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Scientific Integrity Is Threatened by Image Duplications

To the Editor:

The identification of errors in published research has led to a surge of corrections and retractions recently (1). The identification of errors is facilitated now by online communities that offer training and information exchange. In addition, advances in image processing (2) allow image duplications to be identified more easily, making it possible to screen a paper rapidly even without the need to understand its scientific content. Are image duplications also an issue in pulmonary research?

I began to address this by using my own OpenCV-Python image analysis software tools to screen randomly selected scientific papers. I then undertook a more systematic approach by selecting a previous volume of the *Journal* in an attempt to identify image duplications. Visual inspection of images was followed by a selective upload to imagetwin.io, an online service (still under development) that identifies duplicated regions among and within images. When in doubt, images were further tested using Sherloq (https://github.com/GuidoBartoli/sherloq), an open-access software package that is also still under development and includes various forensic tools, including error-level analysis, luminance gradient, and noise separation, as well as Affinity Photo for key point detection (https://affinity.serif.com/de/photo/). A final judgment was made using a large graphics workstation. Whenever the image legend was not sufficient to understand the content, the full text was used for clarification.

In a randomly selected volume of the *Journal*, there were 37 papers containing photomicrographs that could be examined in detail with the numbers ranging from a few to more than two dozen images per paper. Altogether, this analysis flagged eight papers (22% of the eligible sample) as containing irregular image content; these findings were deposited at PubPeer, a website that archives questions regarding published research. Authors were notified by PubPeer, which provides an opportunity to respond. Elisabeth Bik has defined three classes of image duplication (3). Category I is defined as, "Figures containing two or more identical panels, either within the same figure or between different figures within the same paper, purporting to represent different experimental conditions." Category II "…included microscopic or blot images with a clear region of overlap, where one image had been shifted, rotated, or reversed with respect to the other." Category III "…consisted of images that were altered with complete or partial duplication of lanes, bands, groups of cells…, sometimes with rotation or reversal with respect to each other, within the same image panel or between panels or figures." In the present analysis, 2 of the 37 papers contained a simple duplication (Category I), whereas 4 papers involved Category II duplications, and 2 involved duplications with alteration (Category III). Duplication of images between papers was not systematically examined but was found by chance in one Category III paper.

Why do duplications occur? Many probably represent simple oversight or carelessness, but a few are difficult to explain away as simple errors. As expected, duplications tend to occur more frequently in papers with many images (3). The number of image duplications in this small sample is higher than the 4% reported previously after visual inspection only (3, 4). However, extension of the current analysis to papers related to interstitial pulmonary fibrosis published in another, unrelated journal identified duplications in 16 of the 171 eligible papers (9%). This indicates that image duplication is indeed an issue in pulmonary research and not a problem unique to the *Journal*.

Based on this analysis, I urge biomedical journals to adopt a much stricter approach to screening papers for anomalies in the figures of their papers, in terms of biological object or sample enumeration, Cartesian image representation, and documentation and referencing, before publication. After publication, original images should be made available in scientific image repositories to prevent image theft, analogous to screening for plagiarism of text. Authors need to check the final versions of their manuscripts more carefully for possible data or image mix-up.

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Institutions and research agencies need to involve integrity officers with special training in fact-checking in cases in which intentional manipulation may have occurred (5). Existing guidelines are already comprehensive (6), but editorial offices and reviewers need to look more critically at the images presented and to engage image analysis experts when needed to detect anomalies or errors before publication. ■

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Erratum: Attenuation of Lipopolysaccharide-induced Lung Vascular Stiffening by Lipoxin Reduces Lung Inflammation

It has come to the *Journal*'s attention that there is an error in the article by Meng and colleagues (1), published in the February 2015 issue of the *Journal*. In Figure 7C, an incorrect image was inadvertently included for the middle panel in the third row, which was intended to depict F-actin staining of endothelial cell at 40 kPa substrate treated with LPS for 2 hours. Instead, an image of the 1.5 kPa, 6-hr LPS condition was shown.

The authors have corrected this here in an updated version of Figure 7C; they apologize for the confusion. ■

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