 doi:10.20944/preprints201810.0181.v1

A Democratic Method and Index to Rationalize Authorship Decisions and Determine the Order of Authors

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Keywords: Authorship contributions, Authorship Score, Authorship Conflicts, First Author, Decision Making, Bibliometry

ABSTRACT

Disputes on authorships or the order of authors on publications are among the most common conflicts in science, particularly where multi-author papers have become the norm. Here, I propose an adaptable and generalizable method to rationalize and democratize decisions about authorships, which can be applied in diverse scientific areas. In the process, the authors of a manuscript collect, discuss, score, and weight their contributions to the final manuscript. The decision process is assisted by a simple spreadsheet-based "authorship matrix", which helps to break down the complexity of different contributions and their importance. The matrix generates a score *s* describing the percentage of the author's total contributions and can be used to determine authorship and their order. The transparency and simplicity score *s* can reduce conflicts and thus increase productivity in collaborations.

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Introduction

Publications increase the visibility, funding prospects, prestige, and career opportunities of scientists. In this context, bibliometric parameters such as the number of their publications, citations, the *h*-index[1] or the impact factor of scientific journals have gained a lot of importance. At the same time, multi-author papers have become the norm in many fields, making it increasingly difficult to assess the contribution of each author.[2–4] Many journals now require specifying author contributions (such as conception, experiments, writing etc.), but again, the list of authors for a specific contribution is often long. In addition, an informal code behind the authorship order exists that can vary between scientific disciplines or countries.[2] Often, the first author did most of the practical work and the last author is the principle investigator and corresponding author. Where this is the case, the first and last positions are more prestigious than positions in the middle and are often disputed between colleagues.[5] Such authorship order conflicts can become very emotional and have the potential to disrupt the group climate and collaborations. When the first authorship dispute occurred in my group, I was looking for a way settle it in a rational way. The point systems proposed by Schmidt[4] or Kosslyn[6] are primarily designed to determine who becomes an author or not on a paper, and seemed too little flexible as the categories for possible contributions (e.g. conception, experiments or writing) are fixed and fixed points are allocated to each category. However, the importance of each category may vary substantially from paper to paper. Moreover, the decision process could be perceived as undemocratic or not transparent, if the PI makes such decisions and the decision can always be questioned due to different opinions on the importance of a specific contribution. In fact, almost 70 % of the coauthors of multi-author manuscripts disagree with the corresponding author's perception of individual contributions.[7] This discrepancy may partly from the challenging and complex cognitive task of self-reporting.[8] To increase the acceptance, transparency, and quality of authorship decisions and their interpretation, it would therefore be desirable to formalize and democratize the decision process. Here I propose a decision making protocol assisted by an adaptable "authorship matrix", which generates a single number, the contribution score *s*, which describes an author's total contributions to a manuscript in percentage.

Generating the Score *s*

To finalize the list of authors and their order on a publication, all, or at least the most important authors of a study (for example all potential first and last authors), come together, discuss their contributions and create an authorship matrix (Fig. 1). Authors with minor contributions can also be included to provide an external opinion, and collaborators can be added to the discussion by phone or a video conference.

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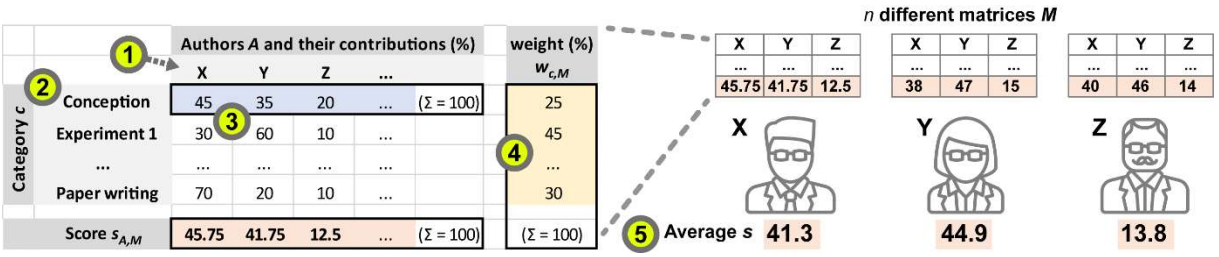

Fig. 1. *Example authorship matrices for three authors (X, Y, Z). An empty matrix is created (steps 1-2) and duplicated. Then all authors fill in points (step 3) and weigh categories (step 4) in their own matrix* M *to generate the contribution score* s *(step 5). In this example, author Y could become first author, as she has the highest score s.*

Such a matrix can easily be generated and adapted in a spreadsheet program within minutes and is used to determine the score *s* with the following steps (see Fig. 1).

(1) Each author *A* (X, Y, Z…) is entered in the columns of an empty matrix.

(2) Next, relevant categories of different contributions to this manuscript are identified are the rows of the matrix. Categories can include conception of the project, different experimental contributions, simulations, data analysis, paper writing, funding acquisition, or student supervision.[4] This empty "parent" matrix is duplicated and then every matrix *M* is filled out by each of the *n* participating authors individually.

(3) i) Now, all authors describe their own contribution to the first category.

ii) Next, every author distributes 100 points or "contribution percentages" $p_{c,A,M}$ (blue) in that category among all authors in their own matrix *M* that reflects that author's contributions best in their subjective opinion.

iii) All authors can see everyone else's points. Optional: Extreme opinions can briefly be discussed and authors can adjust the numbers in their own matrix. Here some moderation of the PI may be helpful. Steps i-iii are repeated for all remaining categories.

(4) Then, each author weights the importance of each category for the final paper (category weight $w_{c,M}$ in %) in their matrix. For example, an experiment may have been particularly challenging and time-consuming in an author's opinion, so that they can weight contributions to that category higher than other categories.

(5) Each individual matrix *M* generates the contribution score $s_{M,A}$ for all authors A reflecting their total contribution to the paper in % (red). The final contribution score *s* of each author is determined as the average over their s_A in an the individual matrices, or

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$$s = \frac{1}{n_M} \sum_M \sum_c (p_{c,A,M} \cdot w_{c,M} /100)$$

In my field and group, the student/postdoc with the highest score would become the first author and the other (non-PI) authors are sorted according to their contribution scores. Principle Investigators / corresponding authors are moved to the end of the list. If the corresponding authorship is in question, the PI with the highest score becomes (last) corresponding author. If scores s of several authors are very close, first or corresponding authorships may be shared if permitted by the journal. Additionally, a reasonable minimal *s* could be agreed upon to justify an authorship.

In addition to establishing the matrix as a tool and sharing the concept with all group members, we agreed on a few additional rules to make the method most effective.

1) We do not discuss authorship orders before a manuscript is ready for submission.
2) We determine contribution scores with the authorship matrix for all multi-authorship papers, even if there is no open dispute about the order.
3) If a manuscript goes through extensive revisions, the authorship matrix / orders can be adjusted before resubmission.
4) In collaborations with external groups, I try to agree on using the matrix for a potential future publication or inventor shares on patents at the beginning of a collaboration.

Discussion

Using this method to determine *s* has a number of benefits. It is inherently difficult to compare someone's time devoted to the project, their experience or efficiency, or the originality of their ideas. These issues can be discussed when assigning the contributions points p_c or the category weight w_c, but in the end, each author can make their own decisions. As everyone sees everyone else's scores, extreme points / opinions are discussed, and authors may adapt a somewhat more realistic view. Even if no consensus is achieved, extreme positions are averaged out in the end.

I also like getting a final overview on who did what. I was at times surprised that someone did more or less, than I actually thought, or that I almost forgot someone's contribution to an early stage of the project.[7,8] Students get a chance to critically assess their work, and get feedback and acknowledgement from collaborators and their supervisor. To know how the decision process is going to be, and that it will be fully transparent and somewhat democratic, prevents or reduces potential tensions throughout the collaborative project. It gives credit to less vocal team members, may help to reduce underrepresentation of female

scientists in publications,[9] and encourages collaborations. The discussion and decision process is relatively fast; in our experience, it takes about 30 minutes.

As the authorships are only determined before submitting a manuscript, everyone is likely to stay motivated throughout the writing process. It makes of course sense to assign someone as the lead for a new project, but sometimes students or postdoc leave before a project is finished, or new people enter a project and give it an unforeseen new direction.

The matrix-assisted method proposed here helps to break down the complexity, and structure the decision process, and could therefore be a valuable tool for ombudspersons. Finally, journals or funding agencies awarding fellowships may in future not only ask to specify author contributions, but also their contribution scores *s*. to increase transparency.

I realize that many will object to this method and the score *s* as it could inevitably end the common practice to include authors that did actually not intellectually contribute to a paper. Maybe some have also developed other ways to deal with authorship conflicts, or it does not make sense in their discipline or for their particular manuscript. In any case, democratizing and rationalizing authorship decisions using the score *s* could be very useful to those who want to settle or reduce authorship conflicts in their groups, creating a more collaborative, professional and productive working environment.

SUPPLEMENTARY FILES

Example of an authorship matrix (Microsoft excel file)

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