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A proposal for the inclusion of accessibility criteria in the publishing workflow of images in biomedical academic articles

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Abstract

In spite of the importance of visual content in academic publishing, biomedical articles do not offer accessible images, mainly because of the lack of text alternatives. According to a process-oriented accessibility philosophy, this article proposes the use of image-related texts, such as captions or mentions, as text alternatives of images, since they are solutions based on the current practices of authors of biomedical images. We also present two tools created to guide authors in writing comprehensive text alternatives. The aim of this proposal is to increase the opportunities of an actual application of accessibility principles within the biomedical academic publishing.

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Keywords: Accessibility, accessible images,electronic publishing, image alternative text, image description, behavioural change.

1. Introduction

Visual information conveyed by pictures, graphics and all type of images has a pivotal role in complementing the text information. In particular, most of the academic works published in digital format include visual information. Images are a critical source in the communication of science concepts [1], since scientific information is required to

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be “visible” for being understandable [2]. Figures are a very common type of information especially used in full-text biomedical journal articles [3] [4], where they provide essential information [5]. A growing number of clinicians, educators, researchers and other professionals use digital images in their work [6].

However, currently readers with special needs such as blind people are prevented from accessing the visual content of journal articles, as they are not accessible [7]. This fact is particularly relevant in biomedical literature, which is an important source of information for people with visual disabilities [8] [9]. Additionally, scientific publications are required to guarantee an equal access to information for individuals with disabilities for social and legal reasons, and many legal mandates over the world require public and private organizations to provide accessible services and products.

Traditional approaches to accessibility have focused on the conformance with purely technical criteria defined in accessibility guidelines at the end of the publishing chain. As accessibility efforts have historically had a strong failure rate despite the investments made on them [10] [11], new approaches focus on the process rather than on the outputs [12]. According to this approach, the best way to design accessible products is by addressing accessibility issues from the beginning of the product lifecycle. In particular, several organizations working on accessible academic publishing address the need of delivering every native digital content (“born-digital”) in an accessible way (“born accessible”) [13], assigning a pivotal role to the content authors, in our case academic researchers.

An overview of the image publishing workflow shows that accessibility affects different steps in which many actors are involved (see Figure 1).

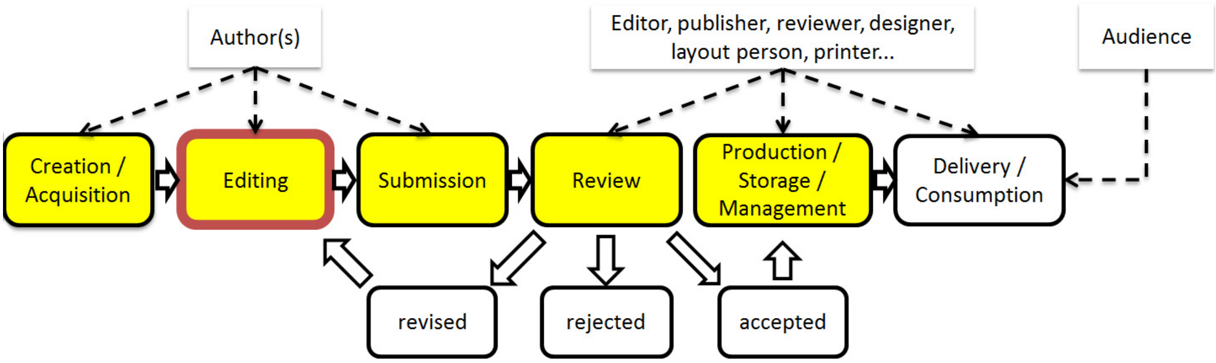

Figure 1 Image authoring workflow including accessibility issues. The Creation, Editing, Submission, Review and Production steps are affected by accessibility issues, the Editing step also by image editing software. Figure created by the authors based on the generic digital publishing chain [14] and the generic peer-review process [15].

Since our aim is to introduce changes in the habits of the authors involved in academic publishing, we followed the Behaviour Change Wheel (BCW) [16], a method for the definition of behaviour change interventions supported by evidences. As a first step, we conducted an interview in Barcelona between September and October 2013 with 22 researchers in the biomedical field and we identified knowledge gaps, process difficulties and key behaviours (see Splendiani and Ribera [17] for a complete report of interview results).

As a second step, we designed a proposal according to the three components of intervention of the BCW model:

- The capabilities of the authors: interventions that should increase their knowledge, skills and understanding on how to make images accessible.
- The opportunity of making accessible images: interventions that should prompt authors to create accessible images by providing them appropriate tools, examples and standards or creating a favorable social context.
- The motivation of the authors: interventions that should stimulate and persuade authors on reasoning about the ethical and legal consequences of making accessible images.

As one of the identified key behaviours was a strict follow-up of the publisher guidelines, in our proposal we mainly assign to publishers the lead role for executing the changes (see table 1).

Table 1 Intervention functions, actions and actors involved in an accessible image workflow.

Component	Intervention function	Action	Actors
Capability	Education	Inform authors about readers with disabilities. Offer simulation tools in order to perceive images as those readers do.	Publisher
	Training	Provide guidelines, examples and evaluation tools.	Publisher
Opportunity	Enablement	Improve image editing tools in order to create accessible images.	Image editing software developers
	Restriction	Introduce validations within the submission process.	Publisher
	Environmental restructuring	Introduce accessibility criteria within the publisher image editing process.	Publisher
Motivation	Persuasion	Inform about disabilities prevalence. Inform about legal requirements.	Publisher
	Incentivisation	Inform about findability benefits. Give rewards to accessible images (time to be published, discounts in color publishing).	Publisher

2. Text alternatives in academic biomedical images

A particular and also very important issue related to image accessibility is the creation and inclusion of text alternatives. Alternative text descriptions are considered essential for conveying the content for certain type of images, such as maps, graphs, math and science images [18]. In biomedicine, the lack of a meaningful text alternative to images is one of the main barriers that limit the access to the content [7].

According to the accessibility guidelines, a text alternative has the function to provide a textual replacement for images, when these cannot be rendered or accessed. The textual replacement must serve the same purpose and present the same information as the original visual content (the image). A short text alternative conveys the purpose and information of the image in a short phrase or sentence, while a long text alternative provides a rich, expressive description necessary to explain the details of the graphic [19].

Writing an alternative text for images in general, and for complex images in particular, is one of the most difficult issues to deal with in the accessibility field for several reasons:

- the task is challenging and time-consuming. It has been estimated that it can take 50 minutes to describe in detail a moderately complex line graph [20].

- It depends on the personal interpretation and the context, since text descriptions are preferred only in cases in which the information is not redundant to the text [18].

Some organizations, i.e. NCAM [21], DIAGRAM [22], UKAAF [23] and ONCE [24], provide general high-level principles on how to textually describe images. They also present detailed guidelines for the textual description of specific types of images, especially for figures displaying data, such as bar charts, pie charts, line charts and scatter plots. In our opinion, these guidelines fall short in their purpose, as they present the following limitations:

- Type of image. Detailed guidelines on how to textually describe technical images with high information such as those commonly found in Medicine and Biology fields do not exist. For example there is no specific guideline on how to describe an X-Ray image.

- Context and audience. Existing guidelines are mainly addressed to a generic audience and intended for common publications, and they are not related to the current practices of academic authors on the process of creating and selecting images for image submission to academic journals.
- The concept of alternative text is unfamiliar to many academic authors [17] and it is not transparent for sighted readers.

How can we address these limitations? A mechanism for providing text alternatives integrated in the current image publishing workflow could be the solution. In order to minimize workflow changes, in this article we suggest the use of image-related texts, such as captions or mentions, in biomedical academic articles as text alternatives.

Previous research [7] has noted that captions and mentions of images are widely used in biomedical academic articles and they have characteristics compatible with long text alternatives, suggesting their suitability as potential alternatives to images. However, the research also showed that existing captions and mentions fall a bit short as they play just a complementary role of the visual information [17]. We think captions and mentions could serve as text alternatives if authors improve their content and include a richer description of the visual content.

In order to help publishers to implement this solution, we envisaged two tools that could be included in the image submission workflow. These tools minimize the extra work of adapting images to special needs requirements and increase the opportunities of an actual application of accessibility principles.

3. Proposed tools

3.1 The "Image Text Alternatives Decision Tree"

The "Image Text Alternatives Decision Tree" (figure 2) helps academic authors on deciding where and how to include the alternative text and to select the appropriate image-related text. The tool was inspired by the image sorting decision tree proposed by the DIAGRAM Center [25] and it was contextualized in the academic publishing workflow.

Based on the previously mentioned interview with authors, five functions for images were identified: illustrative function, summary function, emphasis function, example function and data display function. Once the function is decided, authors are prompted to evaluate the importance of the image content, taking also into account its related text. When an image-related text is considered descriptive enough, the alternative text would be reduced to a brief title for identifying the image, according to the preference of blind and visually impaired users, as some authors confirm [26].

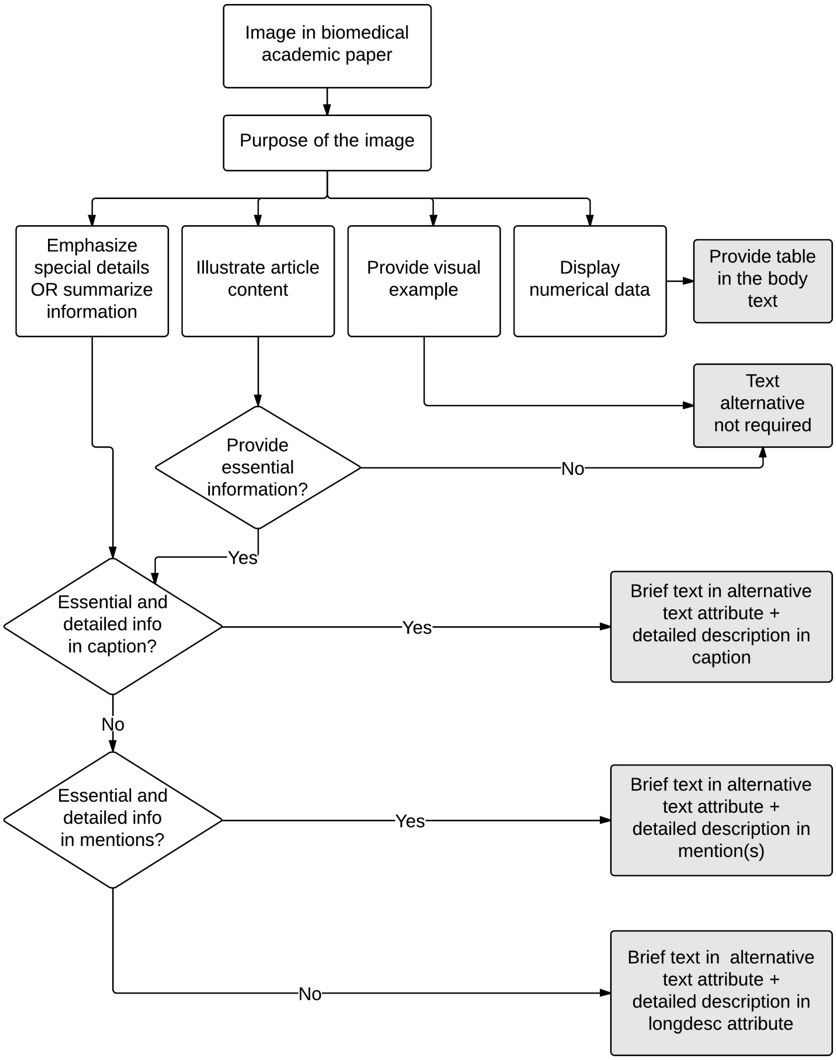

Figure 2 The Image Text Alternatives Decision Tree.

A complete example of the application of this tool is described in Splendiani and Ribera [27].

3.2 Checklist for the content of caption

A checklist was developed with the aim of orienting authors in the creation of suitable, effective and meaningful captions as alternative texts for images. The content of the checklist was based upon common information needed in the caption cited by researchers [17] and recommended by: renowned manuals of style - Chicago Manual of Style (15th ed.), Publication Manual of the American Psychological Association (6th ed.) and American Chemical Society Style guide (3rd ed.) -; the submission guidelines of renowned international publishers in biomedicine - Springer, Wiley-Blackwell, New England Journal of Medicine, Nature and Science –; the guidelines provided by the International Committee of Medical Journal Editors (see table 2).

Table 2 Elements of the figures described in the caption cited by the participants of the interviews and recommended in the bibliography. In the case of medical images, there was no agreement among the participants about the inclusion of clinical information in the caption.

Figure element described in the caption	Cited by the participants	According to manuals and submission guidelines	Apply to
Identify/explain labels	x	x	all types of figure
Abbreviations	x	x	
Color code	x		
Modifications (focus, cropping, etc.)	x	x	
Source	x	x	
Description of variables	x	x	statistical graphics
Unit of measurement of the axis	x	x	
Statistical analysis details	x	x	
Areas of interest	x	x	other figures in Medicine and Biology (photos, etc.)
Magnification rate (scale)	x	x	
Modality	x	x	
Clinical information	*	x	
Cut type	x	x	other figures only in Medicine (photos, etc.)
Reconstruction type	x	x	
Method of staining		x	other figures in Biology (photos, etc.)
lanes in electrophoretic gels and blots		x	

The checklist verifies whether the image is identified and labels or abbreviations are correctly applied and ask the author to explain colors, acquisition apparatus and modifications to the original image and to describe areas of interest and clinical background by answering the following questions:

Questions and recommendations applying to all types of figure:

- Is the image clearly identified? Identify it.
- Does the figure use labels? Explain labels, including symbols, letters, arrows and numbers.
- Does the figure use abbreviations? Explain abbreviations and acronyms.
- Does the figure convey information by colors? Explain the meaning conveyed by colors.
- Has any modification/ adjustment/ enhancement been applied to the figure? Explain the modification, selective digital adjustments and enhancements (cropping, brightness, color, sharpness, etc.).
- Does the figure refer to an external source? Specify the external source and appropriate credits.

Questions and recommendations applying to statistical graphics:

- Does the image include variables? Describe the variables.

- Does the figure show Cartesian coordinates (x and y axis)? Describe the units of measurement of the axis used in the graphic.

- Does the image provide a statistical analysis? Specify essential information related to the results of the statistical analysis showed in the figure, including the statistical significance, the type of analysis, information about the sample, the standard deviation, etc.

Questions and recommendations applying to other figures in Medicine and Biology (photos, etc.):

- Does the figure highlight areas of interest? Explain the areas of interest marked in the image.

- Has a magnification been applied to the figure? Specify the scale of the image.

- Has the figure been acquired by a specific modality? Specify the acquisition modality of the image (e.g. radiography, CT, etc.).

- Is the clinical background included? Describe the clinical background of the image (for example, the clinical profile of the patient showed in the image).

Questions and recommendations applying to other figures only in Medicine (photos, etc.):

- Has a specific cut type been applied to the figure? Specify the cut type of the image (for example, for a MRI the cut can be axial, coronal or sagittal).

- Has any reconstruction been applied to the figure? Specify the reconstruction type of the image (for example, for a MRI the reconstruction can be a rendering 3D).

Questions and recommendations applying to other figures only in Biology (photos, etc.):

- Has any method of staining been applied to the figure? Specify the staining method used in the image (for example, to enhance contrast in a tissue showed in a micrograph).

- Are electrophoretic gels and blots included in the figure? Detail any relevant information about lanes in electrophoretic gels and blots.

An application of the checklist is showed in the following example, according to the following scenario: a researcher has to submit an image for an article in a biomedical journal, as for example the image in figure 3.

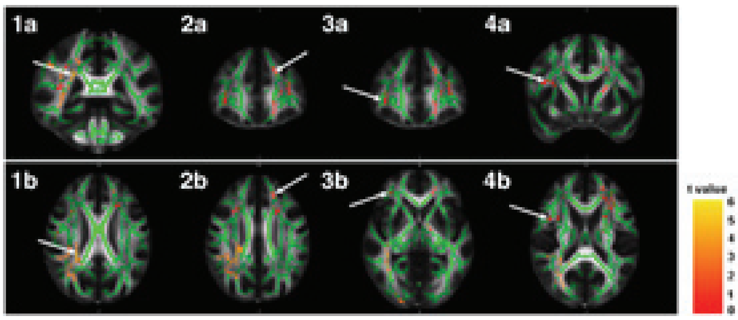

Figure 3 Example of a biomedical visualization for testing the checklist for caption creation. Source: Soriano-Raya et al. [28].

He has created a caption (figure 4) according to the guidelines provided by the publisher of the journal where he wants to submit the article. He wants to check (table 3) if the caption includes all the information required for a meaningful and consistent description of the figure, in order to use it as an effective text alternative.

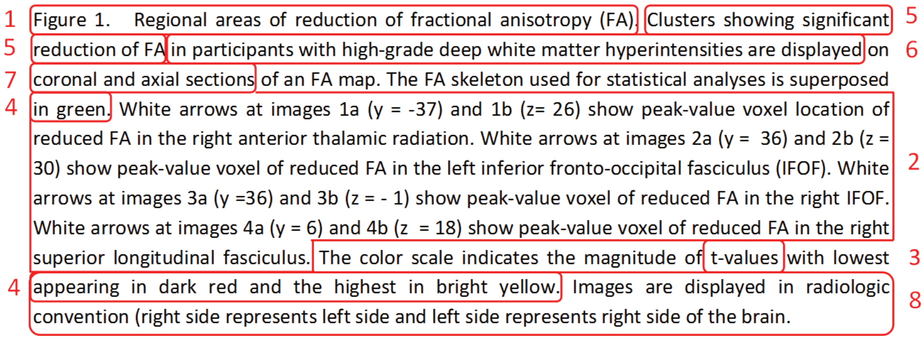
1 Figure 1. Regional areas of reduction of fractional anisotropy (FA). Clusters showing significant 5
5 reduction of FA in participants with high-grade deep white matter hyperintensities are displayed on 6
7 coronal and axial sections of an FA map. The FA skeleton used for statistical analyses is superposed
4 in green. White arrows at images 1a (y = -37) and 1b (z= 26) show peak-value voxel location of reduced FA in the right anterior thalamic radiation. White arrows at images 2a (y = 36) and 2b (z = 30) show peak-value voxel of reduced FA in the left inferior fronto-occipital fasciculus (IFOF). White arrows at images 3a (y =36) and 3b (z = - 1) show peak-value voxel of reduced FA in the right IFOF. White arrows at images 4a (y = 6) and 4b (z = 18) show peak-value voxel of reduced FA in the right superior longitudinal fasciculus. 2
The color scale indicates the magnitude of t-values with lowest 3
4 appearing in dark red and the highest in bright yellow. Images are displayed in radiologic convention (right side represents left side and left side represents right side of the brain. 8

Figure 4 Original caption of the figure 3. The text has been segmented in numbered sections for its identification in the checklist. Source: Soriano-Raya et al. [28].

Table 3 Checklist questions, application and localization of the recommended information in the caption of Figure 4 and specific suggestions for the correct application of the recommended information.

Question	Correct?	Detailed suggestion
Is the figure clearly identified?	Yes (1)	No modification is required.
Does the figure use labels?	Yes (2)	No modification is required.
Does the figure use abbreviations?	No (3)	A modification should be applied: substitute “t-values” by “Student's t-test values”.
Does the figure convey information by colors?	Yes (4)	No modification is required.
Has any modification/ adjustment/ enhancement been applied to the figure?	N/A	
Does the figure refer to an external source?	N/A	
Does the figure include variables?	N/A	
Does the figure show Cartesian coordinates (x and y axis)?	N/A	
Does the figure provide a statistical analysis?	No	An addition should be applied: Provide the p value.
Does the figure highlight areas of interest?	Yes (2 & 5)	No modification is required.
Has a magnification been applied to the figure?	N/A	
Has the figure been acquired by a specific modality (e.g. radiography, CT, etc.)?	No (8)	An addition should be applied: include “Diffusion tensor imaging (DTI) of the brain”.
Is the clinical background included?	Yes (6)	No modification is required.
Has a specific cut type been applied to the figure?	No (7)	A modification should be applied: substitute “on coronal and axial sections” by “on coronal (1a-4a images) and axial (1b-4b images) sections”.
Has any reconstruction been applied to the figure?	No	An addition should be applied: “For details on preprocessing methods see Materials and Methods section”.
Has any method of staining been applied to the figure?	N/A	
Are electrophoretic gels and blots included in the figure?	N/A	

The final figure caption will be as the one showed in figure 5.

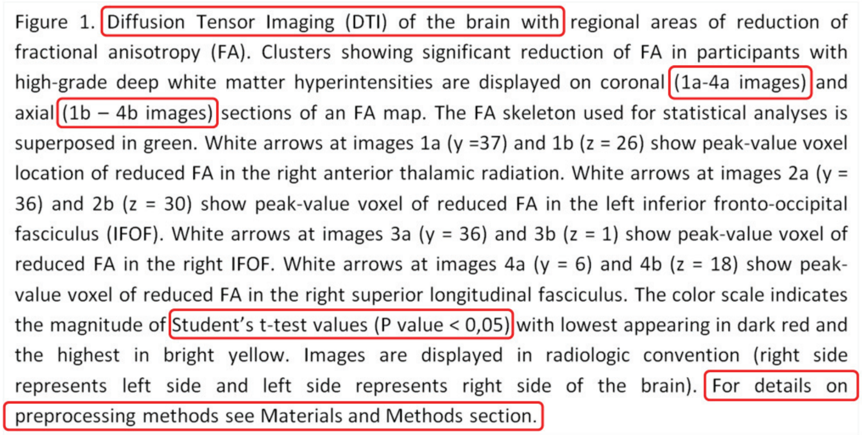
Figure 1. Diffusion Tensor Imaging (DTI) of the brain with regional areas of reduction of fractional anisotropy (FA). Clusters showing significant reduction of FA in participants with high-grade deep white matter hyperintensities are displayed on coronal (1a-4a images) and axial (1b – 4b images) sections of an FA map. The FA skeleton used for statistical analyses is superposed in green. White arrows at images 1a (y =37) and 1b (z = 26) show peak-value voxel location of reduced FA in the right anterior thalamic radiation. White arrows at images 2a (y = 36) and 2b (z = 30) show peak-value voxel of reduced FA in the left inferior fronto-occipital fasciculus (IFOF). White arrows at images 3a (y = 36) and 3b (z = 1) show peak-value voxel of reduced FA in the right IFOF. White arrows at images 4a (y = 6) and 4b (z = 18) show peak-value voxel of reduced FA in the right superior longitudinal fasciculus. The color scale indicates the magnitude of Student's t-test values (P value < 0,05) with lowest appearing in dark red and the highest in bright yellow. Images are displayed in radiologic convention (right side represents left side and left side represents right side of the brain). For details on preprocessing methods see Materials and Methods section.

Figure 5 Revised caption of the figure 3 with the proposed modifications highlighted.

3.3 Validation of the tools

Although a formal validation is beyond the scope of this stage of the research, we contacted two local editors of electronic journals (*BiD: textos universitaris de biblioteconomia i documentació*, ISSN 1575-5886 and *JACCESS: Journal of Accessibility and Design for all*, ISSN 2013-7087) to get a first impression of the main stakeholders. Both publishers considered useful the proposal, give us very positive feedback and offered their respective journals as testbeds.

4. Conclusions

After verifying the lack of appropriate accessibility of images in biomedical academic articles, a new approach is taken following the guidelines of the BCW model. Specifically, the inclusion of a text alternative is reviewed and a solution is proposed: to use article content and captions to provide a full description of the image. In order to make this solution feasible, two tools are presented.

The proposal offers considerable advantages over the solutions currently suggested by the accessibility community: it connects abstract accessibility guidelines to the current publishing practices and converts the creation of alternative descriptions into a part of the content-writing practices of authors. Hence, it is reasonably expected to be achieved.

The solutions presented are mainly theoretical and they have not still been tested on real grounds. Only an initial, positive, assessment with local editors has been done. As future work we plan to test the application of the solutions proposed in this article in an actual submission and publishing process, in order to evaluate the interpretation and application of the guidelines by the authors.

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