Managing Editors and Digital Images: Shutter Diplomacy

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Their tools include laser-scanning confocal microscopes, PhosphorImagers, spectro-meters, densitometers, and digital cameras. Biomedical scientists are increasingly using techniques to capture data electronically and are generating digital images with these data. To reproduce the images at the highest quality in their publications, managing editors must serve as liaisons between authors and typesetters-printers.

Typesetters and printers are rapidly moving to the electronic production of film or plates for the printing process. That is, they are using computer software for typesetting and page layout and are importing electronic figure files (digital images) into the layout to create completed pages. It is necessary for typesetters to obtain, in one way or another, a digital image of authors' figures. It is the job of managing editors to serve as intermediaries between authors and typesetters or printers to ensure that the highest-quality images are printed in their journals. Editors must understand the jargon of the typesetters and printers and their requirements for image reproduction and the authors' jargon and their abilities regarding the production of digital images.

Why Digital Images?

In the past, typesetting machines produced text in the journal layout, which was photographed to produce film; photographs sent by authors as figures in a manuscript were rephotographed by the printer, and the film for the image was "stripped" (literally taped) into the film containing the text. Desktop-publishing programs (such as QuarkXPress, Adobe PageMaker, and Adobe FrameMaker) and high-end composition systems (such as Xyvision, Penta, and Miles 33) now allow images and text to be married in a layout electronically, saving considerable time and labor. The digital workflow also eliminates the possibility of human error associated with stripping images, such as inverted or mirror images.

Typesetters have 2 ways to obtain a digital image to include in a page layout. They can scan the hard copy of a figure to create a file with the information for producing a screen, or pattern of dots, that will be placed on film to reproduce the image; alternatively, they can obtain a file with this information from the author. The author can use an image manipulation program (such as Adobe Photoshop) or a drawing program (such as DeltaGraph, MacDraw Pro, Corel Draw, or Adobe Illustrator) to produce these files.

Scanning of figures is still the most widely used method of generating digital images. Here we will discuss this process in detail and use it to illustrate the technical fundamentals of successfully reproducing an image in a printed journal. We will then discuss the reasons for using digital images created by authors, describe some of the pitfalls associated with using these images, and list guidelines for authors to consider when producing them. With an understanding of this information, managing editors and their staffs can not only convey their requirements to authors, but also can take on more proactive roles, such as screening digital artwork for technical compliance and even, if time permits, manipulating authors' files to render them compliant.

Types of Figures

Four types of figures are printed in scientific journals:

Continuous-tone images are black-and-white photographs (such as electron micrographs) that contain a continuous range of tones from white through gray to black (many of the terms used in this article are defined in reference 1). For printing on paper, these images are converted into a pattern of black dots of various sizes. Collections of larger dots are interpreted by the eye as dark areas of an image, and smaller dots as lighter areas. The converted image is referred to as a halftone.

Line art is any illustration or artwork that is constructed from individual lines of a fixed shade or color (such as graphs and schematic drawings).

Combination halftone images contain elements of both halftone and line art. A common example is a labeled gel, in which the labeling is outside the halftone area.

Color images can contain any color in the visible spectrum.

Scanning Authors' Figures

Continuous-tone images are typically scanned at 300 dots/inch (dpi); this value is referred to as the resolution of the image. The scanner creates a grid that is 300 samples X 300 samples = 90 000 samples per square inch; it measures each point on the grid and assigns it a tonal value of 0 to 255, which is called an 8-bit scan (8 binary bits of data, or $2^8 = 256$). Line art is typically scanned at a resolution of 1000 dpi, which creates a sharper delineation between the lines and the background and results in fewer jagged edges on the lines. It is possible to scan line art at such high resolution without creating files that use an immense amount of memory, because each scanned point on the grid is only 1 bit of data (or binary), which indicates whether the point is black or white. Combination halftones combine properties of both line art and halftones, so they are digitized with an 8-bit scan at a compromise resolution of around 600 dpi. This creates a very high-resolution file for the halftone that is not outrageously large (about 5 to 10 megabytes, or MB), and it is high enough resolution that the labels in the figure are still crisp. Color images are typically scanned at 300 dpi; but instead of

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an 8-bit scan describing 256 levels of gray, the scan is 32 bit (2^{32}) to accommodate the 16.7 million colors available to the printer.

Printing Digital Images

It is important for a managing editor to understand the basics of the printing process. This process is the basis for the requirements that typesetters and printers impose on the processing of digital image information.

Screening

The machine that interprets the information in a digital file and creates an image on film is called an imagesetter. When the digital image is sent to the imagesetter, a grid is created over the image with 150 lines/inch in each direction (the screen ruling). In a halftone image, the value assigned to each point on the grid will be an average of the information from the 300-dpi scan. Each tonal value (from 0 to 255) is translated into a dot. The imagesetter has a resolution equal to 16 times the screen ruling (16 X 150 = 2400 dpi); thus, each point on the 150-line/inch grid can be made up of a grid of 16 X 16, giving 256 possible dot sizes. The differently sized dots fool the eye into seeing different shades of gray, even though only black ink is placed on the paper. A good way to see how an image in a journal is created from dots is to look at a printed halftone through a magnifying glass.

Offset Lithography

This is the term for the printing process used by scientific journals. The dots on the film produced by the imagesetter are transferred to an aluminum plate, which has a coating where exposed areas (dots) are attracted to ink and unexposed areas are attracted to water. The plate passes by ink and water rollers, and the ink it picks up is then transferred to a rubber roller, which in turn transfers the ink to paper. Strong pressure is applied to the sheet of paper in the process, and one result is that the dots that make up an image typically come out larger on paper than they are on the plate; this is referred to as dot gain.

The Press Curve

The printer creates a press curve to compensate for dot gain, essentially adjusting the size of the dots from the imagesetter to counteract their increase in size in the printing press. In addition to an actual dot-gain setting, the press curve has a setting for "gamma" output, which regulates the contrast between the lightest and darkest parts of an image, and a setting for tonal range. The tonal range is set so that no dots will be larger than a specified percentage of the maximum (for example, 98%); this avoids bleeding of one dot into another, potentially losing detail in the shadow area of an image. Conversely, the white or "highlight" areas of an image cannot be totally without ink; the smallest dot is set to a specified percentage greater than the minimum (for example, 2%) so that detail in the highlight area is not lost.

The figure proofs that are sent to authors cannot possibly be an exact representation of the way the figures will look on the printed page.

Printing Color

Color images are printed by separating their colors into 4 components: cyan, magenta, yellow, and black (CMYK). The separation can be done by a scanner, and this process is what printers are referring to when they talk about a "separation". Each of the colors in an image is created by assigning a percentage of 0 to 100 to each of the aforementioned colors (for example, a red color could be created from 0% cyan, 100% yellow, 100% magenta, and 0% black). These numbers are transformed into dot densities on 4 separate pieces of film (1 for each color), which are used to create 4 plates. The color image is then printed on a multipass or multiplate press, with a single piece of paper receiving ink from each of 4 plates.

CMYK is referred to as subtractive color (that is, black is achieved by the presence of all inks), as opposed to RGB (red, green, and blue), which is additive color (that is, white is achieved by the presence of all 3 colors as lightwaves). RGB is the color process used by computer displays and can generate many more colors than can be generated by CMYK. In particular, many magentas and purples are difficult to create in CMYK, and authors should consider avoiding these colors when preparing an image for publication.

Printers' Proofs

One of the most important issues for a managing editor to appreciate, based on an understanding of the printing process, is that the figure proofs that are sent to authors cannot possibly be an exact representation of the way the figures will look on the printed page, as they have not gone through the rollers of the printing press. The typesetter uses a proofing output device to simulate the tonal effects, color effects, and dot gain of the printing process. Typesetters make great efforts to calibrate their proofing devices to ensure that the output matches the printed product as closely as possible. It is important, however, for editors to let their typesetters know that they want proofs to be equal to or slightly less than print quality, so that authors are not disappointed when they see the print version.

Another tool that a typesetter may use to prepare proofs is image-swapping technology known as an open prepress interface (OPI) or automatic picture replacement (APR) to produce page proofs for authors. The process allows a low-resolution version of an image to be inserted into the page layout for placement, so the proofs can be printed much more quickly. The low-resolution image is swapped for the high-resolution version when the file is sent to the

imagesetter. The use of this technology can affect the format of digital images that can be used by the typesetter (see below).

Problems with Scanning Images

The main problem with scanning images stems from the fact that authors frequently use digital data-capture devices and produce their figures (both images and line art) with computer software. That is, the first generation of the figure is electronic, and a good (for example, continuous tone) paper copy may not necessarily exist. The output of a digital file by an author on either a laser printer or a color dye-sublimation printer is produced by a process similar to that described above, in which a PostScript interpreter (the printer driver) creates a pattern of dots, which is placed on paper. The pattern is made up of a specified number of dots per inch, which is referred to as the line screen of the image.

When a typesetter scans such an image, a second line screen is applied, and that rescreening process can corrupt the uniformity of the black and white mix produced by different-size dots in the gray portions of an image. This is because it is virtually impossible to line up the line screen of the image with the sampling line screen of the scanner. For 1-bit line art, the scanner will not see perfect black or white points on the image; since it can only fill or not fill each point, the scanner must interpret the mixed points and decide whether to fill or not fill the point in the file that it creates. The result can be an undesirable wavy pattern in the scanned image called a moiré. (For a more detailed discussion of this issue, including a very helpful discussion of how to produce line art with less propensity to yield moiré patterns when scanned, see reference 2.)

Digital Images from Authors

Authors want typesetters and printers to use their digital image files. They want to avoid the possible loss of quality associated with creating a paper copy and having it scanned, and they would prefer to avoid the cost of producing camera-ready paper copy. It is also vastly easier to label, crop, and collage figures in the digital environment. Because it is always in managing editors' interest to try to accommodate authors' wishes, they must understand the problems associated with using these files and be able to communicate to authors the best way to avoid many of the problems.

Managing editors must provide detailed instructions to authors, describing the correct settings for files to be used by the typesetter and printer.

Data Integrity

The first problem of which both authors and editors must be aware is the risk to the integrity of an authors' data posed by manipulation of the digital file. We are not referring here to the possibility of deception, which has been considered elsewhere (3) and which we feel is of no greater concern than the possibility of altering numbers in a table. It is, however, entirely conceivable that an image could be unintentionally altered by an author or by a printer through adjustments to contrast, tonal range, or some other digital setting. CBE does not have a written policy on publishing digital images. We suggest that at least the name of the application that was used to create the image should be given in the figure legend.

Typesetter Workflow

In an ideal world, typesetters and printers would also like to use authors' digital image files to improve the quality of the printed work. It is important for managing editors to understand, however, that accepting files for digital images from authors requires a dramatic change in the workflow that printers have established for electronic publishing, at least at present. Scanning figures is an established part of that workflow for printers who use PostScript-based programs for layout. It is an efficient procedure, with well-defined time requirements and cost per subject. Typesetters have established settings for scanning each type of figure, which can be used by an operator whose training is limited to the predictable software environment of the scanner. Using digital files received from authors requires a more highly trained operator who can troubleshoot images generated in a wide variety of software applications and can manipulate image files to compensate for changes imposed by the printer's press curve. It also requires a large array of peripherals to receive different media from authors (Syquest disk drives, ZIP disk drives, CD drives, File Transfer Protocol [FTP] servers, etc.).

Perhaps the greatest problem for typesetters is the undefined amount of time that it takes to handle a digital image from an author and the resulting difficulty in setting charges for this work. A file for a digital image might arrive at the printer ready to be imported into the page layout of the manuscript, requiring only seconds of work by the operator to determine that this is the case. On the other hand, the file might be in the wrong file format (the language used to output the information in the file, such as PostScript, Encapsulated PostScript, and Tagged Image File Format or TIFF), in the wrong mode (RGB versus CMYK), or at the wrong resolution. Some of these problems can be corrected by a skilled operator, but it takes time to do so. Managing editors must provide detailed instructions to authors, describing the correct settings for files to be used by the typesetter and printer (see the next section). It is important not only to indicate what the correct settings are, but also to describe to the author how to achieve these settings in commonly used graphics applications.

Guidelines for Authors

In the discussion that follows we include information about the software applications and file formats most commonly used by typesetters and printers. Specific instructions are given for preparing images with Adobe Photoshop because this application is very commonly used by authors. It is most important, however, for authors to note the preferred file formats and the resolution specifications for particular types of images, and they can prepare images with any software that will produce compliant files. The specific instructions were prepared with Adobe Photoshop version 4.0 for Windows. The Windows and Macintosh interfaces are similar, however, and have not changed substantially in the recent releases of the software.

Media

Typesetters can accept files on a wide variety of media. The most common and easiest to use are 3.5-inch floppy disks and 3.5-inch ZIP disks. Floppy disks can hold up to 1.44 MB of data; ZIP disks can hold up to 100 MB. If an author sends an uncompressed file for a halftone or color image and it fits on a floppy disk, the file is probably too small (too low resolution; see below). Alternatively, if an image file is larger than 100 MB, something is not right, and the authors should check to see that they have followed the instructions below properly.

Standard Software Applications

Just as the word-processing programs Microsoft Word and WordPerfect have become established software applications for producing the text of a manuscript, there are standard software applications that typesetters use to manipulate digital images. Authors should not worry if they are not using one of these applications. If the image is saved in the correct format and sent from within the application in which it was created, the applications that the typesetter is using should be able to open it. This is an important point. Authors should be instructed not to embed their images in another application, such as Microsoft Word or Microsoft PowerPoint, but to send files saved in their original format directly from within the graphics application.

The standard applications used by most typesetters are Adobe Illustrator for line art and Adobe Photoshop for halftones, color figures, and combination halftones. Illustrator can create "object-based" graphics in which fine lines, curves, and objects are determined through mathematical definition (or vectors) and are not created with dots (bitmapped). This means that the graphic can be rendered at any resolution using the vector information. Photoshop creates bitmapped images in which the color properties of each pixel are defined.

Authors should be instructed **not** *to embed their images in another application . . . but to send files saved in their original format directly from within the graphics application.*

File Format: EPS versus TIFF

There are 2 standard file formats for saving digital images. Encapsulated PostScript (EPS) files comprise a PostScript file for printing and a low-resolution PICT or Tagged Image File Format (TIFF) file for rendering the image on a screen (4). PostScript is a language devised by Adobe Systems, Inc as a device-independent, page-description language for use by a wide variety of output devices. It is the standard language that drives most printers and imagesetters. Both vector-based graphics and bitmapped images can be stored as EPS files.

TIFF is a format for storing bitmapped graphic images. TIFF is not a printer language or page-definition language, but was developed to facilitate the exchange of image data between application programs. TIFF does not support object-oriented graphics or text; it is designed solely for image data.

TIFF is the preferred file format for image data, and EPS must be used for vector-based graphics. For color-image data, TIFF files are smaller and print faster because they send less information to the imagesetter for printing each plate (when an EPS file is processed by the imagesetter, the entire file is processed 4 times, once for each plate; the color information for a TIFF file is processed only once). For black and white (noncolor) images, TIFF is still the preferred format. It is important to note that both EPS and TIFF files can be accepted by typesetters, but authors should check with each targeted journal for its preference. Because typesetters and printers use OPI and APR workflows to speed production, TIFF files will generally be the preferred file format. In most cases, TIFF or EPS files will work, but TIFF files will generate a better preview file for authors to view in page proof.

A preview is a version of an image that is used primarily for viewing it on screen. Most software applications that generate EPS files give the user a choice of whether to create a preview version and a choice of file format for the preview. (The preview formats for Macintosh and Windows computers are different and are not compatible.) The default preview is at 72 dpi; this is an acceptable resolution for viewing an image on screen, but renders a poor-quality image on most printing and proofing devices.

If printing instructions are to be included in the image file—such as clipping paths (used to isolate part of an image for printing or placement in another application), line screens, or screen angles (a series of predefined angles used to avoid moiré patterns)—it must be saved as EPS. It is important to note here that a PostScript file and an EPS file are not the same thing. An EPS file is a PostScript file whose purpose is to be placed on a page or within another program as a graphic. Authors should never submit PostScript files.

File Compression

Another reason that TIFF files are preferred for image data is that they can be compressed easily. Image files can be very large (up to 50 MB), and various compression schemes have been devised to store and transport these files using less memory. Some compression standards have been built into the TIFF file format, such as LZW (Lempel-Ziv-Welch) compression. This utility compresses the data without deleting any information (lossless compression). In general, LZW is the best overall lossless compression engine, but any self-extracting file-compression system is likely to work.

Many types of compression programs are available; the most popular are PKZIP and WINZIP for DOS and IBM-compatible systems and StuffIt and DiskDoubler for Macintosh. Most typesetters and printers can accept files compressed with these applications. Compression programs are also available for UNIX systems, and it is important to determine whether your printer and typesetter can handle them.

File compression is extremely useful when transmitting data via telecommunication—bulletin board services (BBSs) and the Internet. A user can compress multiple files into a single, more portable file, then easily transfer the file between locations. However, transferring files as attachments to e-mail is risky and should be avoided whenever possible. Some Internet providers and e-mail software will truncate files or change file formats, rendering the attached files unusable. It is safer and more reliable to send compressed files via FTP or through a proprietary, secure connection like a BBS.

Grayscale Art

Submitted digital halftones must have an image resolution of at least 300 dpi at publication size. To check the size and resolution of the image in Adobe Photoshop, select "Image Size" in the "Image" menu. Make sure that the "Resample Image" box in the "Image Size" dialog window is not checked and that the "Width", "Height", and "Resolution" boxes are linked by the graphic chain (it might be necessary to click twice on the "Resample Image" box to establish this link). This will mean that no resolution (dots or data) is lost when the dimensions of an image are reduced and that the machine does not add dots to an image when increasing its dimensions. Set the print size to the desired size of the image in the printed journal, and make sure that the resolution at this size is above 300 dpi. If it is not, the file might have to be reimported at a higher resolution from the image-capture device that was used. Grayscale images should be saved in the TIFF format by selecting this choice in the format box of the "Save" dialog window.

To compensate for dot gain in the printing process (see above), typesetters will impose dot-gain and tonal-range settings on the file before importing it into their typesetting applications. Authors who are interested can look at how these settings affect the image, but it is not recommended that they adjust these settings in the file that they submit for the digital image. In Adobe Photoshop, dot gain is set by selecting "Color Settings" in the "File" menu, then selecting "Printing Inks Setup". The "Ink Colors" in the dialog window can be left at the default setting of "SWOP (Coated)". Set the dot gain, and make sure that the "Use Dot Gain for Grayscale Images" box is checked. Tonal range (for example, from 2% to 98%) is set by selecting "Adjust" in the "Image" menu, then selecting "Curves". Click on the bottom left point of the line in the dialog window and move it slightly up until the input and output values read 0% and 2%, respectively. Click on the top right point and move it slightly down until the input and output values read 100% and 98%, respectively. If an author has imposed these settings on the image in a file, it is vital that the editorial office be informed (who in turn must inform the typesetter) to avoid having them adjusted another time.

Color Art

As for halftones, the resolution of color images should be at least 300 dpi. As described above, color images are printed using the 4 colors CMYK. It is important to view the image in this mode to get a preview of how the colors will print, although monitors have various calibrations, and the colors might still look different from how they will look in print. All adjustments to color should be made to the CMYK image, and it should be saved in this mode. To change the mode to CMYK from RGB in Adobe Photoshop, select "Mode" in the "Image" menu, then select "CMYK Color".

The color saturation should be set to a maximum of 280%; that is, at no point in the image should the sum of the percentages of the colors used be greater than 280. To check this in Adobe Photoshop, make sure that you are in CMYK mode, then select "Show Info" in the "Window" menu, and click on the "Info" tab. The top left corner of the dialog window shows the percentages of each of the 4 colors used to make up the color at the place in the image where your mouse pointer is located. Make sure that the sum of these percentages at the darkest point in the image is less than 280. Although every attempt is made by typesetters and printers to match the colors, software might not print uniformly across different platforms.

Line Art

Line drawings can be submitted in EPS format by selecting this option in the format box of the "Save" window in the application used to create the drawing. All fonts should be saved to path, if possible; or standard fonts—such as Helvetica, Arial, and Times—should be used. To do this in Adobe Illustrator, first select the text, then select "Create Outlines" in the "Type" menu. Line art can also be submitted in TIFF file format at 1000 dpi at publication size.

As with color and grayscale images, TIFF remains the preferred format. The issues are the same as those mentioned above; if an author has the choice of providing TIFF or EPS, it is wise to choose TIFF. TIFF files, although generally larger than EPS files, do

not have the problems of cross-compatibility encountered with EPS files, such as missing fonts and font substitution.

Color or Grayscale with Fonts or Lines
Authors should follow these guidelines to ensure that their labeled color or halftone images are reproduced properly by the printer.
1) Import the grayscale or color image (minimum resolution, 600 dpi at publication size) into Adobe Photoshop or similar program.
2) Crop the image.
3) In the "Layers" menu, select "New Layer".
4) Create labels in the new layer making sure that the anti-aliased box in the Type Tool window is not checked.
5) Save as a TIFF file.

Hard Copy

The final request that all typesetters are making of authors is that they send a hard copy of the image to indicate what they expect from the output of their file. The most important instruction for authors sending color images is that the hard copy should be output from a file in CMYK mode. This will give the author an indication of what colors the printer is capable of achieving on paper and will serve as a guide for the printer in establishing what the author wants the image to look like.

Typesetters may push to scan the hard copy if they are having trouble with the file, but they should be encouraged to call the editorial office to determine whether there is any way to obtain a usable file from the author. Managing editors trying to convert to digital images will find that this becomes a common task.

Conclusions

Just as it took time for journalists to accept electronic files of manuscripts, so will it take time for digital images created by authors to become the industry standard. When they do, it will mean great savings in the time, cost, and effort of image production for both authors and typesetters, and managing editors will get their prize of faster turnaround of manuscripts from acceptance to publication.

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