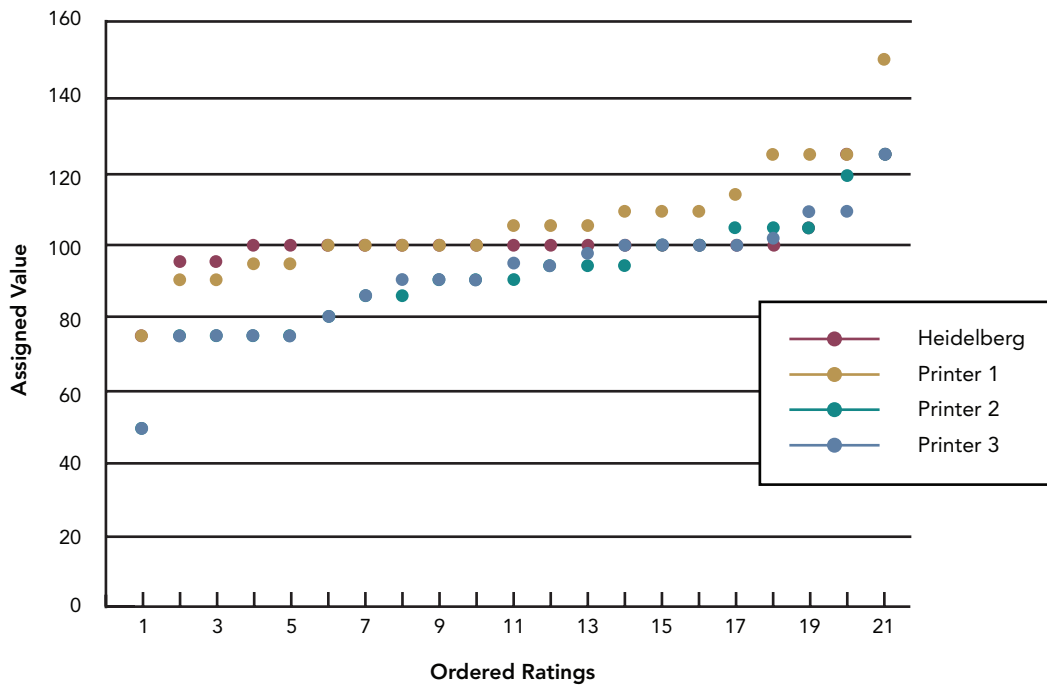


Figure 7. Values assigned by the 21 participants for each of the comparison prints in the “Train” brochure image set on coated media, shown in ascending order

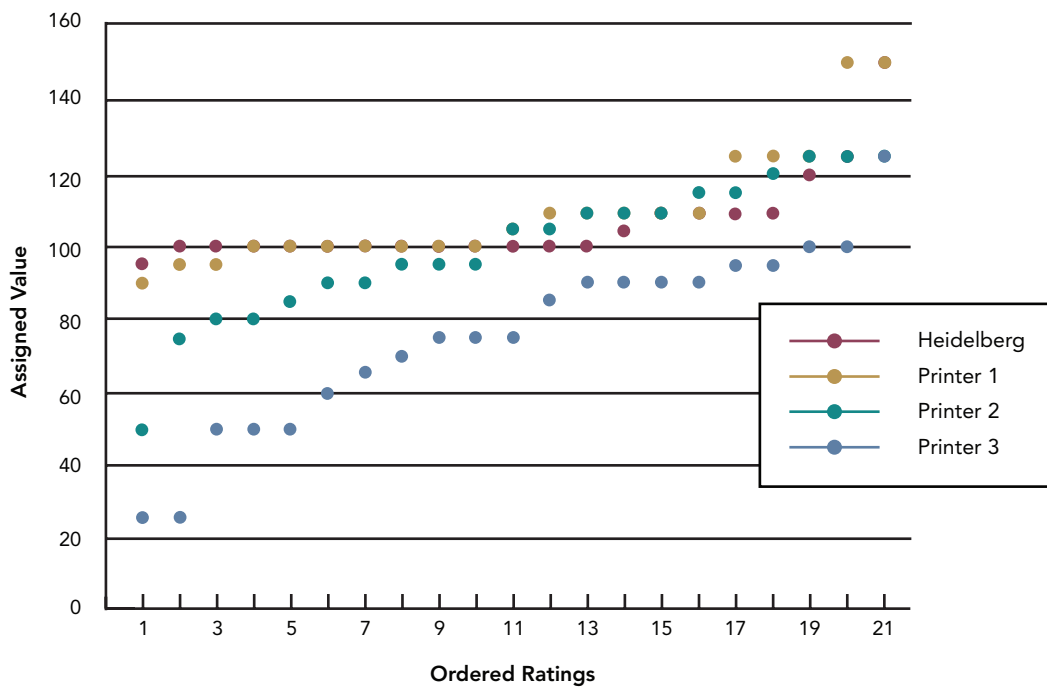


Figure 8. Values assigned by the 21 participants for each of the comparison prints in the “Train” brochure image set on uncoated media, shown in ascending order

Results and Discussion

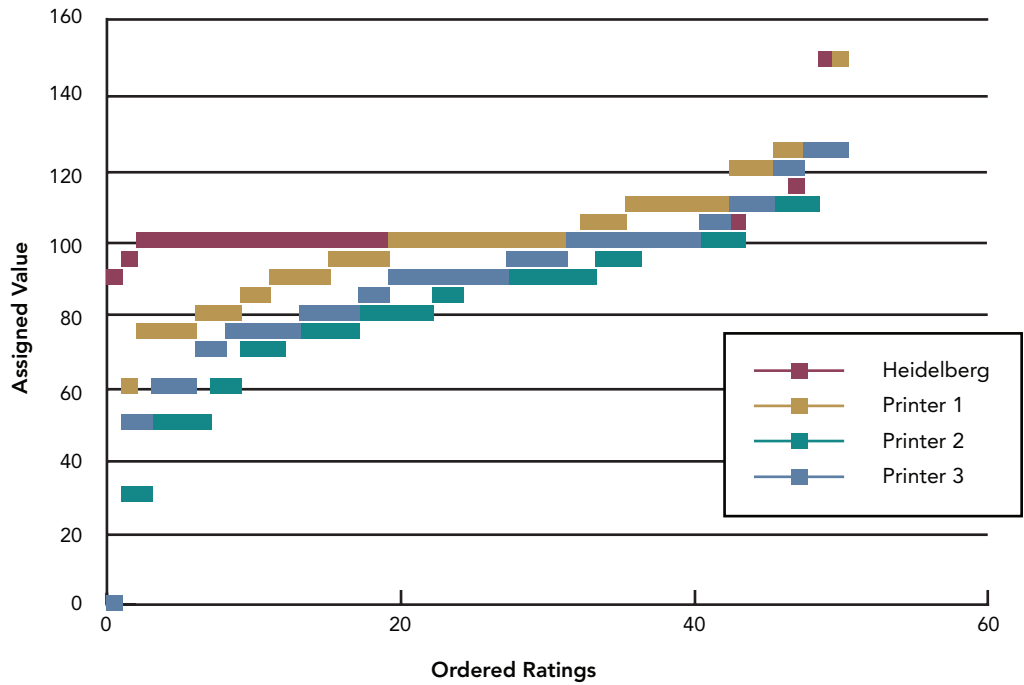


Figure 9. Values assigned by the 38 participants for each of the comparison prints in the "Train" brochure image set on coated media, shown in ascending order

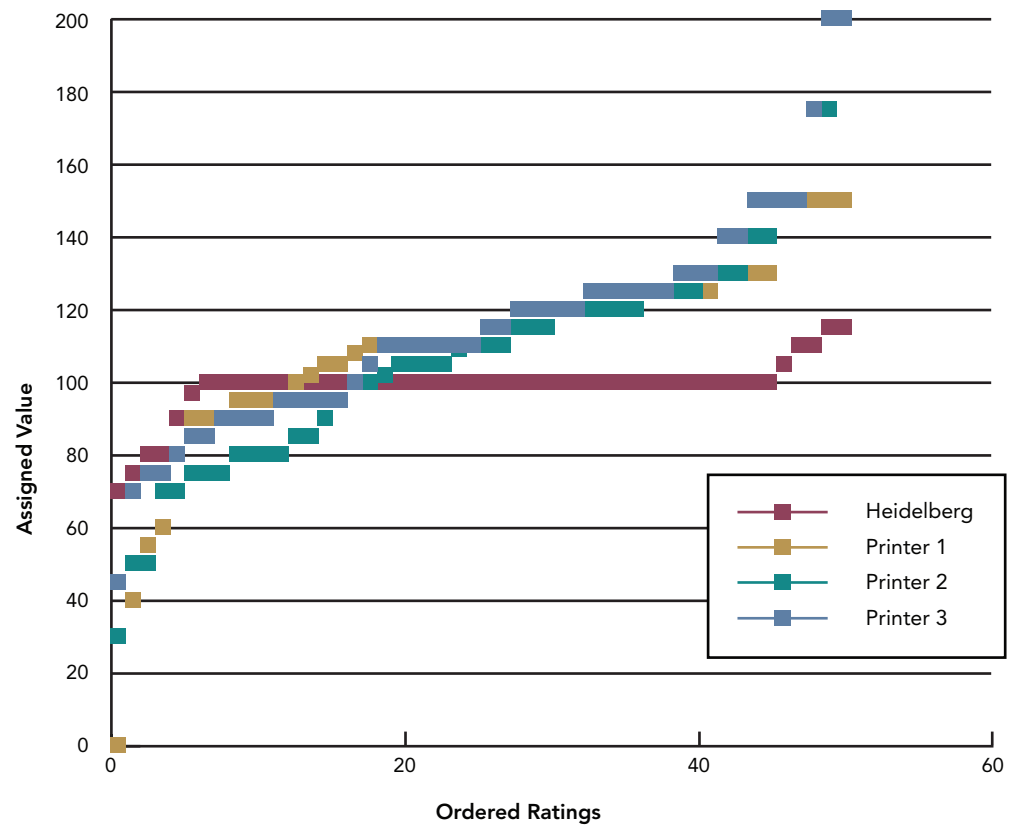


Figure 10. Values assigned by the 38 participants for each of the comparison prints in the "Train" brochure image set on uncoated media, shown in ascending order

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. For this image, the prints were considered comparable.

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. These instances were the China print for Printer 1, (possibly) the Sarah print for Printer 1, and (possibly) the Village Sports print for Printer 3. There were also a few prints—the Train print for Printer 1, the Text print for Printer 2, and the Village Sports prints for Printers 1 and 2—that were rated comparably to the offset reference. 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. Note the relative drops in perceived value between the two studies, especially on Printer 3 for the China, Sarah, and Train images, for the Text image on Printer 1, and for the Print Gallery image on all of the printers. Only the Village Sports image produced similar results in both studies on the uncoated paper.

An example of the individual ratings for one image, the “Train” brochure, reflects the change in the results on uncoated media from the 2007 experimentation to the testing conducted in 2008 (see Figures 7-10). Figure 7 shows all of the ratings for the comparison prints in the current study on coated media in ascending order. Figure 8 shows the results for the current study on uncoated media. Figures 9 and 10 show the results for the 2007 study on coated and uncoated paper, respectively. Note the crossover points, where the assigned values go over the \$1.00 (100) reference value, in each case. For the prints on uncoated paper in the 2007 study, this point occurs much earlier than in the other three cases. This indicates that there were fewer ratings (on a percentage basis) below the \$1.00 mark for uncoated paper in 2007 than for coated paper in 2007 or for either paper in 2008.

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; some thought the differences were inconsequential, some found they added to the value, while others occasionally felt the differences rendered the prints worthless. With the digital prints used in the current study much more closely resembling the reference print, the resultant variability in assessed value was significantly lower. For the 2007 experimentation, a difference of about 14¢ would be needed to be significant at a 95% confidence level for the coated images. For the uncoated images, a difference of about 18¢ would be needed to be significant. For the current study, this difference shrinks to less than 5¢ on either paper. The higher average correlation coefficient between individual and the mean responses for each comparison print cited earlier is further evidence of the reduced variability in the present experimentation.

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 by the participants as they made their assessments support this assertion. The most common print attribute cited as important in their quality decisions was uniformity, which was mentioned for all of the images except the Text document and the Village Sports brochure. For the Text document, text and line quality was the most common attribute mentioned. This was a factor for the Print Gallery page as well. Additionally, sharpness was the most frequent attribute cited for the China print. For the Village Sports brochure, saturation was mentioned most often, with gloss being mentioned on occasion as well. In the 2007 experimentation, lack of uniformity was the most common complaint for the prints made using digital equipment, with concerns regarding text and line quality ranking second. In this earlier work, however, many participants preferred the higher contrast of the digital printer output, especially for the photo book pages and marketing material on the uncoated media. Although there were few comments specific to gloss, higher gloss could have added to the higher contrast and the higher color saturation, which appealed to many participants. In the current study, the comments regarding contrast, saturation, and gloss were largely absent, with the exception of the Village Sports and Train brochures, despite there being readily apparent issues with the image contrast.

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.

Experiment II

As in Experiment I, when data collection was complete, the mean value assigned to each comparison print was calculated, and the correlation coefficients of the individual responses with the mean response for each of the comparison prints were determined. These correlation coefficients were similar to those resulting in Experiment I, with an average of approximately 0.74 and a range varying from 0.56 to 0.84. One of the participants reported a color vision anomaly. His correlation coefficient was on the low end of the range, at 0.59. (This was similar to the 0.60 average in the 2007 experimentation, though lower than those reporting color vision anomalies in that experiment: 0.64, 0.68, and 0.68.) He tended to rate the prints having higher contrast and lower chroma more highly than other participants, but there were a few other participants that liked these renditions as well. His results were not significantly different from those of other participants, on average. All of the results were retained in the analysis.

The mean assigned values for the prints of each image made on each piece of printing equipment included in the experimentation are shown in Figures 11-13, with Figure 11 showing the coated paper, Figure 12 showing the #80 uncoated paper, and Figure 13 showing the #60 uncoated papers. 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 Figure 11), that were rated more highly the offset reference and many that were rated equivalently to the offset reference. The print of the Sarah image from Printer 1 was rated higher than the offset reference, and the prints of the Rose and Flowers images from Printer 3 were rated higher than the offset images. For the Munich image on coated paper, all of the digital printers were rated significantly higher than the offset reference. Only for the Village Sports brochure and the Text image were the prints from the offset press rated consistently better than the prints from digital. 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. Only the Text print made on the 80# uncoated paper on the Heidelberg press was rated more highly than the reference (see Figure 12). Additionally, only the Train print made on Printer 3 on the 80# uncoated paper (as shown in Figure 12), and the Munich print made on 60# uncoated paper (as shown in Figure 13), were rated comparably to the reference print, though the Text print (80# uncoated) from Printer 1, the Shaving prints (80# uncoated) from Printers 1 and 2, the Text print (60# uncoated) from the Heidelberg press, and the Shaving prints (60# uncoated) from Printers 1 and 2 were close.

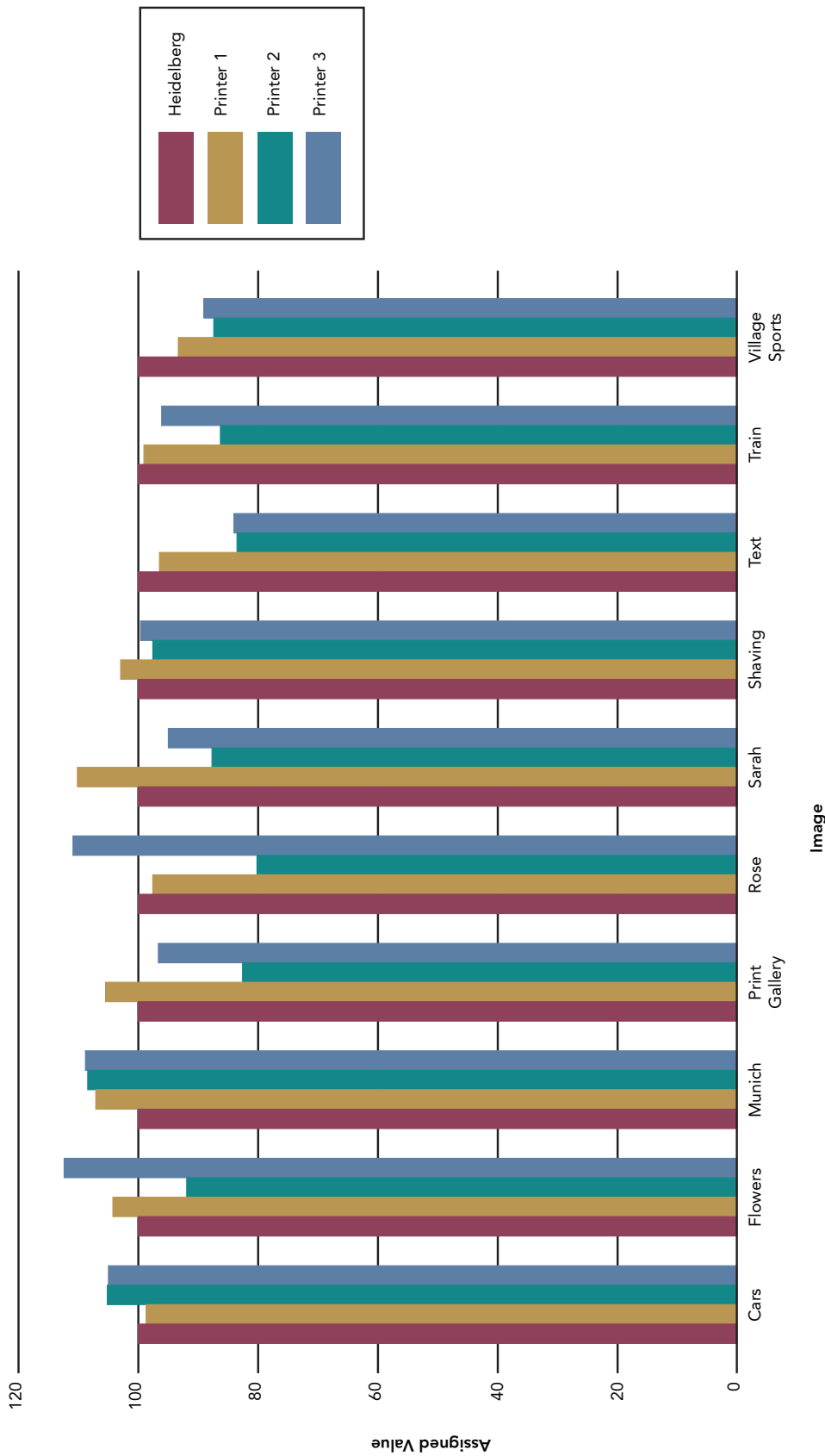


Figure 11. Average assigned value for each image on coated media by printing device

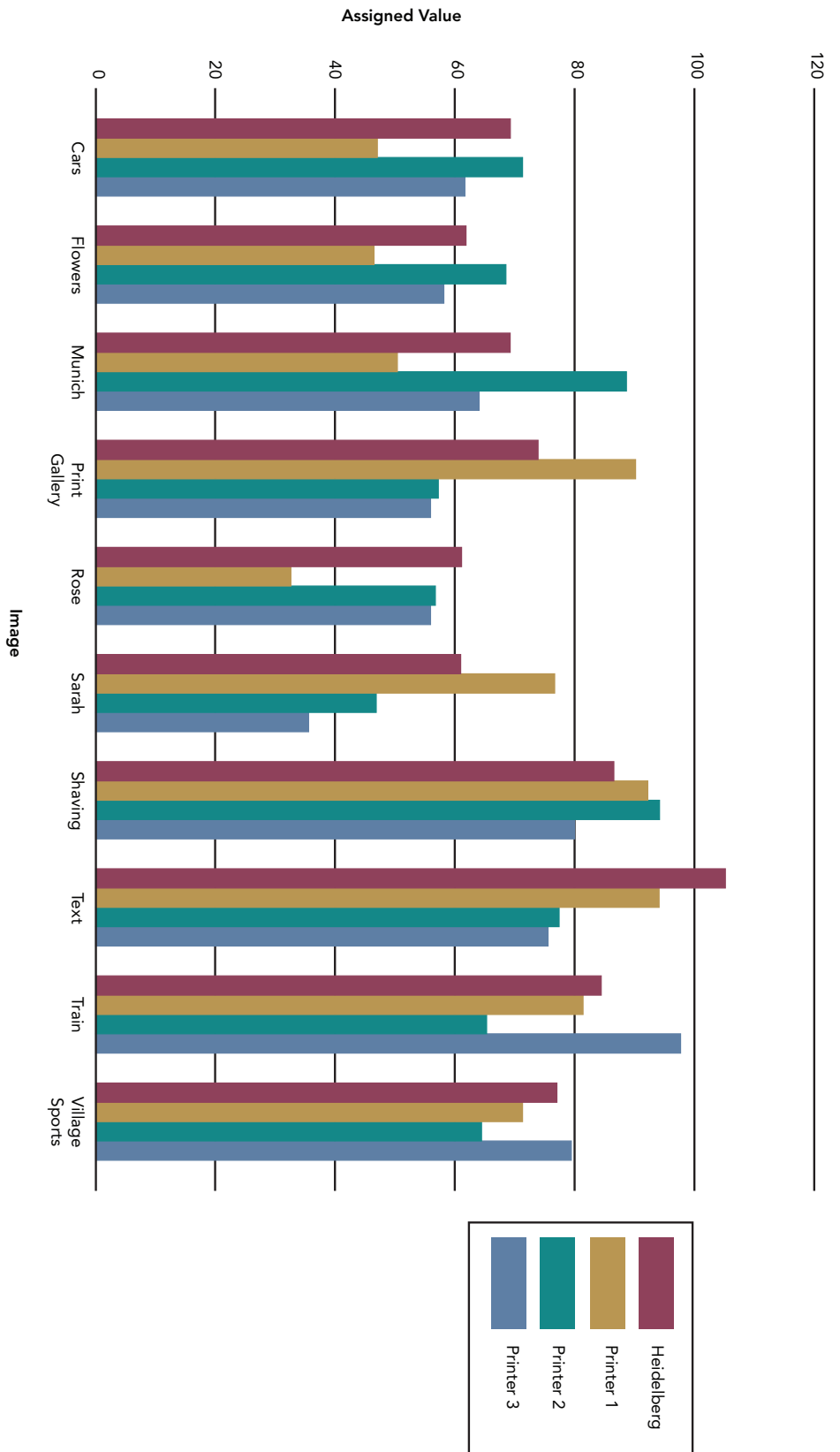


Figure 12. Average assigned value for each image on 80# uncoated media

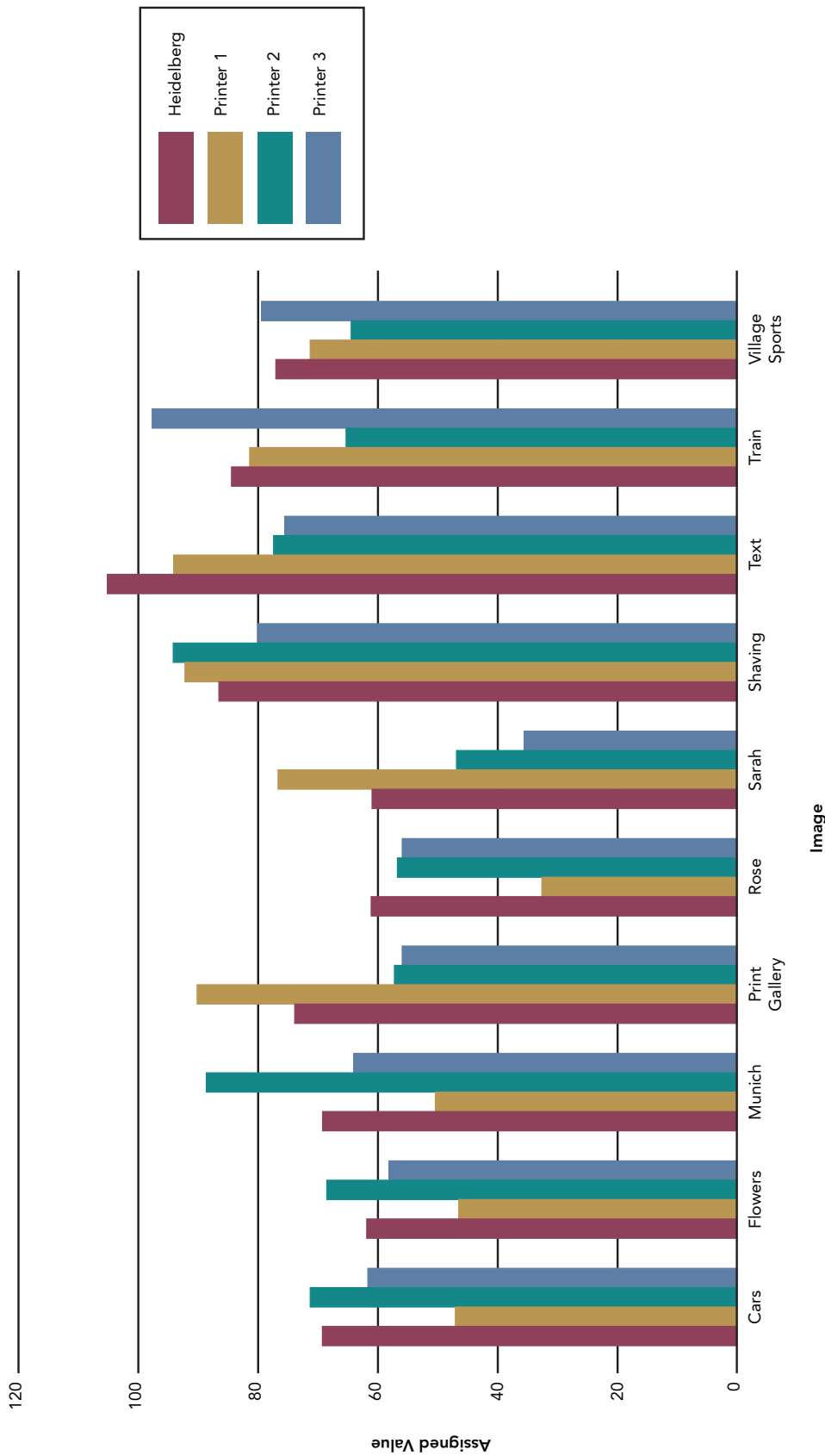


Figure 13. Average assigned value for each image on 60# uncoated media

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 14 for each paper on the offset press and averaged over the digital presses. For all of the photo images—Cars, Flowers, Munich, Rose and Sarah—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 for each printer in Figure 15 and by print technology for each paper in Figure 16. From these graphs, it is evident that the media had a far greater effect on perceived value than the print technology, on average.

Looking back at the responses by image and printer for each paper (see Figures 11-13), there are a few interesting points. One of these is that, though it had some troubles with some of the images on coated paper (as shown in Figure 11), Printer 2 performed well, especially for the photo images that did not contain people (Cars, Flowers, and Munich) on uncoated media (see Figures 12 and 13). Printer 1 performed well for the two photo images containing people, Print Gallery and Sarah, on all three papers; however, it had problems with the Cars, Flowers, Munich, and Rose images on uncoated paper. Printer 3 had problems on the uncoated media in general, except for the Train and, to a lesser extent, the Village Sports and Shaving images. This is interesting since these printers performed well on uncoated stock in the 2007 experimentation. These differences may be due to the expanded image set including more images without large uniform areas, changes in the particular printer set up or maintenance, or the lighter weight paper used in this experiment. While each of the digital printers had lower rated prints for some of the images on one or two of the media used, the overall digital results were essentially comparable to the offset results (see Figure 16).

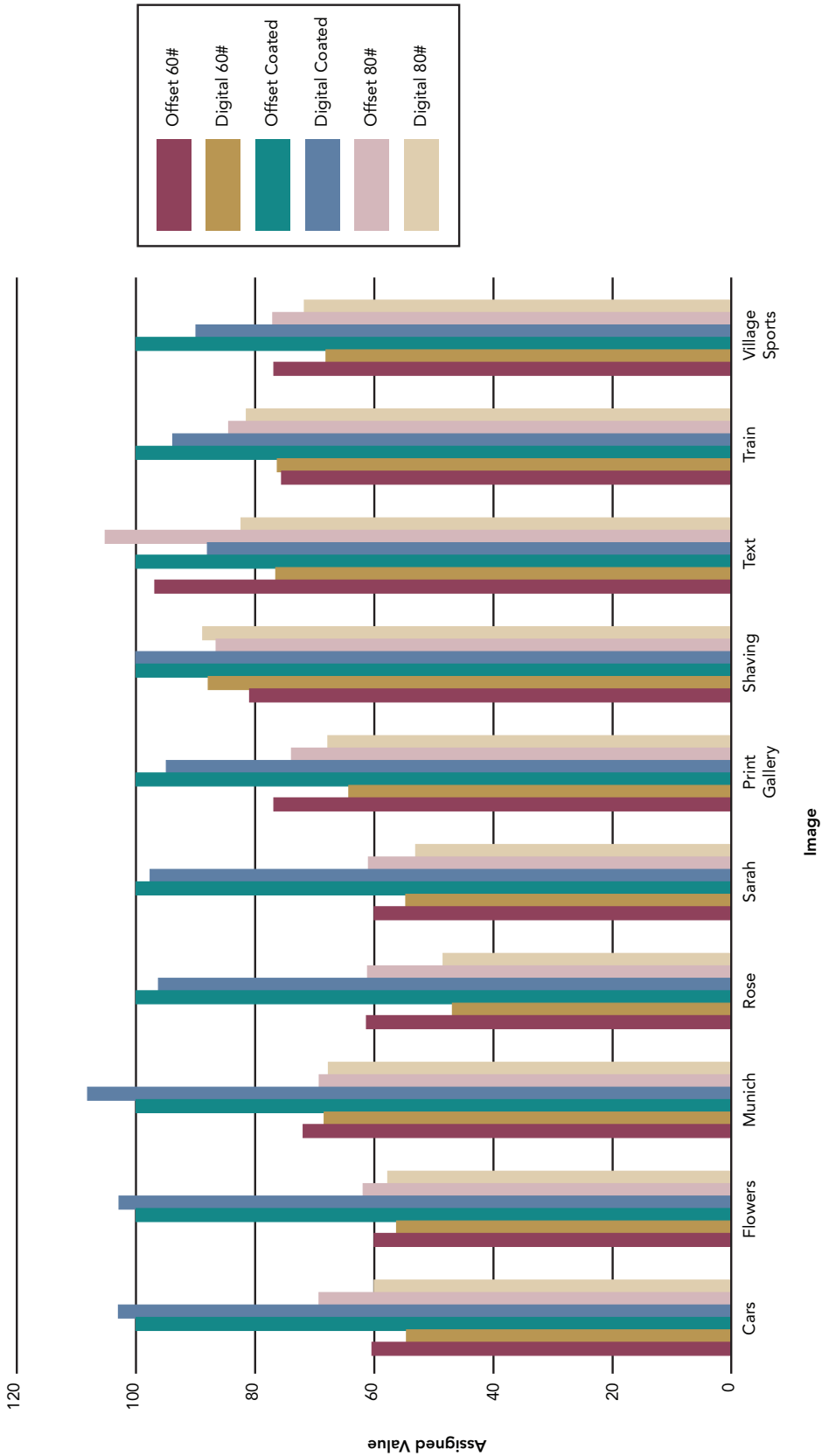


Figure 14. Average assigned value for each image by media

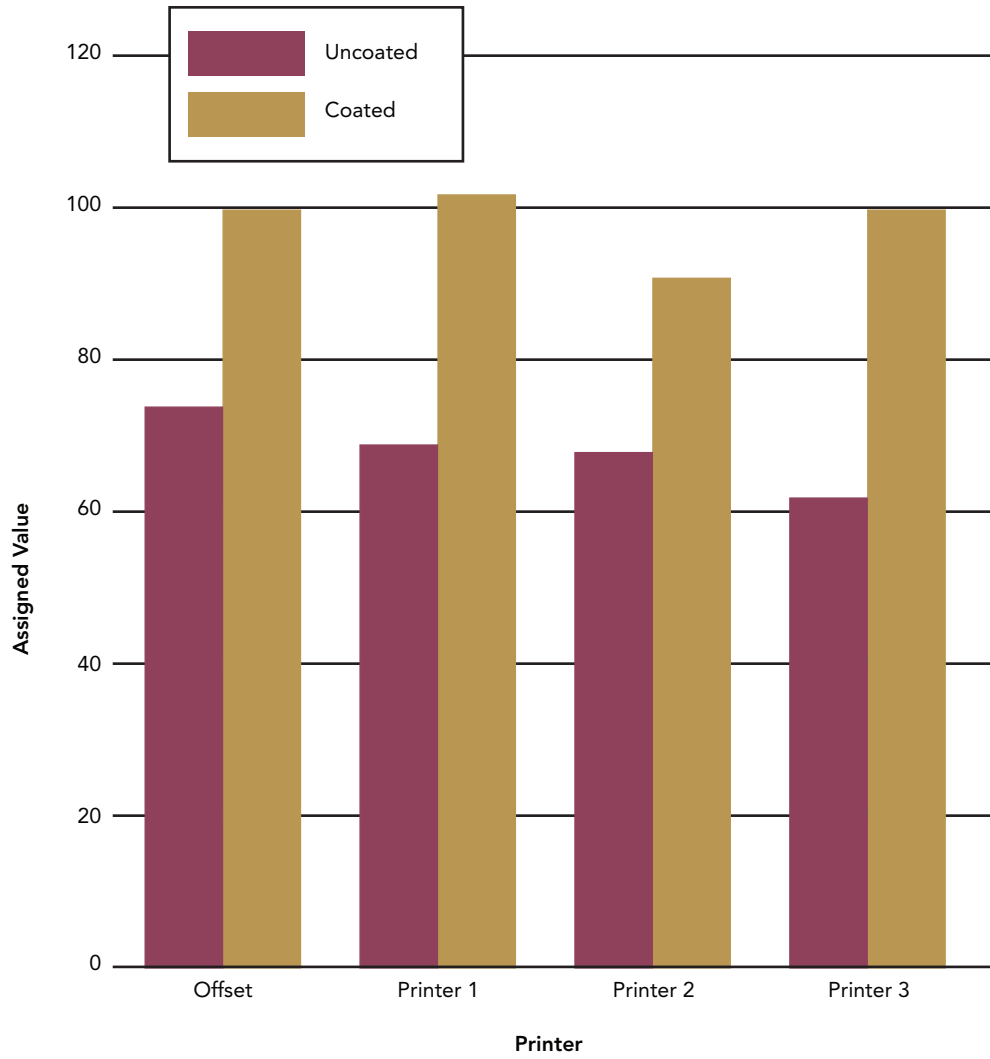


Figure 15. Average assigned value for each printing device on coated and uncoated media

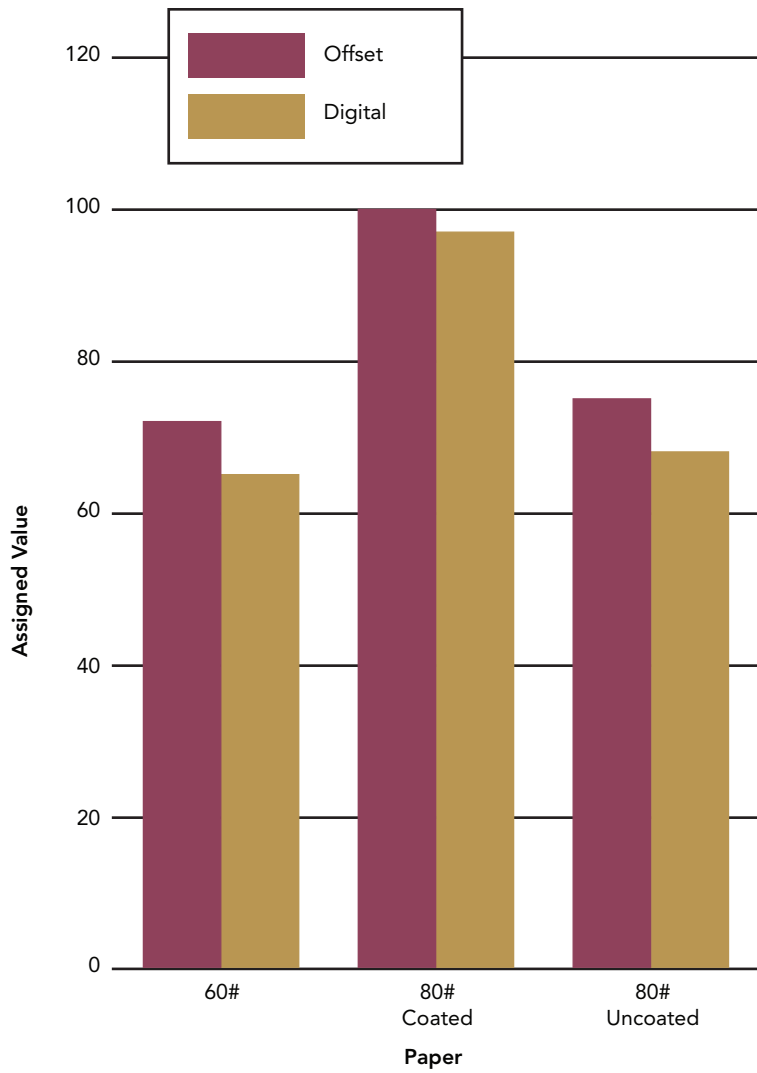


Figure 16. Average assigned value for each media for offset and digital printers

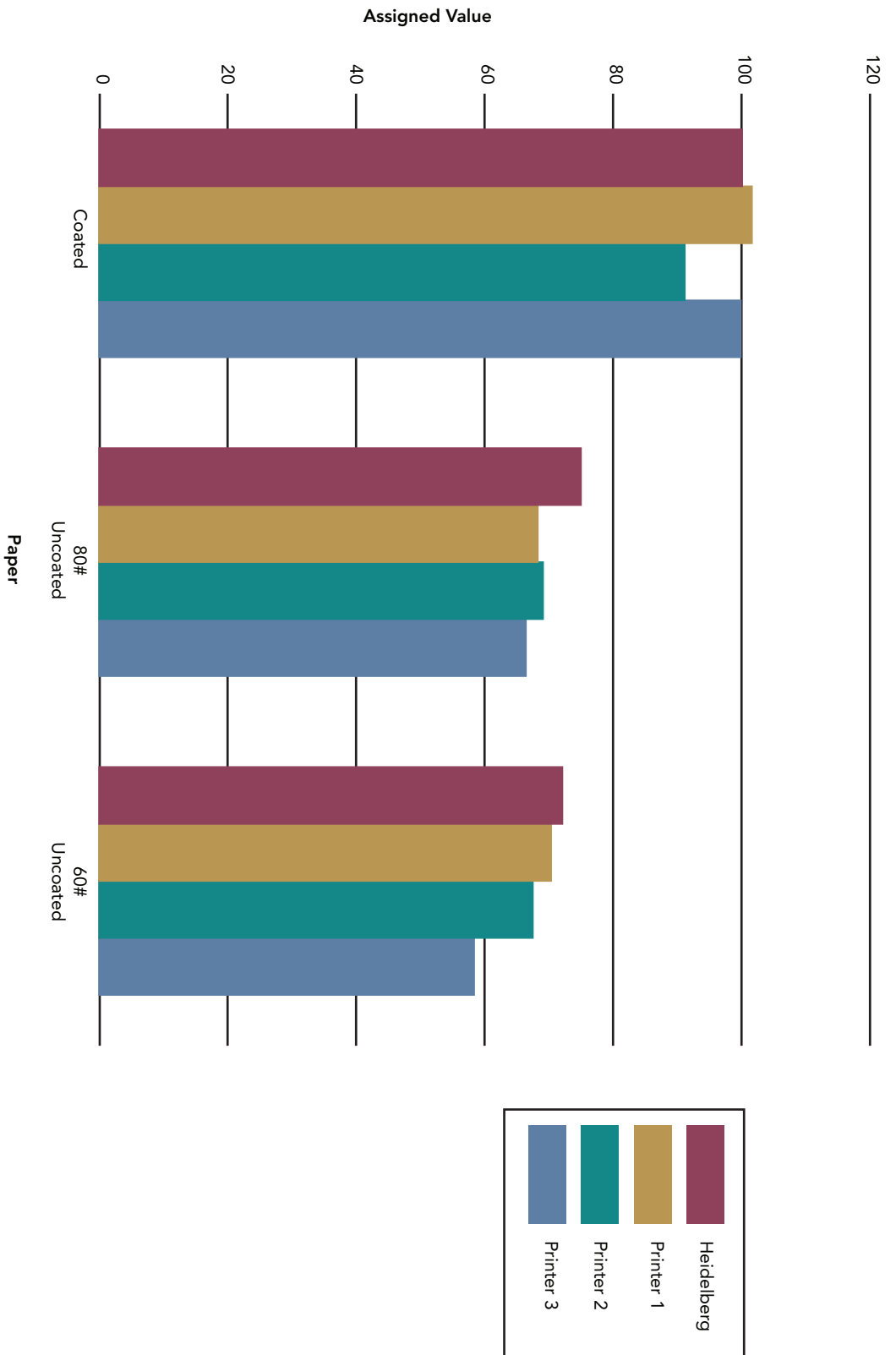


Figure 17. Average assigned value for each media and printer, averaged over all images

The results were also examined as a function of the skill of the participants. The people participating in the experiment included several Graphic Design and New Media students, printing 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 with a correlation coefficient of about 0.92. The relationship was highly linear with a slope of a little 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), and the results are shown in Figure 18. All the differences are positive, indicating that the skilled observers were more critical in general than the naïve participants, which is to be expected. While the differences calculated for the photo prints were much larger, so was the variability in the responses. The difference required to be statistically significant is about 13¢ for the photo images (Cars, Flowers, Munich, Rose and Sarah), about 11¢ for the Print Gallery image (which included a photo), about 7¢ for Text, Train, and Village Sports images, and about 5¢ for the Shaving image. Considering these values, only the Flowers, Sarah, and, (possibly) the Rose print had statistically significant differences between the skilled and naïve observers, with the skilled observers being more critical than the naïve participants.

When the results are examined by paper, however (see Figure 19), 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.

The results were also examined by the gender of the participants. Again, the average assigned values for each image by the female and male participants were determined, and again the results for the two groups were highly correlated with a correlation coefficient of about 0.93. The relationship is linear with a slope of about 1 and a minimal offset. The difference between the genders was calculated (male – female) and the results are shown in Figure 20. Only the Train, Village Sports, and, (possibly) the Shaving print had significant differences between the females and males, with the females being generally more critical than the male participants. Breaking the results down by paper and printer, the females tended to be more critical than the males for uncoated paper and for prints made on Printer 2. It is interesting that, though the difference was not statistically significant, on average the only image that the males rated more critically than the females was the Cars image.

In Experiment I, the most frequent attribute mentioned as important is 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 the important in quality decisions was contrast. Other relevant attributes in this experiment were saturation, gloss, paper quality, sharpness, and text and line quality.

Results and Discussion

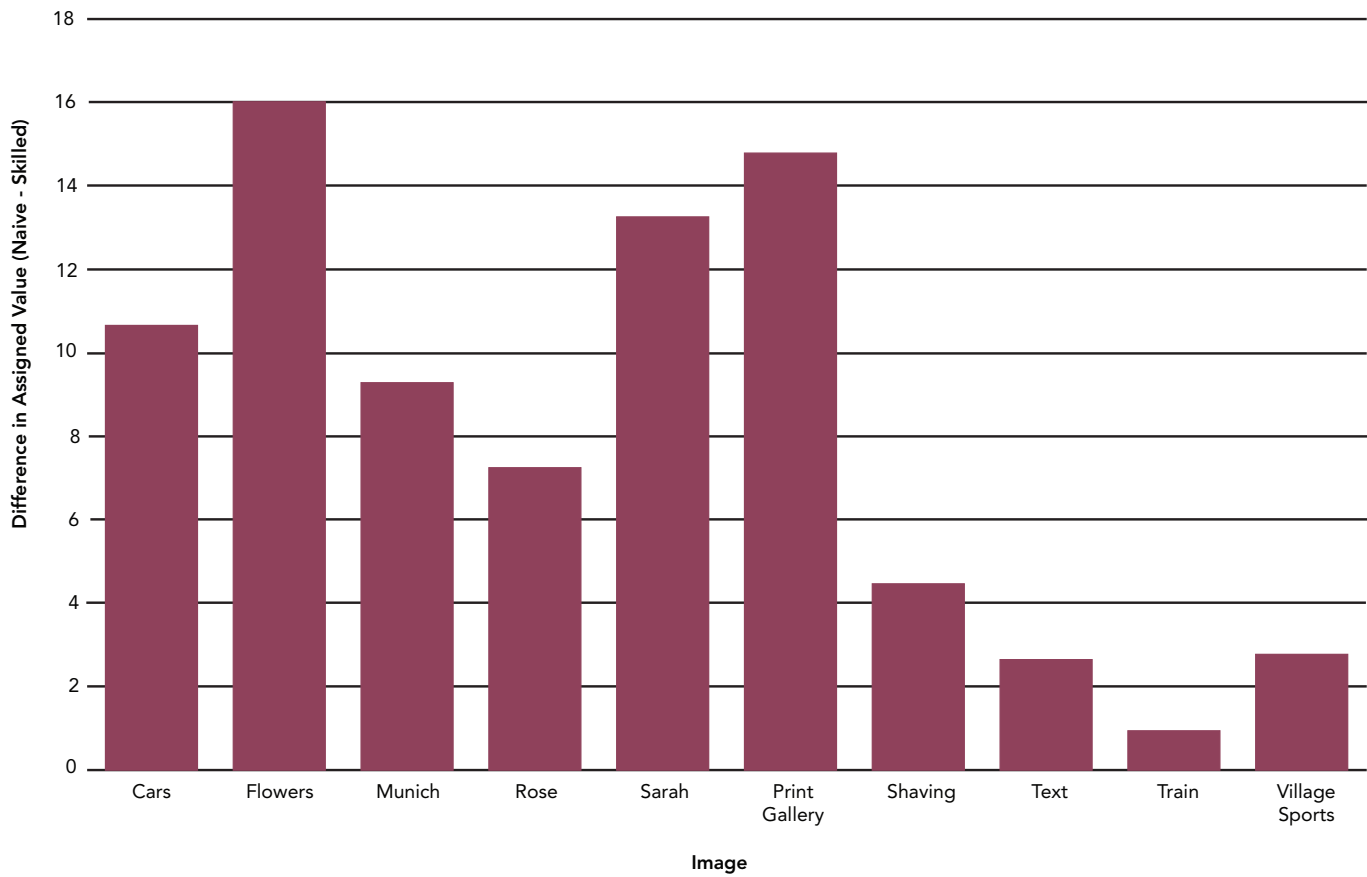


Figure 18. Difference in the average values assigned by skilled versus naïve participants for each image

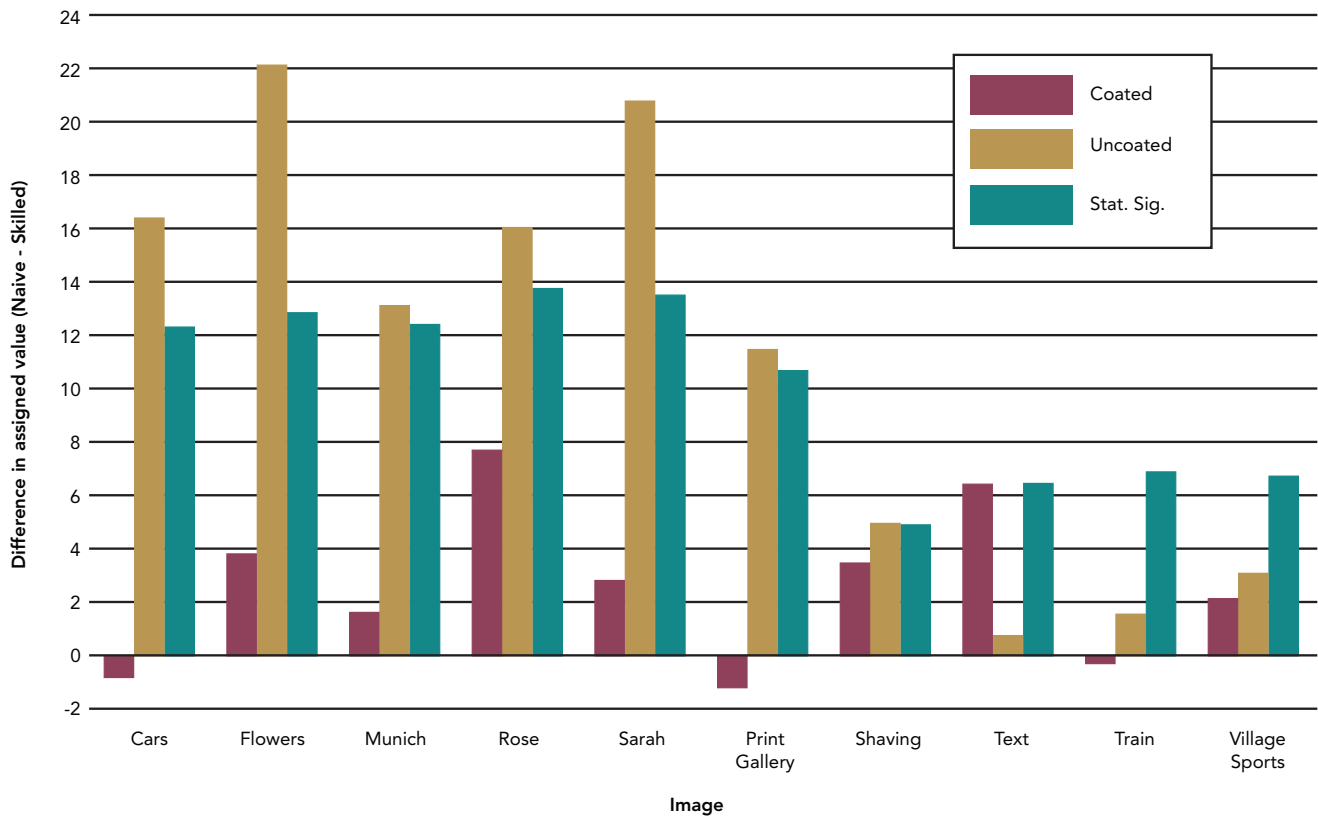


Figure 19. Difference in the average values assigned by skilled versus naïve participants for each image on coated and uncoated paper¹

¹ - The statistically significant bar shows the level needed for the difference to be statistically significant.

Results and Discussion

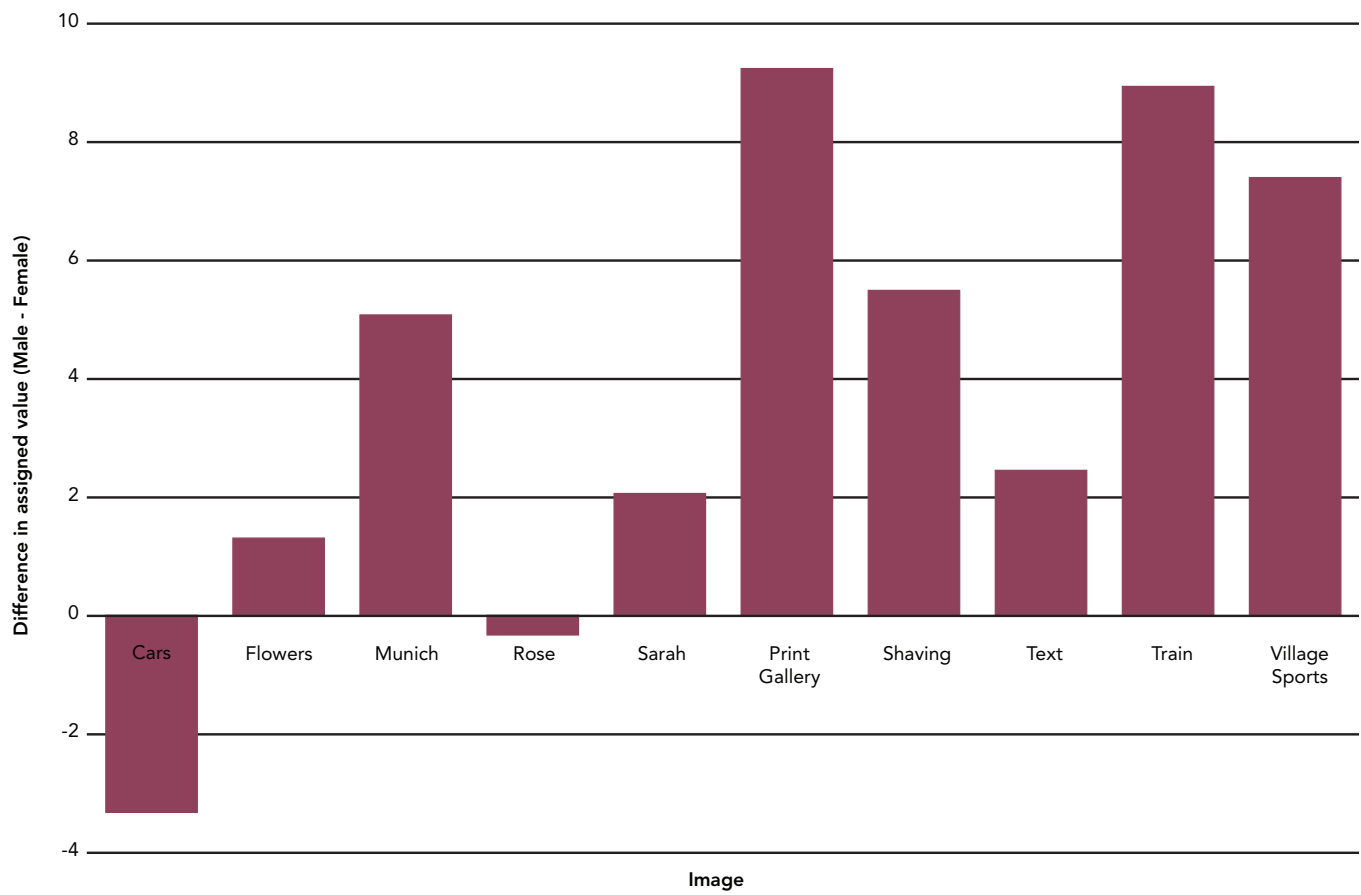


Figure 20. Difference in the average values assigned by male versus female participants for each image

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.

These results are in general agreement with Chung and Rees' (2006a) findings that offset printing image quality issues tend to be related to materials problems, such as lower contrast on uncoated paper, while image quality issues for digital printing equipment tend to involve technical limitations of the equipment, such as uniformity issues and weaker lines and text.

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.

One other interesting result of Experiment II was that skilled observers tended to be more critical of image quality, especially for photo book pages and what were termed "photos for display" on uncoated paper, than observers less schooled in the art of image evaluation.

References

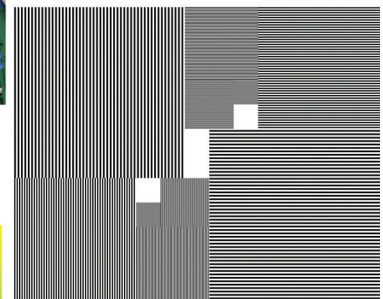
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Appendix A— Images Used in Experiment I

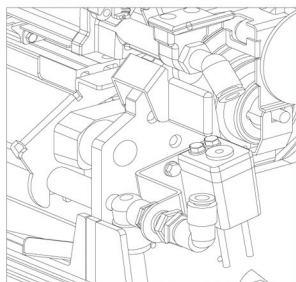
China Photo Page



NIP23 Image

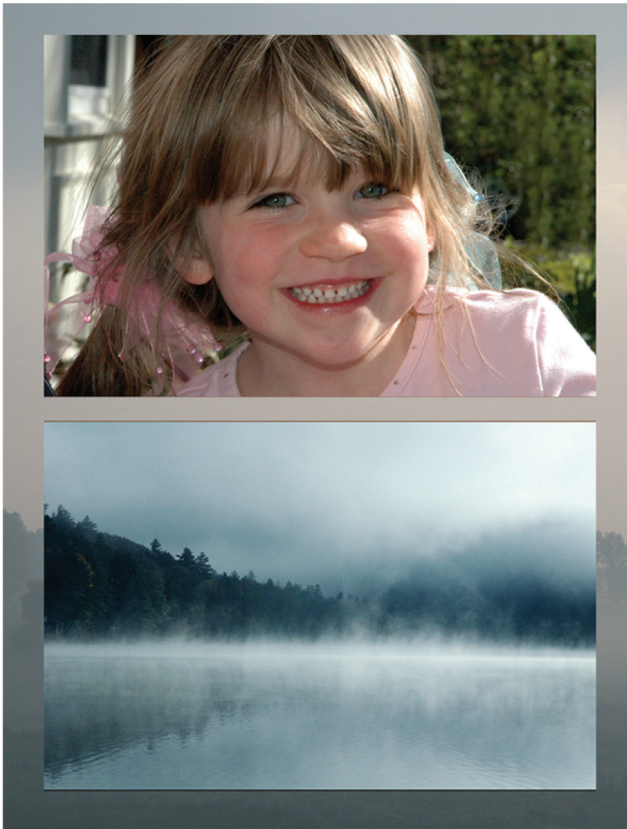


NIP 23 target
(ez/dt 2007)



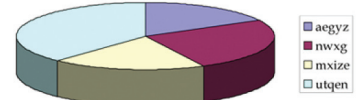
nip23, 18pt. text
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nip23, 1pt. text

Sarah Photo Page

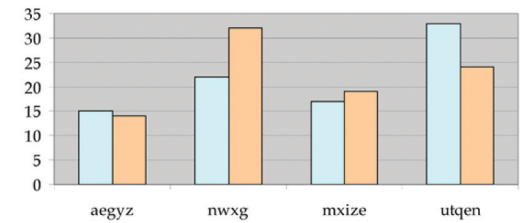


Text Page

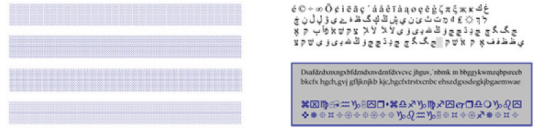
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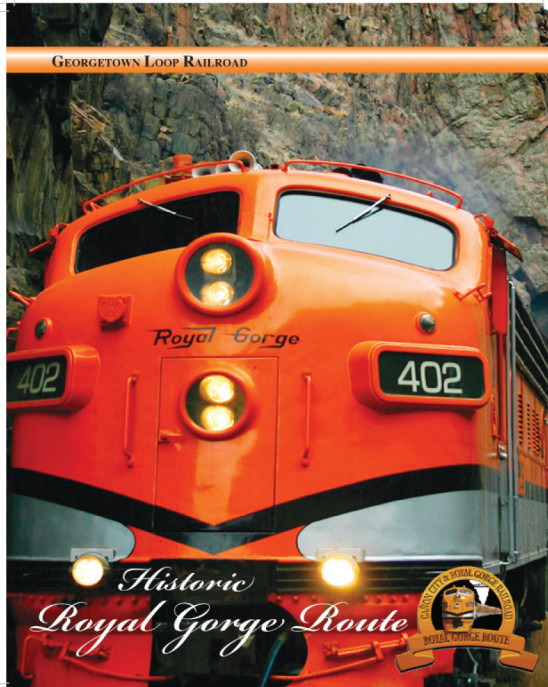
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DALKJO: djflerto gk;lcx.mapoi/3549g;: glij tpotap'b zdagg 'sj' g'hrj' p'ikv nm.bnax:q'f'lk fg l'f'g j g'lj' f'hd'p'g'ok'ij l'ro ori'g'j'f'bh'ar'o'inx.l'bnxn.cv'mbl:c'ir'pk'l'f'j'f'r'v'n -f'fl'f'h' 'e'p'af'j'f'bbv'm b.g'l'u'g'v'f'f' g'lj'f'q'o'i'e'r' d'f'g'j' d'g'b'n'al'a't'g'g'j'g'm bor:l'j'k'b'c'v.nc'm.n'a'r'g'j'p'r'a'k'n'b'l'e'n'b.m'f'f'h' n'g'l'g'm j'r'r'j'p'f'f'h'b'b'b'l's'o'i'a'g'j'p'f'f'h.m'a'r'p' a'r'o' e'o'r'k'f'f'f'h' 'p'r'o'p'a'e'r'f'd'k'l'm's'y'm t'p'o'at's'p'i'r'e:f'h'm's'l' p'r'y'j'p'a'f'g'g'j'f'h'm's'i'y' d'r'o'i'f'j'g'c'v'n... f'la



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Village Sports Mailer

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2007



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Creative games, encouraging kids to have fun with sports, and helping them learn through play are the goals of our program. All coaches are experienced with Red Cross training certification. They're fun, involved, talented young people who enjoy working with children to help them learn and grow while emphasizing safety and fun.

Just the facts
10 one week sessions run Monday through Friday. Complete and mail the registration form, or drop it off at our front desk. Parent or guardian must sign liability waiver on the registration form. Please complete a separate registration form for additional siblings.

Camp Costs
\$79 per session 9:00 am - noon
\$180 per session 9:00 am - 4:00 pm
\$199 per session for extended day (7:30 am - 6:00 pm)
Lunch is available for \$25/session or bring your own.

All summer Sports Camp activities take place at our newly renovated and expanded Village Sports, 5 acre indoor/outdoor facility, featuring:

- Indoor Turf
- Ice Skating Rink
- Mini-golf
- Basketball Area
- Outdoor sports fields
- Adventure Challenge obstacle course
- Water Wars
- Pirate Pete Surf n' Slide
- Active care center with crafts, computers and other educational opportunities

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Summer Sports Camp**

10 Weeks of Great Summer Sports Fun

June 25 1. Lots of Lacrosse
Guest appearance by a Rochester Knighthawk

July 2 2. Star Spangled Sports
(Pro Rated for Holiday week-no camp July 4th)
An "All American" Sports spectacular with a variety of awesome sports and games

July 9 3. Super Soccer
Led by U of R goalie coach John Spuhler

July 16 4. Extreme Hockey
Play with Boston Bruins Prospect Chris Collins

July 23 5. Summer Super Bowl (Football)
SUNY Brockport football grad Brock Thrasher will lead the march to the Super Bowl

July 30 6. Wild World of Sports
A crazy and exciting week of sports you've heard of and some you haven't.

August 6 7. Hockey! Hockey! Hockey!
Play with local hockey stars. A great week for the young hockey fan!

August 13 8. Soccer Insanity
Coach John teams with local soccer players to work on skills and have a blast!

August 20 9. Sports Spectacular
If you love sports, this ones for you. We'll play them all!

August 27 10. Summer All Stars
This week we play all the favorite games from the previous 9 weeks. This is all star games week. Always a favorite!

**Village Sports Registration
SUMMER SPORTS CAMP 2007**

Child's name _____ DOB _____
Address _____
City/State _____ Zip _____
Parents _____
Phone (home) _____ (work/cell) _____
E-mail _____
Emergency contact _____
Phone _____

Choose Your Session & Options:

Sessions	\$79 9-12 morning	\$25 lunch	\$180 9-4 full day	\$199 7:30-6 extended
1. June 25-29	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. July 2-6 (except 7th)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. July 9-13	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. July 16-20	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. July 23-27	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. July 30-Aug 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Aug 6-10	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Aug 13-17	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Aug 20-24	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Aug 27-31	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*Each session takes place at our indoor/outdoor, 5-acre field, turf and ice rink.

METHOD OF PAYMENT
 Check made out to Village Sports
 Credit card (circle): Mastercard Visa Discover Amer Exp

Card # _____
Name on card _____ Exp. Date _____
Total Amount \$ _____

Signature _____
Date _____

To register by mail, send to: Village Sports, attn: Summer Kids Camp, 2830 Baird Road, Fairport, NY 14450

Appendix B— Additional Images Used in Experiment II

Cars Photo Page



Flowers Photo



Munich Photo Page



Rose Photo



Shaving Page

Products

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- Cologne and Eau De Toilet
- Deoderants and Talcum Powder
- Gifts
- Grooming and Manicure Sets
- Hair, Nail and Clothes Brushes
- Hairdressings and Pomade
- Razors & Stropps
- Shampoo and Hair Conditioner
- Shaving Brushes
- Shaving Creams and Soaps
- Shaving Stands and Sets
- Skin Foods and Mointrurisers
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