Biomedical Journals' Standards for Digital Images in Biomedical Articles

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Introduction

Standards for appropriate manipulation of digital data have developed more slowly than has the software for manipulating the images. Half of all cases now investigated by the federal Office of Research Integrity involve questions about digital images.

Although digital data-images are increasingly the norm in the biosciences, most research disciplines have not adopted consensus standards about appropriate manipulation of digital data-images. Increasingly, editors are filling the gap by adopting general guidelines for such images.

Research Design

This research was designed to identify the spectrum of standards/guidelines for digital data-images in a sample of biomedical journals.

Study sample. We identified the principal investigators (PIs) on all research grants awarded between January 2005 and June 2010 to faculty of 8 biomedical departments and centers of the University of Virginia School of Medicine. (These departments and centers were Biochemistry, Biomedical Engineering, Cell Biology, Cell Signaling, Microbiology, Molecular Design, Molecular Physiology and Biological Physics, and Neuroscience.)

Using PubMed searches, we compiled a list of the journals in which these PIs had published during 1995-2010. The resulting list of journals was the sample for the study.

Journals' standards. For each journal, we examined the instructions to authors and related materials to identify its guidelines for digital-data images.

Categorization system for standards. Based on the first 25 journals examined, we created a simple categorization system to describe the range of guidelines. These categories were then applied to the entire sample.

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Results

We identified 161 PIs who had published in 446 different journals during 1995-2010. Overall, 13% of the journals had a clinical focus, 85% focused on sciences basic to medicine, and 1% were "other" (e.g., biomedical education; information sciences). Table 1 gives the breakdown by category for these journals' guidelines for digital images.

Table 1
Categorization of 446 biomedical journals' standards for digital data-images

Category	No.	%
1. no instructions or guidelines for images or illustrations	8	2
2. instructions or guidelines refer to "art" (illustrations) *	215	48
3. instructions or guidelines refer to digital manipulation	179	40
4. detailed instructions and guidelines for digital images	44	10
Totals	*446*	*100*

*Because journals and publishing houses have traditionally used the term "art" to refer to anything that was not text, a journal's instructions for "art" can cover all types of illustrations. Few in this category mention digital images or digital data-images.

Half of the journals had at least minimal guidelines for digital manipulation of images (223 journals, 50%) . Of these, 44 (10%) gave detailed information about their expectations. Excerpts from journals in categories two through four illustrate the range of guidelines found in the sample.

- *Guidelines for "art"/illustrations only*. Journals with instructions for only "art" (illustrations) had statements about graphical formats such as "Art should be created/scanned and saved and submitted as either a TIFF…"(*Optometry and Visual Science*) or "Symbols, letters, and numbers must be legible after reduction …." (*Magnetic Resonance in Medicine*).
- *General guidelines for digital manipulation.* Journals that gave general guidelines for digital images had statements such as "For Graphical images, journals published by Elsevier apply the following policy: no specific feature within an image may be enhanced, obscured, moved, removed or introduced" (*Gene*) and occasionally described policies for screening submitted images.
- *Detailed instructions or guidelines.* Journals that gave detailed guidelines described requirements such as "Authors should retain their unprocessed data and metadata files …" and "The use of touch-up tools … or any feature that deliberately obscures manipulations, is to be avoided" (*Nature*). They often described their screening policies, such as "All images in Figures and Supplemental information from manuscripts accepted for publication are examined for any indication of improper manipulation or editing" (*Blood*) .

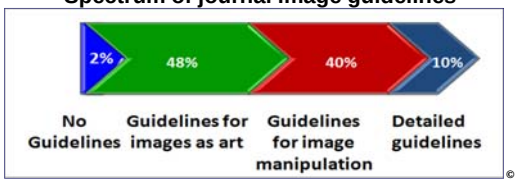
The journals with general (rather than detailed) guidelines often used language from journals such as the *Journal of Cell Biology* or referred to standards outside the journal.

Discussion

Since 2003, when the *Journal of Cell Biology* became the first major journal to set guidelines for digital images and to screen submitted images, some journals had adopted at least minimal guidelines. Some, like 10% of our sample, adopted detailed guidelines. Many of those with detailed guidelines are among the most prominent journals in bioscience. For example, *Science*, *Blood*, and all 34 Nature Group journals now have detailed, explicit guidelines. Further, all Elsevier journals now have basic guidelines as well as strictures against inappropriate image manipulation.

Changed landscape. Journal editors need to shift from thinking about digital-image data as "images" to thinking about them as "data"—and to apply to them the policies for handling, vetting, publication, and storage that normally apply to any research data. Image processing has moved from a controlled setting in which certified technicians processed images to one in which researchers at all levels of experience are responsible for processing their own images, creating an environment ripe for well-intentioned mistakes as well as fraud. Further, new mandates for data sharing and new digital tools will promote more detailed post-publication review by fellow researchers.

Spectrum of journal image guidelines



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Next steps. Inevitably, inappropriately manipulated images will be published, and, if questions arise about an image, the only recourse will be to examine the image as originally captured. All journals should give instructions about images-as-data, whether a general statement as presented in *CSE's White Paper on Promoting Integrity in Scientific Journal Publications* (2009) or detailed guidelines developed by the journal. In addition, journals should require, at a minimum, that authors

1. retain the original captured image and provided it if questions arise during review or after publication
2. retain detailed records of the steps necessary to replicate the published image.

Further research. We plan to study a set of cases involving questioned images in biomedical journals, with a goal of examining whether the journals with guidelines for digital data-images had fewer questioned images than other journals did.