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Opinion Paper

The need to quantify authors' relative intellectual contributions in a multi-author paper

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ABSTRACT

Measuring the contribution of each author of a multi-author paper has been a long standing concern. As a possible solution to this, we propose a list of intellectual activities and logistic support activities that might be involved in the production of a research paper. We then develop a quantitative approach to estimate an author's relative intellectual contribution to a published work. An author's relative intellectual contribution is calculated as the percent contribution of an author to each intellectual activity involved in the production of the paper multiplied by a weighing factor for each intellectual activity. The relative intellectual contribution calculated in this way can be used to determine the position of an author in the author list of a paper. Second, a corrected citation index for each author, called the T-index, can be calculated by multiplying the relative intellectual contribution by the total citations received by a paper. The proposed approach can be used to measure the impact of an author of a multi-authored paper in a more accurate way than either giving each author full credit or dividing credit equally. Our proposal not only resolves the long standing concern for the fair distribution of each author's credit depending on his/her contribution, but it will also, hopefully, discourage addition of non-contributing authors to a paper.

1. Introduction

Scientometric evaluation of an author may account for a significant part of a scientist's administrative reputation (Fowler & Aksnes, 2007) and may be used to support promotional strategies (Hyland, 2003). However, the need for the fair evaluation of each researcher's contribution to allocate appropriate credits using the citation record remains a challenge (Allen, Brand, Scott, Altman, & Hlava, 2014; Hodge, Greenberg, & Challice, 1981; Kennedy, 2003) as has been previously recognized (Hunt, 1991; Laurance, 2006; Sekercioglu, 2008; Verhagen, Wallace, Collins, & Scott, 2003). At the same time, the number of multi-author papers is on the rise (Regalado, 1995; Johnson, 2006; Wuchty, Jones, & Uzzi, 2007). We, therefore, consider it important to develop a more quantitative tool that appropriately represents the intellectual contribution of each author of a multi-author paper. This, in turn, can be used to determine each author's position in the list of authors and to allocate fair credit for citations to the paper according to each author's actual contribution. We argue that a reasonable way to meet that need is

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to devise a quantitative tool that would consider both the number of authors and their respective intellectual contributions to the paper.

To begin to address this challenge, we first propose a list of intellectual and logistical support activities all or some of which might be involved in the production of a peer-reviewed research paper. Intellectual activities include, but are not limited to the conceptualization of the research idea, preparing the literature review, and writing the manuscript. Similarly, some of the logistical support activities include providing the laboratory facilities and/or necessary funds, and language editing. Given the possibility that different intellectual activities might have different impacts on the production of a paper, depending on the nature of the actual work done as well as on the expectations of the discipline(s) and of the journal selected, we also propose using weighing factors to measure the relative importance of each relevant intellectual activity. We then propose a quantitative tool to evaluate the effort of each author for a given paper in relation to the effort of the other coauthors. This value is defined as the relative intellectual contribution (IC^r) of each author for a given paper. Using IC^r, we also propose a simple equation to calculate a corrected citation index, called the T-index, for each author instead of giving all authors either full credit or sharing the credit equally as have been previously proposed (a comprehensive review of these issues has been provided by Waltman (2016)). We argue that this corrected citation index of an author can be used in conjunction with any scientometric index such as the *h*-index (Hirsh, 2005) to give a more precise estimation of the impact of any one author.

2. Background

Authorship of a paper provides intellectual credits to each individual included among the authors. These credits are commonly summed based on the number of papers an individual has authored and then further evaluated using various scientometric measures that depend on the number of citations received by the paper(s). Citation impact indicators currently either use full counting of each citation for each author (also known as whole, integer, or total counting) or fractional counting, where the credits for a publication are fractionally allocated, most often equally, to each of the authors. The full counting approach has an undesirable inflationary effect, since citations received by publications with multiple authors are counted multiple times.

Detailed discussions on the scope and comparative preferences for using different fractional counting approaches are provided by Gauffriau, Larsen, Maye, Roulin-Perriard and Von Ins (2007), Waltman and Van Eck (2015), and Waltman (2016). With fractional counting, each author can either receive an equal share of the citations or different shares depending on the number of authors as well as the position of the author in the author list assuming the order of authors was selected based on contribution. Therefore, compared to full counting, some form of fractional counting better represents the contribution of each author, with the fairness depending on how the credits are being allocated. At the level of evaluating individual researchers, however, the preference for either the fractional or the full counting method is still being debated (Abramo, D'Angelo, & Rosati, 2013; Abramo et al., 2013; Aksnes, Schneider, & Gunnarsson, 2012; Egghe, 2008; Gauffriau & Larsen, 2005; Huang, Lin, & Chen, 2011 ; Waltman & Van Eck, 2015). The simplest approach to distributing the share of credit is to give full credit for a publication to the first author (first-author counting) and no credits to any other author. The unfairness of this approach is obvious.

Approaches that unequally share credits among the authors are generally based on assigning a weighing factor to each author depending on the number of authors and the position of the author in the author list. Typically the highest weight is assigned to the first author, followed by a decreasing weight to the subsequent authors. A number of different algorithms have been introduced including harmonic counting (Hagen, 2008, 2010, 2013, 2014a, 2014b, 2015; Hodge & Greenberg, 1981; Jian & Xiaoli, 2013), arithmetic counting (Abbas, 2011; Egghe, Rousseau, & Van Hooydonk, 2000; Van Hooydonk, 1997), also known as proportional counting, geometric counting (Egghe et al., 2000), and axiomatic counting (Stallings et al., 2013). A list of these counting approaches and a discussion of their comparative merit is provided by Waltman (2016). However, such approaches do not consider the possible greater contribution of group leaders, who in many cases are listed as the last author (Kosmulski 2012). As a possible solution to this problem, Aziz and Rozing (2013) proposed to assign the most weight to the first and the last author of a publication and least weight to the authors in the middle of the authors list. Thus, they have proposed the profit (*p*)-index based on a harmonic weighing algorithm to estimate the contribution of coauthors depending on the number of coauthors and the sequence of the authors in the paper (Aziz & Rozing, 2013). Other researchers have suggested other options irrespective of the order of the authors. For example, Tol (2011) proposed to assign an author's weight based on each author's past publication record, while Shen and Barabási (2014) assigned weights by taking into account co-citation relationships between the publication and each author's earlier work.

Tscharntke, Hochberg, Rand, Resh and Krauss (2007) proposed a percent credit quantification of an author's contribution by giving the highest credit to the first author and half of it to the last author, while credits for the rest of the authors depends on the sequence of authorship with declining importance with position. Sekercioglu (2008) proposed to rank an author based on his/her relative contribution with respect to the contribution of the first author according to the position in the list of authors. Using a more comprehensive approach, Allen et al. (2014) proposed a digital taxonomy with 14 colored badges to delineate the contribution of each author of a multi-author paper.

The 14 categories (colored badges) is one of the outcomes of involving journal editors, funders and researchers to classify authors' contributions as a set of standard roles in publishing a paper. Allen et al. (2014) argued that the digital taxonomy would enable to better describe what an author contributed than being represented by his/her position such as 'author number 8 on a 15-author paper'. The same taxonomy would also help those looking for the most apt peer reviewers, the