 Cite this: *Med. Chem. Commun.*,
2018, 9, 1399

 Received 12th July 2018,
Accepted 12th July 2018

DOI: 10.1039/c8md90036a

rsc.li/medchemcomm

Making figures: are you taking the best approach to maximize visibility?

 Shogo Mori * and Sylvie Garneau-Tsodikova *

You might have heard the expression “a figure is worth a thousand words”. But, how important really is it to make nice, complete, and clear figures? Actually... **extremely** important! Taking the extra time and effort to optimize the quality and visibility of your figures is totally worth it. Figures can most rapidly catch the attention of readers and influence their decision to read or not read your manuscript. This opinion article provides insight into ways to maximize the visibility and impact of your figures! We hope you will find value in the tips provided and can't wait to see all your beautiful figures.

What you put in the literature for the world to see is a reflection of who you are and how you do your science! When writing a scientific manuscript, figures play a critical role in explaining, arguably, in the most succinct and certainly in the most visual way, the ideas and results of your scientific investigations. A figure is a component of an article that can most rapidly catch the attention of readers and influence their decision to keep reading a manuscript or to give up. Actually, nowadays, many scientific journals have table of content images that are meant to inform and capture the attention of readers to ultimately bring them to read your manuscript. The table of content graphic alone could make it or break it for your study. In general, figures can either have a desired positive or an undesired negative impact on readers and a potential to diminish the impact and publication chances of an otherwise important contribution. Figures that are not consistent, that are lacking critical information, or where information is obscured (either due to a small font size or due to a poor choice of colors, such as those indistinguishable by the colorblind, or due to poor resolution), or that are just too hastily put together, could quickly push away readers. It is important to remember that people judge your research by what you write and your figures, so you might as well make the figures the best they can be! The focus of this short opinion piece is on generating figures for publication. It is meant to make you think about ways to maximize the visibility and impact of your figures! The information presented below might seem trivial, but, if you look in the literature, you will quickly notice that many figures contain one or more of the problems that are discussed.

So, what types of figures are we talking about here? Actually, all of them! There are several types of figures that you probably use to depict your work, such as photos, illustrations, graphs/charts, and schemes. No matter which types of figures you decide will best shine light on your discoveries, there are some basic principles that could greatly help ensure that your figures convey the message you want in a way that will be memorable and pleasing to readers:

- **Make figures in final format/size:** remember that if resizing (shrinking or expanding) of your figures is required for publication, some of the quality and visibility of the information presented could, and often will, be lost. In order to avoid losing valuable information, especially when figures have to be reduced in size, why not just make the figures in the size that they will be presented? Most scientific journals use a two-column format and the size of these columns are fairly standard. So, make your figures to fit into either one or two columns so that they will not need to be resized. Doing so will guarantee that your figures are not edited, potentially rendering some of the contents too small to read. In general, your figures should not have to be edited by publishers. Note that many publishers, including the Royal Society of Chemistry, have templates for both articles and chemical structures that you can use to ensure that your figures, when inserted in the manuscript, will fit perfectly into one or two columns with all details clearly visible.

- **Use the font and the font size that are clearly visible and not distracting:** consistent usage of the font and the font size throughout a manuscript can make reading it much more enjoyable. Remember, you are telling a story. Consistency is key to getting your message across. A few points to remember when creating your figures for a scientific audience: (i) use a standard font. Arial is often a good choice, as it is easily readable. Unusual fonts (that may look cute to some) are generally not reader friendly and should be avoided in scientific

University of Kentucky, College of Pharmacy, Department of Pharmaceutical Sciences, 789 South Limestone Street, Lexington, KY, 40536-0596, USA.
E-mail: shogo.mori@uky.edu, sylvietsodikova@uky.edu

manuscripts. (ii) Size 7 (in final format, hopefully you took the principle above into consideration and you are already making your figures in final format) is the smallest one you should ever use. Anything smaller will probably be ignored by readers. Think about this: if readers have to work hard to see the details of your figures, they will be more likely to give up on reading your manuscript. For chemists, also remember to use consistent and appropriate bond lengths and angles when drawing chemical structures.

- **Ensure that symbols in graphs are visible:** in addition to relying on colors to show your data in graphs/charts for example, a great way to emphasize/distinguish data sets is to use various symbols. Symbols are very useful, but they can also be extremely tricky. Symbols in graphs need to be clear and large enough to be easily visible. They need to be distinct enough to avoid any misinterpretation of the data. Even when using colors, the use of different symbols is highly encouraged as some might print your manuscript in black and white. If data are presented with standard deviations, symbols should be selected/presented carefully so that they do not hide error bars.

- **Avoid figures with colored backgrounds and with borders at all cost:** figures with colored backgrounds (especially black or dark ones) are often causes for disasters! If not selected properly, which in almost all cases they are not, they can make the reading experience a torture. When printed (in color or in black and white), the details in figures with colored backgrounds are often extremely difficult to see. Avoid figures with colored backgrounds at all cost! Also avoid bor-

ders around your figures, these only detract from the content of the figure.

- **Align, align, align:** there is nothing more distracting and reflecting of a lack of caring than graphs and schemes with text, symbols, and/or structures that are not aligned properly. Taking the extra time to ensure that everything is neatly presented is totally worth it! Softwares nowadays contain an align function; there are therefore no acceptable excuses for not aligning text on graph axes, chemical structures, text in synthetic schemes, or any other information that can be aligned, all common mistakes often made by many authors. In any given manuscript, all graphs should be presented in a consistent manner (*i.e.*, same overall size; same space between axes and axes labels/titles; and same line thickness). In order to achieve such consistency, authors should prepare one graph in final format and use it as a template for all other graphs. In terms of chemical schemes, authors should ensure that the space around and between text and arrows is consistent and that all arrows are aligned.

While the basic principles above, as depicted in Fig. 1 and 2 are easy to apply, a much more difficult to master concept is that of *using/selecting colors wisely*. The use of colors is often a cause of debate: should one use colors or not when making scientific figures? There are two schools of thoughts: those who believe that colors make figures clear and appealing, and those who give preference to black and white or grayscale figures. Both have advantages and disadvantages associated with them. While black and white or grayscale figures can be used for simple graphs, they often become

Fig. 1 A. An example of a figure containing major mistakes to avoid, including missing information, inconsistency in the font and the font sizes as well as in line thicknesses, undistinguishable symbols and text too small to see, text and structures that are not aligned and/or not centered on graph axes, wrong bond angles and inconsistent lengths in chemical structures, colored background, and selection of colors that may not be visible to colorblind readers. B. A better alternative of panel A, where all the mistakes have been corrected. *Note:* the data presented in this figure were reported in ref. 1.

Fig. 2 A. An example of a 1-column figure made by authors not in final format that needs to be resized by the publisher to fit the journal 1-column format. B. Figure presented in panel A that has been resized to fit one column in the journal. *Note:* you can now see that the text is too small. C. The same figure as in panel A that has been made from the start with the correct font size (Arial 7) and to fit in one column. *Note:* the panels in this figure are inspired by a figure by the authors of this opinion piece reported in ref. 2.

inconvenient and very distracting for more complex figures or images. If selected wisely, colors can greatly enhance the understanding of the data presented. Although selecting colors for figures is a matter of personal preferences and artistic views, one should apply some scientific logic while selecting color schemes. One should also be mindful that some color combinations are indistinguishable to those who are colorblind. Here are some points to consider when selecting colors for your figures:

- **Stick to a few colors and avoid gradients:** if at all possible, the use of too many colors or simple color gradients should be avoided as they tend to be difficult to interpret and could lead to readers misunderstanding the point that you are trying to get across.

- **Use complementary colors:** using complementary colors such as red and green, blue and orange, as well as yellow and purple will ensure great contrast and increase the clarity of your figures. Although clearer and more appealing than combinations of analogous colors, such as red and pink, pale blue and turquoise, as well as yellow and orange, it is important not to forget that a fraction of the population is colorblind.

- **Use colors that are distinguishable by people with colorblindness:** although red and green are complementary colors, there is ~8% of the population that does not distinguish these two colors to different degrees (*note:* blue-yellow color deficiency and full colorblindness also exist, but they are much less common)³ (Fig. 3). Unfortunately, there are

A. An example of colors that colorblind people CANNOT distinguish! **B. A better alternative that colorblind people CAN distinguish!**

Fig. 3 A. An example of a color selection that people with red-green colorblindness (protanopia = lacking or mutated red-sensitive retinal cones; deuteranopia = lacking or mutated green-sensitive retinal cones; monochromacy = full colorblindness) cannot distinguish. B. A better alternative combination of colors that are distinguishable to red-green colorblind people. *Note:* the data presented in this figure were reported in ref. 1. The “colorblindness” and “convert to grayscale” functions in Adobe Illustrator CC 2018 were used to generate the protanopia-type/deuteranopia-type visions and monochromacy depictions, respectively.

some types of figures/images (*e.g.*, fluorescence images of live cells and heat maps) that are very frequently displayed in red and green and are therefore indistinguishable to many readers. It is understandable that these colors are often those of the dyes used for the assays, however, a simple conversion to different colors (that could be additionally presented in supporting materials) could easily fix this problem. Simulation software and websites are actually available to help you visualize how people with different types of colorblindness will see your figures.⁴

• **Use colors that are distinguishable when printed in black and white or grayscale:** it is not easy to consider every type of colorblindness and individual variations in the deficiency. The best way of solving this problem is to use colors that are distinguishable when printed in black and white or grayscale (Fig. 3). Now, you might say, so why use colors at all? As previously mentioned, looking at many different shades of gray (or different black and white patterns) can rap-

idly become confusing. But, as mentioned, both colors and black and white/grayscale figures have their own advantages and disadvantages. It is up to you to decide which will more clearly present your message.

As mentioned earlier, a very important, if not the most important figure in terms of capturing the attention of readers, is the table of content image. Unfortunately, this graphic is often put together too hastily and not much thought is put into its creation. Think about it that way: would you ever go to a movie for which you did not enjoy the preview or that does not have a catchy title (*note:* titles will be the topic of another opinion piece)? Well, the table of content image and your title are the preview for your manuscript. If you want people to read your work, you need to give them a good reason to do so! There are thousands of manuscripts that one can read; the table of content image is a marketing tool to bring readership to your work. Briefly, here are some dos and don'ts to follow when creating a table of content graphic.

Dos

- Apply all of the rules provided above!
- Make *ONE* simple, clear, and appealing figure that fits the dimensions provided by the journal.
- Use colors!

Don'ts

- Don't use a figure from your manuscript.
- Don't use graphs or gels.
- For chemistry manuscripts, do not put too many chemical structures. A few (2–3 at most) should be present in a table of content graphic. Also avoid at all cost specific chemical numbers and specific data associated with a compound (*e.g.*, compound **4b**, MIC = 10 μ M).
- Avoid too much text. A picture is worth a thousand words!
- *Don't make the table of content image too complex!* Making a composite figure with graphics, chemical structures, and cartoons all in one image is definitely not a good way to create a table of content graphic. Remember, table of content images are very small and are not meant to be a complete summary of all the data presented in your study, but instead a window picking the curiosity of the reader enough to lead them to read your paper.

Yes, making good figures is not only difficult, it is actually an art. Just like any other art form, it takes time, discipline, and

a lot of practice to master the art of making figures. We ourselves are still working hard at improving the figures in our manuscripts. So, when crafting your next scientific masterpiece for publication, we hope that after reading this short opinion piece you will ask yourself: am I taking the best approach to maximize visibility?

Conflicts of interest

There are no conflicts to declare.

References

- 1 S. Mori, A. Garzan, O. V. Tsodikov and S. Garneau-Tsodikova, *Biochemistry*, 2017, **56**, 6087–6097.
- 2 S. Garneau-Tsodikova and K. J. Labby, *MedChemComm*, 2016, **7**, 11–27.
- 3 W. E. Thogmartin, *Auk*, 2010, **127**, 460–462.
- 4 Examples of software and websites for colorblindness simulation (*Note*: This might not be a complete list and we would welcome suggestions for others sources), Color Oracle: <http://colororacle.org/>, colorblindr: <https://github.com/clauswilke/colorblindr>, colorbrewer2: <http://colorbrewer2.org/>, Visolve Deflector: <https://www.ryobi-sol.co.jp/visolve/en/>, Coblis: <http://www.color-blindness.com/coblis-color-blindness-simulator/>, Vischeck: www.vischeck.com/, Photoshop and Adobe Illustrator also have incorporated colorblindness simulators.