SpencerLAB
DIGITAL COLOR LABORATORY

Consumer Preference Research: Photographic Print Quality

HP 8-Color *vs.* Conventional Processing
& Competitive 6-Color Inkjet Printers

This report summarizes the results of independent consumer-based research into preferences regarding photographic print image quality. The research was performed by Spencer & Associates Publishing, Ltd. and its *SpencerLab* Digital Color Laboratory with the sponsorship of Hewlett-Packard Company.[1] Significant effort was invested in establishing and executing an unbiased methodology in order to assure the quality and integrity of the research findings. The overall objective was to assess consumer preference regarding the image quality of digital prints produced by the new 8-color HP Photosmart 7960 photo inkjet printer as compared to digital prints produced by conventional processing and by current competitive 6-color photo inkjet printers. A secondary objective was to assess the importance of Richness, Realism, Sharpness, Exposure, and Smoothness in influencing print quality preferences.

Consumers (those who take photos), including photo enthusiasts, were asked to rank photographic prints according to their individual preference for print image quality. Participants compared prints of six different digital photos printed through a variety of inkjet print systems (inkjet printers with recommended glossy photo papers in high quality modes) and conventional processing (wet-process, silver halide photographic paper).

This research involved 367 participants during July 2003, at least 120 in each country on two continents: the United States (New York, California), France, and Italy. These participants provided 2,200 valid, independent preference rankings and ratings, each involving 21 pair-wise comparisons between print systems: 46,210 comparisons. The following trends were identified…

"This goes to show that a printer can be better than traditional photos!"
— French participant

♦ Consumers who take photos – **even photo enthusiasts – preferred the digital image print quality of the 8-color HP Photosmart 7960 photo inkjet printer with HP Premium Plus Glossy Photo Paper over that of conventional centralized photo processing.** When print technology was later divulged, many participants were astonished at the quality of these inkjet prints.

♦ **Prints from the 8-color HP Photosmart 7960 photo inkjet printer print system[2] were preferred over current competitive 6-color photo inkjet printers, each with recommended glossy photo papers in high quality modes.** Participants demonstrated an overall preference, in every venue, for 8-color over 6-color prints.

♦ **Photo enthusiasts and other consumers were similarly positive in their print quality preference for the 8-color HP Photosmart 7960 photo inkjet printer.**

♦ Richness, Sharpness, and Smoothness were the most positive influencers cited in the research, with Richness having the strongest correlation to preference. **Preference for the 8-color HP Photosmart 7960 photo inkjet prints was strongly supported by Exposure, Sharpness, and Realism, while Richness and Realism drove preferences higher on color-intensive images.**

"I've never seen photos that looked this good on an inkjet"
— US participant

The high-quality, color-corrected digital test images were selected to represent a realistic range of consumer experience, including people and scenery; indoor and outdoor; highlight and shadow; memory colors such as skin tones, sky and grass; and vivid, pastel, and grayscale colors. These same digital images were printed on the various photo inkjet printers and through conventional (silver halide) central processing. After ranking and rating the prints by image quality preference, participants of varied age and gender were asked to explain their preferences in terms of major quality attributes. They then repeated this process for each of the six different images, and about 13% were retained for follow-up qualitative discussions.

Quantitative data was analyzed to evaluate overall paired preference ranking, rating, and attribute contributions. Analysis of the research results identified these significant trends: preference for inkjet vs. centrally-processed conventional prints for digital images; the importance of 8-color versus 6-color inkjet printing; and which attributes were most influential in print quality.

"I guess traditional photos are no longer my thing — I've got to get a printer."
— French participant

Some Dimensions of this Consumer Preference Research

(*The full report may be downloaded at* http://www.spencerlab.com.) *September 2003*

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[1] Although this research was sponsored by HP, as an independent test laboratory with a broad base of industry clients, the *SpencerLab* Digital Color Laboratory believes that this report maintains its reputation for the integrity of its test procedures and analyses.

[2] As used herein, a print system is the combination of the driver, printer, ink, and paper (media).

Research Findings

As noted above, the overall objective of this research was to assess consumer preference regarding the image quality of digital prints produced by the new 8-color HP Photosmart 7960 photo inkjet printer as compared to digital prints produced by conventional central processing and by current competitive 6-color photo inkjet printers. The importance of Richness, Realism, Sharpness, Exposure, and Smoothness in influencing print quality preference was also assessed. Unbiased consumer preference data, based solely upon print image quality, was acquired and analyzed.

HP Inkjet vs. Centrally-Processed Conventional Prints

A key result of this research was in the assessment of how prints from the HP Photosmart 7960 photo inkjet printer compared to conventional central processing of the same original digital images. Our research concluded that **consumers who take photographs** – including **photo enthusiasts – preferred the digital print quality of the 8-color HP Photosmart 7960 photo inkjet printer with HP Premium Plus Glossy Photo Paper over centrally-processed, conventional photo processing** in all regions: US and Europe.

"All those were done on an inkjet - WOW."

– US participant

In specific pair-wise comparisons, prints from the 8-color HP Photosmart 7960 photo inkjet print system were preferred 82% more often than centrally-processed conventional digital prints, 1419 to 781 times. These results are shown graphically below:

Preference: HP Photosmart 7960 Photo Inkjet Printer Over Centrally-Processed Conventional Digital Prints

Print System Comparison

8-Color HP Photosmart 7960 Photo Inkjet Prints (HP Premium Plus Glossy Photo Paper) — 1419

Conventional (Silver Halide) Centrally-Processed Digital Prints — 781

0   250   500   750   1000   1250   1500

Participant Paired Preferences

Photo Enthusiasts

Although all of the research participants take photographs (develop at least eight rolls of film annually and/or print at least ten digital images per month, and consider photographic quality to be important), almost half of those (49%) were "photo enthusiasts" (who have creative and artistic interest in photography beyond capturing memories, read about photography, are frequently asked to take pictures, think their work is good enough to sell and/or actually worked as a freelance photographer).

In separate analysis of the participants, in specific pair-wise comparisons, digital prints from the 8-color HP Photosmart 7960 photo inkjet print system were preferred by photo enthusiasts 73% more often than digital prints from conventional central processing, 684 to 395 times. Other consumers preferred them 90% more often than those from conventional central processing, 735 to 386 times. These results are shown graphically below:

"This will make professional photographic prints redundant."
— Italian participant

8-Color HP Photosmart 7960 vs. Competitive 6-Color Photo Inkjets

Pair-wise data analysis showed that **prints from the 8-color HP Photosmart 7960 photo inkjet print system were preferred more often than prints from two current competitive 6-color photo inkjet print systems**, each with manufacturer-recommended glossy photo papers in high quality modes.[4] Participants demonstrated an overall preference, in every venue, for 8-color over 6-color prints; 141% more often than those from "Competitive A" print system, and 82% more often than those from "Competitive B" print system, as shown graphically below:

Overall Preference: 8-Color over 6-Color Printing
HP Photosmart 7960 over Competitive Photo Inkjet Printers

Black & White Image

On the Four Children composite black & white image, preference for the 8-color HP Photosmart 7960 photo inkjet print system over the competitive manufacturers' 6-color photo inkjet print systems ranged from 242% to 95% more than those from "Competitive A" and "Competitive B" print systems, respectively, as illustrated below:

Black & White Preference: 8-Color over 6-Color Printing
HP Photosmart 7960 over Competitive Photo Inkjets

Attributes Results & Discussion

After the participants established their preferences among the various prints for each photographic image, they were asked to consider five predefined image quality factors. Richness (vividness), Realism (true-to-life), Sharpness (detail), Exposure (brightness and contrast), and Smoothness (lack of graininess or other artifacts) were each carefully explained, both verbally and with written definitions in the local language, and understanding was confirmed; participants were given the opportunity to write in additional factors. Qualitative discussions affirmed that these five attributes most influenced participants' print image quality preference, more than gloss and other image print quality factors.

Participants were asked how much each of these attributes contributed to their preference judgments in a positive or negative way. They determined that Richness, Sharpness, and Smoothness were the most positive influencers, while Exposure had the least positive effect – note that poor Exposure would contribute negatively, as would a lack of Realism or Smoothness. Richness correlated most strongly with image quality preference, and Sharpness second – implying that when prints are adequately true-to-life (realistic), properly exposed (brightness/contrast), and not grainy (smooth), consumers prefer more vivid (rich) and detailed (sharp) prints.

Preference for the 8-color HP Photosmart 7960 photo inkjet print system was strongly supported by Exposure, Sharpness, and Realism, even against conventional digital central processing.

Richness and Realism drove preferences higher on color-intensive images, such as Basilica, Forbidden City, and Gas Pump – with their blue skies and vivid colors.

"It really surprises me that this [7960 print] is out of a printer."
– French participant

Research Methodology

As noted above, significant effort was invested in establishing and executing an unbiased methodology in order to assure the quality and integrity of the research findings. The methodology included selecting and optimizing the digital test images; choosing representative print systems; preparing the print samples; overseeing the focus group activity and venues; collecting the print quality preference and attribute quantitative and qualitative data; and analyzing the results.

Test Images

The test images were taken digitally or digitized on a high quality scanner and optimized in order to assure consistent, representative test images. These digital images were re-touched and color-corrected in sRGB[5] at resolutions of 300-600 DPI in 4x6" format, in order to approximate typical digital camera output. These optimized images were saved as JPEG files at quality levels comparable to those typically obtained from 3-MegaPixel digital cameras.

The six photographic test subjects were selected to represent a realistic range of the consumer experience, including: people and scenery; indoor and outdoor; highlight and shadow; memory colors such as skin tones, sky and grass; and vivid, pastel, and grayscale colors in black & white photography. This is illustrated in the table on the following page.

Print Sample Preparation

Copies of each image were printed on each of the print systems, which included conventional digital central processing, and inkjet printers with their recommended high quality photo papers.

Conventional prints were selected by reviewing samples developed from numerous centrally located digital photo processors in order to find representative and consistent sources. Selection was limited to web-accessible consumer facilities. Noting considerable variation among these centralized developers and after discarding poorer-quality alternatives through an extensive review process, a well-known US photo industry company with access through its on-line subsidiary was selected as the most representative and consistent. As in prior research, these prints were used for testing internationally.

In order to increase confidence that sample printers were indeed representative of their vendor model, the most representative print system was selected from a minimum of three cartridges or printers, as appropriate (print heads may be contained within an ink cartridge or may be integral to the printer, depending upon manufacturer/model), after a careful review process.

Test Images

Image	Title	Comment	Image
	Apple Lady	A studio scan of an Asian female chosen to highlight "Realism"	
	Basilica	Digital outdoor photo of sky, grass, and building chosen to highlight "Smoothness", "Realism" & "Sharpness"	
	Forbidden City	Digital outdoor photo of a sky, statue, and building chosen to highlight "Smoothness", "Realism" & "Sharpness"	
	Four Children	Black & white composite stock photos of children's faces chosen to highlight "Sharpness" and "Richness (depth)"	
	Gas Pump	Digital outdoor photo of a vivid object chosen to highlight "Richness" and "Sharpness"	
	Pensive Man	Digital indoor photo of Caucasian male chosen to highlight "Realism" and "Sharpness"	

Where competitive photo inkjet print systems offered unique models and/or drivers for US and European markets, appropriate models and/or drivers were used in each venue.

All prints were mounted in 8x10" dark neutral[6] matting, with white back covering to minimize see-through, leaving all but 1/8" of the 4x6" image directly visible. Prints were marked with a random code to protect their identity. Participants always handled prints with white cotton gloves for protection, and the back covering did not allow participants to see or touch the back of the print. Multiple copies of the print samples were made at the same time, with the same ink cartridges, allowed to dry for 24 hours, and protectively stored in light-shielded archival sleeves to minimize environmental degradation; duplicates were available as replacements if necessary.

Study Participants and Locations

As previously noted, participants in this photo image quality research use a camera, develop film, do not work in the photographic field, and consider photographic quality to be at least of moderate importance. The 49% who were photo enthusiasts met additional criteria as stated earlier. The overall sample pool consisted of 367 participants, 57% male and 43% female, ranging from 18 to over 65 years of age, with all primarily taking pictures of people, pets, and scenery. There were at least 120 research participants in each country, as detailed in the following:

Study Locations and Participants					
Country	City	Quantitative Participants		Qualitative Participants	
		Photo Enthusiasts	Other Consumers	Photo Enthusiasts	Other Consumers
France	Paris	57	63	6	6
Italy	Milan	60	60	6	6
United States	Syosset, NY	30	28	6	6
	San Diego, CA	33	36	6	6
Subtotal		**180**	**187**	**24**	**24**
Totals	**4**	**367**		**48**	

All print quality judgments were made under controlled conditions at specially designed black-and-white surfaced viewing stations with 3500-4000°K lighting. Facilitators were careful to only use terms such as "photos" or "images" (translated, as appropriate) and to avoid making any specific references to conventional developing or to digital printing technology.

Sample Participant Venue

Preference Ranking (Pair-Wise Comparisons)

Sessions were structured into six-participant mini-groups and conducted in the local languages. Each study participant was asked to rank prints of a particular test image, one from each of the various print systems, according to his/her preference for image quality. Prints were arranged face down in random order. Participants were asked to compare the first pair of prints and determine their preference. Each following print was then compared in a pair-wise fashion with each of the prior ones, from which the participant's preference among the group was determined, in rank order from best to worst.

Participants were then asked to enter a numerical value to indicate the relative Print Quality of each print on a scale of 0 to 100.

Each participant repeated this quantitative process for each of the six test images.

Attribute Evaluation

After recording their rank order preference, each participant was asked to explain his/her judgments in terms of five pre-defined color print quality factors or attributes – Richness, Realism, Sharpness, Exposure, and Smoothness – recording whether each quality factor positively or negatively contributed to the preference decision. Additionally, participants were permitted to write-in other factors that contributed to their ranking, such as gloss, etc.

Qualitative Sessions

Focus mini-group participants were randomly selected to comprise one session for photo enthusiasts and one for other consumers in each city, for qualitative discussions to explore the reasons behind their preference rankings, and gather commentary about their thinking. Discussion also included photo-taking habits, preconceptions of conventional processing vs. printed output, and opinions regarding the relative importance of image quality attributes. Responses provided valuable insights, and were colorful, reflecting the participants' passion for pictures.

'Forbidden City' 7960 Print: "The sky is incredible, realistic, with good balance"

— Italian participant

Quantitative Analysis

After data entry, verification, and consolidation, various computer analyses were performed. Preference rankings were analyzed in various areas of interest. Mean ranking were determined for each of the six test images. Detailed pair-wise comparisons were analyzed to determine statistically significant preferences. Since methodology recorded the preference for every instance where a participant compared the print quality and attributes of print system 'X' with print system 'Y' for each X-Y pair, overall a total of 46,210 pair-wise preference comparisons were available for analysis.

Confidence Levels

Statistical analysis of the pair-wise rank order judgments included two non-parametric approaches, consistent with methods used in various groups within our industry. Both methods assume interdependence among the pair-wise comparisons. One relates to the "law of comparative judgments" as laid down by Thurston in 1927;[7] the other is the well-known Wilcoxon analysis, available on various commercial software packages. Where appropriate, both analyses were run and the more conservative result used to obtain 95% confidence. All results presented graphically in this report are believed to be statistically significant.

Other

Our analysis found little overall variation between California and New York, and between the US and European respondents, with some modest differences in France and Italy. Preference variation from image to image, however, was notable with the HP Photosmart 7960 photo inkjet printer ranking particularly high on scenery and color-rich images. Though participants had a stated desire for realism, they often preferred prints that looked like what they wanted, not necessarily accurate representations of the original scene.

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[3] As used herein, a print system is the combination of the driver, printer, ink, and paper (media).

[4] Competitive inkjet print systems are A-size consumer photo printers, comparable in price structure to the HP Photosmart 7960 photo inkjet printer.

[5] sRGB is a standardized, calibrated RGB color space, often used in consumer photographic inkjet printing.

[6] Chroma is within 1 ∂E of neutral.

[7] According to *Optical Radiation Measurements,* Bartleson, C. James and Grum, Franc editors, formally set down by Louis Leon Thurston.

About *spencerLAB*

The *SpencerLab* Digital Color Laboratory is an independent printer evaluation facility that provides services to vendors and corporations for whom color printing is mission-critical. The Laboratory follows strict guidelines in the integrity of both methodology and reporting; vendor-sponsored studies do not guarantee favorable results. *SpencerLab* has developed industry-standard test software, and performs print quality, throughput speed, ink and toner cartridge yield and cost-per-print/TCO, and ease-of-use analyses for color and black & white printers in all technology classes, from inkjet and laser printers to digital color presses.

SpencerLab is operated by Spencer & Associates Publishing, Ltd., a premier IT consulting boutique specializing in the application of Digital Color Technology to all aspects of color imaging. For over a dozen years Spencer & Associates has been providing strategic support to manufacturers in product planning, development, and launch. Color printing workflow analysis, print system selection, and usage optimization services are provided to corporate users.

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