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EDITORIAL
Getting published: how to write a successful neuroscience paper

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Publishing new theories or hypotheses and the evidence relevant to them is critical to the progress of neuroscience. This is why scientists invest a great deal of their time and energy into crafting and publishing their work. Beyond its importance for neuroscience as a whole, however, publishing is also crucial for a career in academia. A string of impressive publications can propel a young researcher to the next academic stage. A poor track record, on the other hand, is a major obstacle when applying for a grant or a faculty position. Publications are the main output measure of scientists and ultimately, it is by their publications that scientists will be judged.

So, how to write a paper that gets published and will have impact on the field? What are the key ingredients of a successful neuroscience paper? In this opinion paper, we – three young mid-career scientists from different fields of neuroscience, developmental, cognitive and molecular neuroscience – will provide an overview of what is in our view essential for writing a successful neuroscience paper. Specifically, this manuscript is directed at early-to mid-career researchers as an aid to master the many challenges associated with scientific writing and publishing. Obviously, there is not just one way to write a successful paper and additional advice can be found elsewhere (e.g. http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2007_04_06/caredit.a0700046; Gopen & Swan, 1990; Day & Gastel, 2006).

The basis: relevant question, convincing approach, compelling data

One of the first and most critical steps on the way to a successful neuroscience paper is the identification of a relevant research question. This step should be made even before you begin to think about experiments. Once you have a relevant idea in mind, make a hypothesis about the possible outcomes that you expect considering the existing literature. A very important part of this process is to choose correctly the experimental approach that you would then follow. When thinking about the 'ideal' results of the study, take the position of a sharp critic, identify weaknesses of your experimental setup and develop alternative explanations for the data. Extending your experimental design to directly address such alternative explanations will make your arguments stronger and thus increase the impact of your work. Finally, when your experiments are finished, ask yourself whether your data are really robust. Do they support the claims you intend to make? Before starting to write a manuscript, always keep in mind: Publishing is not an end in itself. You should not consider preparing a publication when you have nothing to say, even if this requires you to resist pressures to publish every publishable unit (Larkin, 1999; Colquhoun, 2011). However, if you addressed a relevant research question using appropriate (ideally, novel and innovative) methods and your experiment yielded striking results, start preparing the publication reporting your findings.

Writing the main parts of a scientific manuscript

Strategies

Once you have meaningful and reliable data, the question is which journal to submit the findings to. The so-called top journals value novelty and unexpected findings, but other journals may be more interested in careful, extensive analyses of critical processes. You should also consider what type of access policy the journal supports and what is the audience you want to reach. Nowadays the impact of your work is often maximized by choosing a journal with an open access policy opening your work to all the research community. Many of these journals also offer the opportunity to retain the rights to your work. The increased visibility and the empowerment of the scientist make these journals a very attractive option for submitting your work. The open access publication may involve a fee that can be quite high ('gold' open access) and some funders mandate (gold) open access publication. The decision of which journal you will submit your manuscript to should be made before you start writing because it may have considerable implications for the style and format of the manuscript. Manuscripts submitted to the *European Journal of Neuroscience*, for instance, look usually very different from those submitted to *Neuron* or *Science*. You can find the formatting requirements in the journal's author guidelines. In addition, you can always have a look at recent papers published in the journal you have chosen to get ideas about the style and format. Some general hints for scientific writing are summarized in Box 1.

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Box 1. Ten tips for writing a successful neuroscience paper

1 Have the readers in mind: consider the prior knowledge, the expectations and (potential) interpretations of the reader when writing your manuscript.
2 Be clear: use a clear terminology and structure throughout the manuscript.
3 Be concise: avoid repetition, filler words and present your arguments succinctly.
4 Tell a story: establish tension, make your main message clear and vivid, and end with significance.
5 Choose a short and enticing title: use a title that will attract the reader's interest.
6 Illustrate findings with clear figures: present complex tasks or designs, as well as major findings, in clear and appealing graphics.
7 Don't get lost in the data jungle: present data in a logical order and tell the reader what the statistics mean.
8 Write a clear and compelling discussion: discuss the major findings, their implications and relevance to the field.
9 Craft a strong cover letter: highlight your main findings and argue why your paper fits the target journal.
10 Get feedback and revise your paper several times: before submitting your paper to a journal, ask colleagues for feedback and go over your manuscript again and again. There is always room for improvement.

There are different ways people approach the writing of a paper and there are even considerable differences between fields. During your career you will develop your own strategy but we would like to highlight two ways of writing research papers. Some researchers like to first start by drafting the main figures of the story even before the manuscript is finished and as the data is generated. The drafts of the figures will serve as a 'storyboard' of your paper and will also allow you to identify potential holes. If your paper has multiple authors this would be a good moment for discussing results and organizing ideas. Defining a working title for the paper is also a great way to get everybody on the same page regarding what the paper will be about and what would be the main claim. It will help you to focus. Do not worry about the title not being concise and catchy at this stage. It is just a working title. You will refine it before you submit. Having the figures helps immensely. Now you 'just' have to describe what the figures show. After the results section, you can then write the discussion in which you develop what the results mean and what their relevance is, contrasting with the known literature and background. Leaving the writing of the introduction until the end helps as you will have a very good idea of what your story is about and what the reader needs for understanding the manuscript. So what about the materials and methods, the figure legends and the figures? For the figures and legends you can work on them while you write the relevant section in the results. It is also a part that can easily be done by your collaborators, especially if they generated the data. The same goes for the materials and methods. The last tasks would be to write the abstract, to think about key words, which may guide editors in their choice for specific reviewers, and to refine the title to make it clearer, short and catchy.

As mentioned, there are various approaches to scientific writing that depend also on the field. Many experienced scientists, especially in the cognitive sciences, use a different strategy than outlined above. They often begin with the methods section, which makes it easy to get the writing started. The results section is written next, before turning to the introduction and discussion, which need to be particularly closely linked. What is best for you? Discuss with your mentors and colleagues. Ask yourself what the challenges and the structure of your manuscript will be and play around with different strategies. Everybody has their own style. You need to find out what works best for you. Independently of the strategy you use, for a non-native English researcher, we strongly recommend that your manuscript is read and corrected by a native English speaker as this really makes a difference when the editor and reviewers read your paper.

Introduction

The aim of the introduction is to describe the scientific problem, to provide the background of the study and, not to forget, to stimulate the readers' interest. Typically, the organization of the introduction is funnel-shaped. It starts with a rather broad statement that most people can agree to. From then on, the introduction gets more and more specific leading ultimately to the particular hypothesis. The hypothesis should not come out of the blue but needs to be developed step by step. Therefore, arguments should be arranged in such a way that the reader can already see the aim and hypothesis of the research appearing on the horizon before the hypothesis is finally explicitly stated. In the process of developing the hypothesis, the relevant literature needs to be introduced. However, be concise as many journals have a strict limit of 500 words or less for the introduction. To bolster your arguments, original papers are generally preferred over review papers. Citing (mainly) reviews is a common but lazy habit and does not give due credit to those who made the discoveries. The introduction closes usually with a brief overview of the methods that were used to examine the research question or hypothesis and, depending on the journal, the main results found.

Materials and methods

The main purpose of the materials and methods section is to enable the reader (i) to evaluate what you did and (ii) to replicate the study in exactly the same manner. Thus, it is essential to describe clearly and precisely how the experiments were performed. Sometimes it is also necessary to mention why a change in a standard procedure was done. Here again, different fields have a different way of describing the methods used. Look at the materials and methods of papers in different fields and you will quickly notice that they are not all organized in the same way. In cognitive sciences, the methods are often written in past tense and in chronological order. A typical methods section starts with the description of the subjects and experimental design, followed by the techniques that were used, a description of the experimental procedures and an overview of the quantification and analyses performed. In cellular and molecular neuroscience, however, methods are rarely described in chronological order but by the type of method used and by the order that they were performed in the manuscript. If a new technique or method was used or a complex design with many groups or time points of measurement, it is often helpful to visualize the task or design in a figure. If a task or procedure has been described in detail elsewhere, it is reasonable to refer the reader to this literature and keep the description brief. Also note that some journals are switching to a model in which the classic short materials and methods section is accompanied by an extensive and detailed methods section provided as supplementary material. The standards and

rigor of this part of the manuscript have been clearly increasing and rightfully so.

Results

The results section serves to present the results of your research and hence the evidence for your arguments. It is not necessary to report every detail of your results, focus instead on those results that are relevant to your hypothesis and interpretations. Summary statements may help to point the reader to the relevant data. In general, take the reader by the hand and guide them through your results. You can refer to results in figures or tables and describe what can be seen. Here, it is very important that the results section is more than just a string of statistical findings. For example, in a (fictitious) paper on the influence of stress on memory for neutral and emotional items, the results may read as follows:

> The ANOVA showed a significant main effect of condition ($F_{1,94} = 3.52$, $P < 0.01$) and a significant condition × emotion interaction ($F_{1,94} = 4.79$, $P = 0.02$).

Although this may be correct and accurate, if several of these sentences appear next to each other, the results section is not very pleasant to read. An alternative could be:

> Overall, stress impaired memory performance ($F_{1,94} = 3.52$, $P < 0.01$) and this effect was most pronounced for emotionally arousing items (condition × emotion interaction: $F_{1,94} = 4.79$, $P = 0.02$).

Linking statistics and content makes the results more comprehensible and it allows you to tell your story. Major findings should also be displayed in figures, which need to be clear, easy to understand and nice to look at (see below). As a general rule, key findings should be presented in figures, whereas relevant but less important data can be shown in a table. For less important findings, it is often reasonable to give summary statistics in the text. Primary analyses, however, require exact statistics. In order to prevent the reader overlooking key findings, it is useful to present these findings in more than just one sentence.

Discussion

The purpose of the discussion is to provide answers to the questions posed in the introduction, based on the data reported in the results section. In terms of its structure, the discussion follows the opposite logic to the introduction. In contrast to the introduction, the discussion moves from the specific to the general, starting with the specific data found in the manuscript and ending with the broader implications of the findings to the field. More specifically, the first paragraph of the discussion states the primary objective of the study again and summarizes briefly the main findings. The following paragraphs then discuss each of the key findings separately, beginning with the most important result. How does the finding relate to the existing literature? How can the finding be explained? Are there alternative interpretations to the one favored and do the data speak to these alternatives? Address all of these aspects but be concise, brief and specific. Refer to weaknesses or potential limitations of the study, if there are any, and discuss their implications for the interpretation of the results. However, when doing so, avoid an apologetic tone. The final paragraph is again dedicated to the major finding, discussing its broader implications and relevance. Do not worry about reiterating the main finding throughout the discussion. In this way you can make sure that it does not get overlooked.

Figures

The figures are a key part of most papers, especially in the molecular and systems neurosciences, and that is why we want to single them out in this section. They are used not only to make a specific point but to give your colleagues the possibility to make their own conclusions based on your original data. Also, given that scientists are flooded with papers and there is less and less time to read, your colleagues are more and more likely to just skim through your paper. They will often rely mainly on the figures to make their opinions about the paper. It is therefore essential that you put the same effort you put into choosing the wording of the text into crafting your figures. For example, do not use the raw output of Matlab but use Inkspace or Illustrator to remove visual clutter from your graphs. Focus on the necessary minimum to understand the data. Also pay attention to consistency; use the same color schemes (obviously appropriate for color blind people), always the same size and font of text, and importantly, align everything neatly. The trick is to avoid clutter and make the figure look calm and organized. Show that you put some effort into this. Also, if necessary, use drawings to illustrate complicated experiments. In short: you want your figures to be as beautiful as the data being conveyed and you want the visual language to convey the same clarity as the arguments you are bringing forward. Obviously make sure not to tamper with the data! Adhere to the standards for image and data integrity. If you are in doubt check the journal guidelines or ask people with more experience.

You may argue that scientists are not trained to be graphic artists. But if you think a bit about it, you will realize that it is as much part of communicating your work as writing. As much as we can learn to write good prose we can learn to use the proper visual language. We recommend having a look at the available literature. More specifically Edward Tufte's 'Visual Explanations: Images and quantities, evidence and narrative'. An excellent, more hands-on introduction to data visualization and graphic language for scientists that was published as a series of small articles in Nature methods can be found here: http://blogs.nature.com/methagora/2013/07/data-visualization-points-of-view.html

Pique curiosity: title and abstract of a manuscript

How do you identify a relevant paper in your field? Most likely, you will go through the table of contents of journals relevant in your area of research or use a search system such as PubMed and first check the titles of the articles. If a title sounds interesting, you read the abstract and based on the abstract you decide whether or not you read the whole paper. That is the way most researchers identify papers of interest and this underlines the crucial importance of the title and abstract of your paper. The title of your paper should be as short as possible, usually not more than 15 words. It should be precise, catchy and focus on the main message of your paper. Use the active voice in the title as this makes a stronger statement. Nice examples are 'Neurons in medial prefrontal cortex signal memory for fear extinction' (Milad & Quirk, 2002) or 'Sleep inspires insight' (Wagner *et al.*, 2004). Titles such as 'Effects of…', 'A study on…', or 'Examining the…', however, are clunky and will not do the job of attracting people's interest.

As with the title, the abstract needs to be brief, precise, and enticing. The aim of the abstract is to present a short version of your manuscript. Thus, it should include information on the background of your study, your aim or hypothesis, the methods used, the key findings as well as the implications of the research. The word limits

for abstracts can be as low as 100 words, forcing you to be very concise. The abstract and title are written at the very end, when the main parts of the manuscript have been finished. They are certainly among the most difficult parts of a paper. Think carefully about them. The abstract and title have a critical influence on editors and reviewers as to whether they deem your paper suitable for publication and on whether your paper will reach the audience you are targeting.

Communicating with the editor: the cover letter

When submitting your manuscript, it is usually accompanied by a cover letter. This cover letter is not just a formality; it is an important document that can decide whether your manuscript is sent out for review or not and it should be prepared (at least) as carefully as the manuscript itself. Some journals have specific requirements for information that is to be provided in a cover letter, for example, related to potential conflicts of interest or the originality of the manuscript. Read the author guidelines carefully to make sure that your letter includes all the required information. In any case, the cover letter is your chance to communicate directly with the editor and to lobby for your manuscript. Therefore, your cover letter should capture attention, highlight your main findings and argue why your paper is timely and a good fit for the target journal.

In general, the cover letter should be written like a formal business letter, including your contact details and addressing the editor in a formal manner. Begin your cover letter with the title of your manuscript and the names of the authors. Then, describe in one or two paragraphs the background of your research, the main findings and their relevance. However, remember that the editor cannot be an expert in all topics covered by a journal, so avoid technical jargon and describe your findings in a clear and easily accessible manner. This part of the cover letter should end with your argument why the journal should publish your paper. Here, it is not sufficient to simply state that your findings are 'novel and important' (of course, all our findings are novel and very important). Be specific. For example, you could refer to the scope of the journal as outlined in the journal's homepage. The cover letter might also be the right place to recommend suitable reviewers and to name researchers who should not review the manuscript. Although, editors are in no way bound by such suggestions, they are often appreciated. Most journal online systems have a special section where you can recommend or oppose reviewers and you should definitely use the online system for your suggestions as it can be quite annoying for editors to refer back to the covering letter and manually keep track of the names when selecting reviewers. Furthermore, note that in general the editor reads the cover letter herself/himself and reading a lengthy cover letter can be pretty tiring. So, be concise and avoid redundancy. In most cases, a one-page cover letter should be sufficient to enable you to put your case across and convince the editor to consider your paper for publication. Finally, use the 'author checklist' to ensure that you have done everything you need to do during the submission process. Most journals insist that the names and contact details of all authors are supplied in the online system as part of the submission process, so authors should make sure that they have up-to-date email addresses for all of their co-authors (even those that have since left the research group). This is critical, as papers cannot proceed to review without these details. Moreover, for some journals it is also very important that you state, at some point in the manuscript (mostly in the methods), explicitly that you have ethical permission (and adhere to local and national regulations) for the experiments on animals or humans and name the local and national ethical review bodies. You can also refer to this statement in the cover letter then. Finally, a critical thing that refers to the cover letter as well as to all other parts of the manuscript is to carefully proofread your manuscript (including the reference list). A poorly proof-read paper with many errors in it leads reviewers and editors to ask the question (whether fairly or not): 'If they are so sloppy in the presentation of their work, how careful and precise were they when they performed the experiments?'. This is certainly an impression you definitely do not want to create. When you are sure that everything is complete and in good shape, hit the submit button and go to the pub!

The last mile: revising the manuscript

It is very rare that a manuscript gets accepted in exactly the way it has been submitted. Almost all manuscripts require some kind of revision and when submitting a manuscript to a journal, the invitation to submit a revised version of your manuscript is what you can hope for. Usually, you have between 2 weeks and 3 months to submit the revision, depending on the specific journal. Start working promptly on the revision and do not wait until the very last minute as a revision might take quite some time. The process of revision begins with the specific comments you get from the reviewers (and possibly the editor). These comments are the basis of your revision. Go through all comments and think carefully about how to respond to each of them. It is important to show that you take the comments seriously. Write a response letter in which you cite all comments of the reviewers and respond to each comment separately and clearly. Try to understand each point that the reviewer is making and answer every comment directly and specifically. Typically, a reviewer expects you to change the manuscript in some way, for example, to rephrase a sentence, to add some analyses or to clarify an issue. These changes should be marked in the manuscript and their exact location (page, line) should be indicated in the response. Dealing with the reviewers' comments is not always nice and easy to do as they criticize with more or less emphasis, what you have done and put a lot of effort into. Stay positive and open-minded. It often helps to consider the reviewer as a partner with whom you will work together to improve the manuscript rather than as an opponent you have to argue with. Also, do not forget that reviewers are volunteers who are not paid for their job and that the peer-review process is at the very heart of the scientific method and ensures scientific quality. Thus, you should value their work and respond politely to their comments. Even if you disagree with a reviewer's comment, respond respectfully and argue in a matter-of-fact style why you did what you did and why you think that the changes requested by the reviewer are not reasonable (although it will appear strange if you refuse to follow the majority of the reviewers' comments). Reviewers may also propose additional experiments with the aim of improving the manuscript or strengthening a point of the results. If you agree with the case made by the reviewer, you should seriously consider conducting the experiments as the effort and new data will be very well seen the by reviewer. However, if the additional experiments suggested by the reviewer are of very limited additional value or are clearly beyond the scope of your paper (of course, one can always do more experiments), you should carefully argue why, in your view, the additional experiments are not reasonable. Furthermore, sometimes there may be also conflicting statements from two reviewers. If this happens, clearly state your position and address the conflicting positions in your comment. In extreme cases, you may also contact the editor and ask for advice on how to solve this issue.

While most reviewers are constructive and well-meaning, focusing on the improvement of the manuscript as a whole, some reviewers can be rather destructive and harsh. Dealing with those reviews is particularly challenging. Although such reviews can be quite annoying, it is advisable to do your best to address the raised issues as far as possible. Do not reply in the same impolite tone the reviewer chose (although this requires some self-control!). As with the initial submission, the revised manuscript and the point-by-point response to the reviewers' comments are accompanied by a letter to the editor. The purpose of this letter is twofold: it should express your gratitude for the invitation to submit a revised version of the manuscript and it should succinctly outline the changes you have made in response to the reviewers' comments. If the comments of a reviewer have been particularly irritating or inappropriate, you may also comment on that in the letter to the editor. However, you should keep this comment rather factual and never make any personal comments on a reviewer. The latter is generally inappropriate and, in addition, you cannot know who the reviewer is, unless the journals operate open peer review which only few do so far. Perhaps it is a close friend of the editor or even their spouse. Finally, you should also thank the editor for their support in the letter accompanying your revision.

Even in the unfortunate case that the editor reaches an unfavorable decision and you are not invited to re-submit your (revised) manuscript, it is advisable to revise your manuscript along the lines of the reviewers' comments, as far as is possible and reasonable. This may improve your paper and increase its chances of success when submitting the paper to another journal. It is not unlikely that the same reviewer will review your manuscript again in the future, especially if you decide to transfer your manuscript reviews via the neuroscience peer review consortium to another journal. If you have not made any changes in response to the reviewers previous comments, this will be pretty disappointing for the reviewer (remember, it took them several hours to review your paper), thus significantly reducing the likelihood of getting a more favorable decision on this second run. In sum, revising your paper often costs a lot of effort and it may require challenging your previous work, it is, however, a critical step in improving the quality of your manuscript and ultimately in getting your paper published.

What is a successful neuroscience paper?

Neuroscience is among the scientific fields with the highest output rates (Larsen & von Ins, 2010), producing more than 50 000 papers per year (PubMed search with the terms 'brain' or 'neuro' for 2014). How can your paper been seen amongst such a vast number of papers? More generally, what makes a neuroscience paper successful? Some people seem to define the success of a paper based on the impact factor of the journal in which it was published. According to this logic, a successful paper is one published in one of the known high-impact journals, whereas a paper published in a journal with a lower impact factor would be considered less successful. The impact factor might be useful as a measure of a journal's impact, but it is not at all suited to evaluate individual authors or research papers. Using the impact factor of a journal as the criterion for the success of a research paper can be destructive and frustrating, especially for young scientists, as acceptance rates in high-impact journals are very low and the papers accepted in these journals are not necessarily better than those published in other journals. Thus, a paper's impact is by no means to be confused with the impact factor of the journal it was published in. An indication of the actual impact of a paper can be seen several years after publication, for instance, in the number of citations the manuscript got, the number of views or downloads. In our view, a paper is likely to have impact and thus to be successful if it presents novel data or ideas in an accurate, concise, and comprehensible manner to fulfil the major objective of every scientific publication: to increase the readers' knowledge of the specific subject and to inspire new ideas.

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About the authors

The authors are scholars of the FENS-Kavli Network of Excellence, a network of young neuroscientists, with the goal of fostering exchange – scientific or about science policy - between excellent junior/mid-career neuroscientists who are either currently working in Europe or received their academic training in Europe.

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