
ESTUDIOS / RESEARCH STUDIES

Is There a Rationale for Author Byline Order? A Case Study of the Journal of Informetrics

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Abstract: Multiple authorship on research publications is common in many disciplines. Is the order in which authors appear in the byline determined by consistent criteria? This study investigated co-authored papers published in the *Journal of Informetrics* in 2016, the year in which this representative journal of the area of informetrics started to publish the articles with the author contributions form, as a case study to determine if there is consistency in the author order based on author contributions. For the papers studied, there was greater consistency for the first and last authors, and less consistent rationale for the order of the remaining author positions for the papers studied. A survey sent to the authors of the publications studied revealed that authors believed the first and last author positions played a more distinctive role. The lack of agreement and function of author order in other positions raises the question about the significance of author order and its purpose in determining the credit authors receive for co-authored publications.

Keywords: Scholarly communication; Informetrics; research collaboration; co-authorship; author credit; byline order; author contribution

¿Existe una justificación para el orden de los autores en la mención de autoría? Un estudio de caso de la investigación en informetría

Resumen: La autoría múltiple en publicaciones de investigación es común en muchas disciplinas. ¿El orden en el que aparecen los autores en la mención de autoría está determinado por criterios consistentes? Este estudio investiga los artículos en coautoría publicados en *Journal of Informetrics* en 2016, el año en el que esta revista representativa del área de la informetría comenzó a publicar los artículos junto al formulario de contribuciones de los autores, como un estudio de caso para determinar si hay coherencia en el orden de los autores según sus contribuciones. Para los artículos estudiados, hubo mayor consistencia para el primer y último autor, y una justificación menos consistente para el orden de las posiciones de los autores restantes. Una encuesta enviada a los autores de las publicaciones estudiadas reveló que los autores creían que la posición del primer y último autor desempeñaba un papel más distintivo. La falta de acuerdo y función del orden de los autores en otras posiciones plantea la pregunta sobre la importancia del orden de los autores y su propósito para determinar el crédito que reciben los autores por las publicaciones en coautoría.

Palabras clave: Comunicación científica; Informetría; colaboración en la investigación; coautoría; crédito del autor; orden de la mención de autoría; contribución del autor.

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1. INTRODUCTION

The transition to Big Science, characterized by Price (1963) by the advent of research teams, resulted in a process of social construction in which researchers began to play specific roles during the development of scientific production (Kosmulski, 2012, Corrêa Jr. et al., 2017). Although this process is collaborative and socially dependent, the bodies that evaluate science around the world (including scientific policies) have focused on assessing the products resulting from research, rather than focusing on understanding the social positions or the roles played by the researchers for the advancement of science (Wagner, 2018).

In this context, in the analysis of the behavior and development of a scientific field, many important aspects of the construction of knowledge are neglected by not understanding the roles that researchers, research groups or institutions adopt in the development of a cooperative scientific project. This impacts on the rankings of both scientific production and citations (Frandsen & Nicolaise, 2010; He et al., 2012) that are used as tools for evaluating the productivity and impact of researchers, institutions, and countries, as well as to understand the diverse competences in a scientific field. In this sense, rankings are inefficient if they disregard the social aspects of the construction of knowledge, such as the effective participation of the authors in the preparation of the work, the type of participation or contribution of each author in the process of research, the motivation for citing certain references or the dynamics that ruled the team during the development of the study.

Related to this theme, some studies have suggested to analyze the performance of researchers by proposing: specific algorithms and relative values to calculate the fractional contribution of the authors, according to the position they occupy in the byline (Trueba & Guerreiro, 2004, Kosmulski, 2012); harmonic and variable co-authorship credits according to the position in the byline, seniority of the author, and size of the research team (Hagen, 2013, Hagen, 2014); attribution of different weights for research activities (Rahman et al., 2017); or the size of the teams and the theoretical or empirical nature of the research (Bornmann & Osório, 2019). It is noteworthy that the process of identifying the effective contribution of each author is a great challenge for the authors and editors of scientific journals, due to the increase in multiple co-authorships in several areas of knowledge.

Parallel to this challenge, there is growing attention to ethical issues related to co-authorship and the order of co-authors in scientific publications.

This interest has led research institutions and organizations, journal editors, and researchers interested on the topics to propose guidelines and recommendations related to ethical behavior in the process of attributing authorship in different disciplines, as an attempt to minimize the negative effects of hyper-authorship in science.

Several studies on policies and conduct guidelines for co-authorship in specific areas have emerged in recent years aiming to increase the transparency and equity of the process of attribution. However, aside from the medical sciences, in other fields such as in the social sciences, mathematics, technologies, and engineering, the discussions on ethical issues and necessary guidelines to achieve good scientific practices and resolve misconduct in collaborative research have not been so prolific. Furthermore, by ignoring these issues, problems tend to be overlooked and deviations in ethical conduct that often turn into departmental traditions arise (Youtie & Bozeman, 2014).

In this sense, we emphasize the possibilities and importance of the byline – the section where the names of the authors is listed (NIH, 2018) – of articles for co-authorship, together with the other discussions and measures among the scientific community that could be adopted, for the configuration of a system of attribution of competence, merit, and responsibility for the knowledge that is generated with the publications. In this vein, the byline reflects and presents the researchers that made substantial contributions to earn credit for the authorship of the publication, and identifies the competencies and importance of the necessary activities in a field of knowledge. In the last ten years, several studies have addressed different aspects related to the byline: the contribution of the authors according to their position (Burrows & Moore, 2011; Mattsson et al., 2011; Kosmulski, 2012; Liu & Fang, 2014, Corrêa et al., 2017; Duffy, 2017; Larivière et al., 2016; Logan et al., 2017; Mongeon et al., 2017; Tarkang et al., 2017; Yang et al., 2017); the relation between position and the characteristics of the authors (Costas & Bordons, 2011; Fox et al., 2018; Bu et al., 2019; Laudel, 2019); credit (Hagen, 2013; Jian & Xiaoli, 2013); the readers' perception (Zbar & Frank, 2011; Jian & Xiaoli, 2013; Bhandari et al., 2014); and the impact of the publication (He et al., 2012; Bu et al., 2019).

Although some fields and scientific journals have established different rules to determine who can be considered an author of a work, the order of the byline commonly represents the relative contribution of the authors, based on the (often unspoken) conventions that govern the scientific practices of

a field or journal. Some institutions or groups of researchers might also present different behaviors, for instance choosing to list the authors by alphabetical order or distinguishing the main author as the first one or the last one in the list (Kosmulski, 2012, Waltman, 2012, Yang et al., 2017).

Recently, some journals have included the list of authors' contributions as a way of minimizing the negative effects of hyper-authorships and undeserved credit, offering readers the possibility to identify the real participation of each author in the development of the article. Yang, Wolfram, and Wang (2017) highlighted the importance of including this list of authors' contributions in scientific journals.

In this sense, we understand that an analysis of scientific productivity at the micro (author) level should take into account the relative contribution of each author in articles in co-authorship, since dedication, involvement, activities, and the time spent on conducting research can vary greatly among the co-authors of the paper. For instance, as noted in the scientific literature (Kosmulski, 2012, Waltman, 2012; Abramo & D'angelo, 2015, Yang et al., 2017), in general, dedication tends to be higher when authors occupy prominent positions (first or last author) in the byline than when they occupy intermediate positions. Given this, the research question we address can be summarized as:

Is there any relationship between the assignment of the order of authors in the byline, the type of activity performed by the authors, and their ongoing and comprehensive participation in the fundamental stages of the development of an article?

In this sense, our paper aims to evaluate the plausibility of establishing the order of the authors in articles in co-authorship as an indicator of their relative productivity in the field of the metric studies of information. Working with co-authored articles published in the *Journal of Informetrics* (JOI) in 2016, we aim to:

- I. Identify and describe the level of participation of co-authors in the different activities of the development of the article;
- II. Describe the understanding of the co-authors of the articles regarding the role of each author position in the byline in the development of the research (main author, conceptual contributor, technical participant, and supervisor or advisor).

The *Journal of Informetrics* is a fundamental journal for the publication of research on quantitative aspects of information science that requests and discloses the list of authors' contributions. JOI

is considered one of the main journals specialized in the metric studies of information and its articles a good representation of the research in the field (Egghe, 2012, Das, 2013).

We believe that by identifying the breadth of the contribution of each author according to their position in the byline, represented in the form of an indicator of relative productivity resulting from the report of their effective participation in the development of the research, the results of our paper can contribute to improve the analysis and understanding of the scientific dynamics in general and more specifically in this area of information science. We also consider that the characterization of the authors' understanding of the role and contribution of each co-author to develop their articles in co-authorship may offer an overview of the role of authorship in science, in addition to offering grounds for a reflection on scientific policies and whether they support the discussions on the process of attribution of authorship by researchers, guidelines for good scientific practices, and editorial committees.

2. METHODOLOGY

Initially, we identified the 41 "regular papers" co-authored articles that contained the list of contributions by each author published in the four issues of the *Journal of Informetrics* in 2016. These articles represent 49% of the 84 articles published in the four issues of that year. For each article, we then retrieved: the type of co-authorship, alphabetical orders of authors (we identified 13 articles with alphabetical ordering and 28 with non-alphabetical ordering), the names of the authors, and their positions in the byline. We identified 125 authors from the corpus of articles analyzed.

For each co-author of the 41 articles analyzed, we identified their participation in the 5 fundamental activities of the development of research and publication process listed by Elsevier and assigned a value of 20% for each activity in which they participated. Thus, each author was assigned a percentage between 0 (when the author did not participate in any activity) and 100% (when they participated in the development of all five activities), that corresponds to the sum of the percentages.

We consider that the proportional contribution of the merit of each co-author according to their involvement in each stage contributes to a more accurate estimation of the real participation of the co-authors in the development of a publication. We should note that, according to this criterion, the sum of the percentages of participation of all authors is not necessarily equal to 100%, as it could

be higher as the co-authors' participation in an activity is not mutually exclusive. We should also clarify that the choice of assigning equal credit for each of the five activities reflects the equal relevance of all stages and activities for achieving the final scientific result, since the absence of any of them would make the publication of the article impossible. The investigation of the perception of the importance of, and contribution to, each activity among the authors in different areas might be the focus of future research.

To identify the authors' understanding of the role of each author/position in the development of the article, we created a questionnaire that was sent to the 125 authors of the 41 analyzed articles. The survey (see Appendix 1) included 6 questions:

- Do you believe that the authorship order reflects different roles and functions in the development of a paper? (Q1);
- Do you believe that the order in which the authors are listed in the article's byline reflects their contribution (either quantitatively or qualitatively) in the development of the article? (Q2);
- Do you believe that the first author listed in an article performs the function of...? (Q3);
- Do you believe that the intermediary author(s) listed in an article perform(s) the function of...? (Q4);
- Do you believe that the last author listed in an article performs the function of...? (Q5); and
- Do you believe that the corresponding author listed in an article performs the function of...? (Q6).

The authors that answered the questionnaire included affiliations in Finland, China, Greece, United Kingdom, Japan, Sweden, Switzerland, Russia, United States, Italy, Israel, Germany, Belgium, Spain, South Africa, France, Portugal, and Hungary. We obtained more than 30 responses from the total of 125 authors. 8 email addresses were invalid, as we were notified that they did not receive the questionnaire, 3 were not found, 2 authors replied that they were not interested in participating in the research, and 1 had passed away. Thus, out of a total of 125 authors, and the possibility to obtain 113 responses, with the feedback of 30 authors there was a participation of 26.5% of the authors of the accessible universe.

The results from the questionnaires were summarized in tables and associated according to the following aspects: the different roles played by the authors in a scientific work, by order in the byline (first author, middle author, last author, and corresponding author); the order of the authors associated to the quantitative and qualitative contribu-

tion related to the order in which the authors are listed; and whether there is an association between the role of the authors and the type of contribution made in the development of the article.

The methodology that is proposed in this paper can be applied in any area of knowledge, especially for studies that aim to analyze research productivity and collaborative behavior in science from a micro perspective (at the level of researchers and research groups). In order to analyze this, it is necessary to have the lists of the authors' contributions, something that has been disclosed by an increasing number of scientific journals in recent years from the most varied areas of knowledge, a fact also analyzed by Yang, Wolfram and Wang (2017).

3. RESULTS AND DISCUSSION

Table I presents the levels of co-authorship in the articles published in the JOI in 2016. We observe that more than half of the articles (27 out of 41) have 2 or 3 co-authors, with approximately the same number of articles for each of these levels of co-authorship. This result is similar to the one identified by Mena Chalco et al. (2014), when analyzing the most frequent type of co-authorship in the Social Sciences, and by Hilário and Grácio (2017), when identifying the number of co-authors of the publications by Brazilian researchers in Information Science with a level 1 Research Productivity Grant (PQ1). The presence of 4 co-authors was also significant in the corpus, which may indicate a tendency for information science researchers to form larger groups of co-authors/researchers when carrying out empirical studies.

We can observe that only articles with 2 and 3 co-authors were ordered alphabetically. In this sense, an alphabetical order was used in the majority (54%) of articles with 2 co-authors and in 43% of the articles with 3 co-authors. Of the 7 articles with 2 co-authors listed in alphabetical order, 2 were published by authors with different levels of education (ordered from the author with the lowest education degree to the author with the highest degree) and 5 were published by authors with the same level. Of the 6 articles whose byline did not follow an alphabetical order, 5 were published with authors listed increasing levels of education (from the lowest degree to the highest degree), and 1 with authors ordered by decreasing levels of education (from highest degree to the lowest degree).

Of the 6 articles with 3 co-authors listed in alphabetical order, 3 were published by authors with the same level of education, 2 with authors listed by increasing levels of education (from the lowest degree to the highest degree), and 1 published by authors

Table I: Level of co-authorship of the “regular papers” published in the JOI in 2016

# co-authors	Mean percentages of the contributions					
	Alphabetical		No alphabetical		Total	
	# articles	%	# articles	%	# articles	%
Two	7	54	6	46	13	100
Three	6	43	8	57	14	100
Four	-	-	10	100	10	100
Five	-	-	2	100	2	100
Seven	-	-	1	100	1	100
Ten	-	-	1	100	1	100
Total	13	32	28	68	41	100

with decreasing levels of education (from the highest degree to the lowest degree). Of the 8 articles with 3 co-authors and no alphabetical ordering, 5 were published by authors with the same level of education, 2 with authors ordered by increasing levels of education listed increasingly (from the lowest degree to the highest degree), and 1 with authors ordered by decreasing levels of education (from the highest degree to the lowest degree).

We believe the results related to articles with 2 and 3 co-authors listed in alphabetical order can be explained by the adoption of the criterion of “equilibrated contribution” (Frandsen & Nicolaise, 2010), especially when the relationship among the authors is homogeneous (in the case of authors with the same level of education) or equally important (quantitatively and qualitatively), as highlighted by Henry (2013) in relation to the criteria for attribution of authorship. However, the presence of articles with authors with heterogeneous relationships listed by increasing levels of education from the person with the lowest degree to the person with the highest degree might also mean that the alphabetical order was not intentional, but rather a coincidence, considering that the contribution percentage tends to be higher for authors who occupy the first position in the byline and decreases for the subsequent positions.

On the other hand, we can observe in Table I that the articles published by teams of 4 or more co-authors did not follow an alphabetical order. This result is in line with Hilário and Grácio (2017), who observed that as the number of co-authors exceeds the usual size of research teams in information science (2 to 3 authors), the field in which the area of the metric studies of information is included, the use of alphabetical orders decreases and even disappears in large research teams.

Furthermore, the results in Table I can be linked to Lozano’s observation (2014), who stated that

co-authors in small teams tend to be more participative in the development of research and their contributions more equal, whereas in large teams the ordering of authors by contribution is more effective and fairer to represent the role and performance of each author, considering the visibility of the first position in the byline. Thus, the results in Table I are aligned with Lozano (2014) as in 7 (out of 13) articles with 2 co-authors, the byline followed an alphabetical order; in articles with 3 co-authors an alphabetical order was followed in 6 cases (out of 14); while in articles with 4 or more co-authors that did not happen.

It is important to note that alphabetical order has also been the object of several criticisms, for being considered unfair and alien to the scientific policies that exist around the world (Henry, 2013, Lozano, 2014, Conroy, 2018, Weber, 2018). The term “alphabetical discrimination” was coined to denounce the unfair favoritism towards those researchers who are lucky enough to have names that start with the first letters of the alphabet. This criterion for ordering, far from being neutral, also privileges some researchers’ visibility and prestige, as the authors listed first are always highlighted (textually, at the least) even if their contribution is not very substantial. This situation is even worse when the other authors are made invisible and subjugated under the clause “et al.” (required by some citation styles), affecting also the indicators of productivity and impact of these researchers.

In this context, we consider that alphabetical order can be an option for small groups of researchers who contributed equally to the development of a publication. Table II shows the percentage of authors who contributed to each activity, by type of ordering (alphabetical or no alphabetical) and the position in the byline. We observe that in the articles with 2 co-authors, regardless of whether they are listed in alphabetical order or not, the first au-

Table II: Percentage of authors that contributed to each activity considered fundamental for the development of research, by level of co-authorship, alphabetical order or not, and position of the author

Level of co-authorship	Alphabetical order? (# of articles)	Position of the author	Activity					
			Conception and design	Collection of data	Contribution of data or analysis tools	Analysis	Writing of the paper	Others*
			% of authors who contributed	% of authors who contributed	% of authors who contributed	% of authors who contributed	% of authors who contributed	% of authors who contributed
Two co-authors	Yes (n=7)	1st author	100%	100%	100%	100%	100%	-
		2nd author	71%	43%	43%	71%	86%	14%
	No (n=6)	1st author	100%	100%	100%	100%	100%	-
		2nd author	100%	83%	100%	83%	100%	-
Three co-authors	Yes (n=6)	1st author	100%	67%	80%	67%	83%	17%
		2nd author	100%	67%	67%	84%	100	-
		3rd author	100%	67%	40%	67%	67%	-
	No (n=8)	1st author	100%	88%	75%	100	100%	-
		2nd author	75%	38%	75%	75%	50%	13%
		3rd author	38%	13%	13%	63%	50%	25%
Four co-authors	No (n=10)	1st author	100%	80%	80%	90%	90%	10%
		2nd author	90%	60%	60%	60%	60%	10%
		3rd author	40%	60%	60%	50%	50%	20%
		4th author	60%	30%	50%	40%	80%	10%
Five co-authors	No (n=2)	1st author	100%	100%	100%	100%	100%	50%
		2nd author	100%	100%	100%	50%	50%	-
		3rd author	50%	50%	100%	10%	100%	50%
		4th author	50%	50%	50%	50%	-	50%
		5th author	50%	-	-	50%	100%	50%
Seven co-authors	No (n=1)	1st author	100%	-	100%	100%	100%	-
		2nd author	100%	100%	100%	100%	100%	-
		3rd author	100%	-	-	100%	100%	-
		4th author	100%	-	-	-	100%	-
		5th author	100%	-	-	-	100%	-
		6th author	100%	-	-	-	100%	-
		7th author	100%	-	-	-	100%	-
Ten co-authors	No (n=1)	1st author	-	-	-	100%	100%	-
		2nd author	-	-	-	100%	100%	-
		3rd author	100%	-	-	-	-	-
		4th author	-	-	-	100%	-	-
		5th author	-	-	-	-	100%	-
		6th author	-	-	-	100%	-	-
		7th author	-	-	-	100%	-	-
		8th author	100%	-	-	-	-	-
		9th author	-	-	-	-	100%	100%
		10th author	100%	-	-	-	100%	-

thor always participated in all essential activities. In articles with 3 co-authors listed alphabetically, the first author only participated in the conceptualization of the research in all papers.

As for the other fundamental activities (data collection, contribution of data or tools, analysis, and writing of the paper), first authors participated in these activities in most of the articles (with percentages varying between 67% and 80%). On the other hand, the contribution of the first author was more substantial in articles with 3 co-authors not listed alphabetically, corresponded to a greater level of participation in the activities of conception and design of the research, analysis of the results, and writing for 100% of the articles. In addition, the percentage of participation of the first author in the activities of data collection and tools was higher in articles with 3 co-authors listed non-alphabetically order than in articles with the co-authors listed in alphabetical order.

In articles with 4 or more co-authors, the first author tended not to participate in all five fundamental activities. With the exception of the articles with 5 co-authors (2 articles), the first author did not participate in 100% of the articles for all activities. It is also worth noting that in the only article published with ten co-authors, the participation of the first author was lacking in comparison.

These results are in line with the consideration of the first position of the byline for the co-author who contributed most to the development of the work (Frandsen & Nicolaise, 2010; Witter, 2010; Youtie & Borzeman, 2014; Yang et al., 2017). It is also worth noting that White (2001) also highlighted the role of the first author as the person responsible for the article, including what in it is cited, although it is possible for this assumption not being reliable in articles with multiple co-authors from large research teams.

It is also important to highlight that, with the exception of the article with ten co-authors, for the other 40 articles, regardless of whether they followed an alphabetical order or not, the first author always participated in the conception and design of the research. This suggests that the size of the teams could dilute the contribution of the co-authors in an article and question the adopted criteria to differentiate scientific collaboration from co-authorship (White, 2001, Lozano, 2014).

It is also noteworthy that, with the exception of 1 article with 4 co-authors and another one with 3 co-authors, both listed in alphabetical order, in all other 39 articles, the first author always participated in the writing of the paper.

Table II also shows that the authors in middle positions in the byline tended to participate in a smaller number of activities than those in the first or the last position. This result would be in line with the observations by Corrêa Jr. et al. (2017).

Regarding the participation of the last author (and here it should be noted that in the case of articles with 2 co-authors, the second author was considered as the last author in the analysis), the writing of the paper was the activity performed in the highest percentage of articles, 100% of the articles with 2 co-authors listed in no alphabetical order, articles with 5 co-authors, 7 co-authors, and ten co-authors, and in 86% of articles with 2 co-authors listed in alphabetical order. In articles with 3 and 4 co-authors, the participation of the last author in the writing varied between 50% and 80% of the articles.

We can also observe that the activities of data collection and contribution of tools presented the lowest frequency of participation for the last author, showing in general low percentages or absence. Furthermore, only in articles with 2, 3, and 4 co-authors, did the last author participate in the collection of data and contribution of data or analysis tools, which means that the smaller the number of researchers who share a research objective, the greater their involvement in the construction of the study, as also pointed out by Lozano (2014). It should be additionally noted that in articles with 6 or fewer co-authors, the participation of the last author occurred with a lower level of contribution in the analysis stage.

In addition, the last author was the position with the highest percentage of participation in the "other contributions" category, that included, according to the authors, coordination and supervision activities. This reinforces the idea that the last author is usually the coordinator or supervisor of the study, as highlighted by White (2001), Yang et al. (2017) and Weber (2018).

In general, the area of the metric studies of information presented similar results to those identified in the literature for the order of authors and their relative contribution, spotting the first author as the one with the most active participation (Witter, 2010, Abramo & D'angelo, 2015, Henry, 2013, Youtie & Bozeman, 2014) and the last author as the one with the supervisor role (White, 2001, Yang et al., 2017, Weber, 2018).

However, our research showed that in the field of information science, or more specifically in informetrics, these dynamics did not follow the trend observed by Yang et al. (2017) for medical journals,

Table III: Mean percentage of the total contribution of authors to all activities, by type or ordering and level of authorship.

	Mean percentage of the total contribution of the author					
	Level of authorship					
	Two co-authors		Three co-authors		Four co-authors	Five co-authors or more
Order	Alphabetical (7 articles)	Non-alphabetical (6 articles)	Alphabetical (6 articles)	Non-alphabetical (8 articles)	Non-alphabetical (10 articles)	Non-alphabetical (4 articles)
1 st author	100%	96%	78%	93%	84%	80%
2 nd author	69%	85%	83%	65%	70%	75%
3 rd author			65%	43%	54%	60%
4 th author					54%	40%
5 th author						40%
6 th author						30%
7 th author						30%
8 th author						20%
9 th author						20%
10 th author						40%

in which the main contributions corresponded to the first and the last author listed in the byline. We consider that this observation may be associated with the epistemology of the information science field, as well as the differences in the size of the teams that participate in the development of a paper.

Table III shows the mean of the total contributions of the authors (expressed as a percentage of all five fundamental activities) by position in the byline and level of authorship, according to the author contributions of the articles published in the *Journal of Informetrics* in 2016. From Table III we can observe that in articles published with 2 and 3 co-authors, on average, all co-authors participated in more than 43% of the fundamental activities, regardless of whether they were listed in alphabetical order or not, presenting a decreasing order of contribution from the first author to the others. On the other hand, in articles with 4 or more co-authors (not listed in alphabetical order), on average, only the first and the second authors presented an active participation. That is, on average, the first author participated in at least 80% of the activities and the second author in 66% of the activities.

These results are similar to those identified by Yang, Wolfram, and Wang (2017), who reported the greatest contribution of the authors in the first and second positions of the byline.

The results in Table III are also in line with those in White (2001) and Lozano (2014), who stated that the greater the number of authors in an article, the lower the co-authorship threshold, a value that can affect the criterion of "contribution" estab-

lished by the group for the attribution of authorship. In this sense, we note that in the articles of our study with more than 4 co-authors, the total participation in the research (equivalent to the involvement in 100% of the activities), only happens by those were listed as first and second authors, leaving following positions of the byline for those who presented lesser contributions.

Table IV presents another view of the results in Table III, according to three categories of positions in the byline - first author, middle author, and last author - for a better visualization of the trends of the means of the authors' total contributions. This is helpful since as the number of co-authors increases, the number of authors in middle positions also increases, thus making it difficult to identify a general average trend for these positions. In addition, it was possible to apply a paired t-test to statistically test, by level of authorship (2, 3, 4 or more co-authors) and presence or not of alphabetical order, the mean difference of the total contribution of the first and last authors, as these positions are present in all levels of co-authorship. We adopted a significance level of 0.05.

From Table IV, we observe that the mean of the total contribution of the first author is always greater than the last author's, regardless of the level of authorship (2, 3, 4 or more co-authors) and the presence or absence of alphabetical order. In addition, in the articles with middle co-authors, the mean of their total contributions is between the mean of the total contributions of the first author and the mean of the total contributions of the last author. Thus, the

Table IV: Descriptive statistics of the percentage of the authors' contribution by alphabetical order and non-alphabetical order.

# co-authors	Alphabetical order?	Author position in by-line	Mean	Std. Dev.	Min.	Max.
Two	No (n=6)	First	85%	17%	60%	100%
		Last	96%	10%	75%	100%
	Yes (n=7)	First	100%**	0%	100%	100%
		Last	69%	30%	40%	100%
Three	No (n=8)	First	93%**	15%	60%	100%
		Middle	65%	28%	20%	100%
		Last	43%	27%	0%	80%
	Yes (n=6)	First	78%	35%	25%	100%
		Middle	83%	15%	60%	100%
		Last	65%	31%	20%	100%
Four or more	No (n ¹ =14)	First	83%**	23%	40%	100%
		Middle	54%	30%	20%	100%
		Last	51%	32%	20%	100%

1 For Middle authors, n=39

**Statistically significant mean difference of total contribution of the first author and the last author with the significance level of 0.01

*Statistically significant mean difference of total contribution of the first author and the last author with the significance level of 0.05

mean of the authors' total contributions decreases as their positions move from the first one to the latter ones. This aspect is more evident in articles that do not follow an alphabetical order in which the mean of the total contribution of the authors is well defined by the order in which they were listed. This behavior might represent the co-authorship ordering criterion by volume of contribution, highlighted by Henry (2013), that considers that the co-authors listed first are the ones that most contributed to the fundamental stages of the development of research.

However, the differences between the means of the total contribution of the first author and the last author were only statistically proven for articles with 2 co-authors listed in alphabetical order ($p=0.033$), articles with 3 co-authors with no order ($p=0.01$), and articles with 4 or more co-authors ($p=0.009$). The impossibility of proving statistically the differences between the means of the total contribution of the first and the last author for the other levels of co-authorship (2 unordered co-authors and 3 ordered co-authors) might be linked to the fact that these categories included the smallest groups of articles (6 articles each). In this sense, future studies with larger samples would be necessary to evaluate this aspect.

Table V presents the perception of the 30 authors about the role of the first author in the development of the article. The opinion of these authors is linked to answers to the first question of the survey: Do you believe that the authorship order

reflects different roles and functions in the development of a paper?"

In Table V, we can observe that none of the respondents considered the listing of a co-author in the first position to be associated with being the supervisor or advisor of the research. Still, all 30 participants believe that the function of the first author is associated with the order in which they appear in the byline, given that none of them selected the response opposed to this view. On the other hand, 1 respondent stated that the order has no relation to the functions performed by the authors and 2 other respondents said that they had no opinion on the matter.

Among the "other" answers, some respondents also indicated the need to contextualize the issue of the author's position in the byline by field of knowledge, since, according to them, there is a preference for alphabetical ordering in some areas (this criterion was also considered by Henry, 2013). One of the respondents stated that in the experimental areas of the natural and life sciences there are many articles that are co-authored between supervisors and students or less experienced authors and in these cases the first author should be the main contributor. This aspect is associated with the criterion of authorship ordering by reverse hierarchy highlighted by Henry (2013). In addition, this respondent stated that in order to validate this hypothesis, it would be necessary to analyze the contribution of all of them (as it is being done in the present research).

Table V: Authors’ understanding of the functions performed by the first author in relation to Q1

Function of the first author	Q1: Do you believe that the authorship order reflects different roles and functions in the development of a paper?						Total	
	Yes ¹		No ³		Other ⁵		Total	
	# respond.	% ²	# respond.	% ⁴	# respond.	% ⁶	# respond.	% ⁷
The main author	21	100	-	-	2	29	23	77
A conceptual contributor	6	29	-	-	1	14	7	23
A technical contributor	5	24	-	-	-	-	5	17
A supervisor or advisor	-	-	-	-	-	-	0	0
The function is not related ⁸	-	-	-	-	-	-	0	0
The order is not related ⁹	-	-	1	33	-	-	1	3
No opinion	-	-	1	33	1	-	2	7
Other	1	5	-	-	5	71	6	20

Note: The data in this table refers to questions 1 and 3 of the questionnaire.

1. Total of participants that answered Yes to Q1=21
2. % calculated in relation to the total number of participants that answered Yes to Q1 (21)
3. Total of participants that answered No to Q1 = 3
4. % calculated in relation to the total number of participants that answered No to Q1 (3)
5. Total of participants that answered something else to Q1= 7
6. % calculated in relation to the total number of participants that answered something else to Q1 (7)
7. % calculated in relation to the total number of participants (30)
8. I believe this author’s role or function is not associated with their order on the paper’s byline.
9. I believe the order of the authors (all of them) is not associated with their order on the paper’s byline.

Table VI: Authors’ understanding of the functions performed by the middle author(s) in relation to Q1

Function of the middle author(s)	Q1: Do you believe that the authorship order reflects different roles and functions in the development of a paper?						Total	
	Yes ¹		No ³		Other ⁵		Total	
	# respond.	% ²	# respond.	% ⁴	# respond.	% ⁶	# respond.	% ⁷
The main author	-	-	-	-	-	-	-	-
A conceptual contributor	9	43	-	-	2	29	11	37
A technical contributor	12	57	-	-	2	29	14	47
A supervisor or advisor	1	5	-	-	1	14	2	7
The function is not related ⁸	4	19	-	-	-	-	4	13
The order is not related ⁹	1	5	3	100	1	14	5	17
No opinion	1	5	-	-	-	-	1	3
Other	3	14	-	-	4	57	7	23

Note: The data in this table refers to questions 1 and 4 of the questionnaire.

1. Total of participants that answered Yes to Q1=21
2. % calculated in relation to the total number of participants that answered Yes to Q1 (21)
3. Total of participants that answered No to Q1=3
4. % calculated in relation to the total number of participants that answered No to Q1 (3)
5. Total of participants that answered something else to Q1=7
6. % calculated in relation to the total number of participants that answered something else to Q1 (7)
7. % calculated in relation to the total number of participants (30)
8. I believe this author’s role or function is not associated with their order on the paper’s byline.
9. I believe the order of the authors (all of them) is not associated with their order on the paper’s byline.

Table VI presents the perceived function of the authors listed in the middle positions of the byline according to the participants’ answer to the first question of the questionnaire. We observe that, in the overall results, a significant portion (47%) of the authors participating in the study considered

that the middle author(s) perform the function of technical participants. However, when limited to the group of respondents who agree that the order of the authors reflects different roles and functions (Yes to Q1), this function seems to be even more significant, considering that 12 respondents (57%)

selected this option for the middle authors. Overall, the consideration of the function of conceptual contributors for this position was also significant among respondents, as indicated by 11 participants (37%). As in the case of the technical contributors, when limited to the group of respondents that agree that the order of the authors reflects different roles and functions, the role of conceptual contributors for middle authors also appears with a greater level of contribution corresponding to the selected answer of 9 participants (43%).

It is important to emphasize that this result is consistent with those in Table II, in which we observed that the percentages of participation of middle authors in technical activities, data contribution and analysis of results tend to be higher than 70%.

From Table VI, we also observed that no respondent believes that the middle author has the function of the main author of the paper. Furthermore, a small number (4≈13%) of respondents indicated that they do not believe that the function of the author(s) is associated with the order in which they are listed in the byline. Another 5 respondents, among the ones that selected the answer No to Q1, believe that the order of the authors is not associated with the order in which they are listed.

In relation to question 4 (concerning the function of the middle author), some respondents preferred to develop their answers rather than select one of the options: while 4 respondents reported

that none of the authors has a specific function in the development of the article, 3 respondents preferred to develop their answers. They mentioned that the middle author is probably the least important, although it depends on the research team and the area of knowledge (a result that is aligned with the percentage of participation in the stages of development of research from Table III).

Respondents also emphasize that they may have different roles and levels of contribution to the development of the article. One of the respondents suggested the ordering by decreasing level of education degree, that is, going from the one with the highest degree to the one with the lowest degree, leaving the position of middle author to those who played a minor role in the research. This criterion was considered by Henry (2013), however, only for the positions of first and last author, the most coveted positions in the byline as highlighted by Youtie and Borzeman (2014).

We would like to highlight the importance of some of the respondents' comments related to the necessity to consider the context and the area. Although here it is possible to identify a widely accepted behavior, as some authors considered that they had experiences in which the listing order followed other criteria, we do not believe this practice could be generalized.

Table VII shows the perceived function of the author listed in the last position of the byline. We ob-

Table VII: Authors' perception of the functions performed by the last author in relation to Q1

Function of the last author	Q1: Do you believe that the authorship order reflects different roles and functions in the development of a paper?						Total	
	Yes ¹		No ³		Other ⁵		Total	
	# respond.	% ²	# respond.	% ⁴	# respond.	% ⁶	# respond.	% ⁷
The main author	1	5	-	-	-	-	1	3
A conceptual contributor	8	38	-	-	1	14	9	30
A technical contributor	5	24	-	-	1	14	6	20
A supervisor or advisor	18	86	-	-	3	43	21	70
The function is not related ⁸	1	5	1	33	-	-	2	7
The order is not related ⁹	2	10	1	33	1	14	4	13
Other	4	19	-	-	6	86	10	33

Note: The data in this table refers to questions 1 and 5 of the questionnaire.

1. Total of participants that answered Yes to Q1=21

2. % calculated in relation to the total number of participants that answered Yes to Q1 (21)

3. Total of participants that answered No to Q1=3

4. % calculated in relation to the total number of participants that answered No to Q1 (3)

5. Total of participants that answered something else to Q1=7

6. % calculated in relation to the total number of participants that answered something else to Q1 (7)

7. % calculated in relation to the total number of participants (30)

8. I believe this author's role or function is not associated with their order on the paper's byline.

9. I believe the order of the authors (all of them) is not associated with their order on the paper's byline.

serve that the majority (70%) of the respondents believe that the last author performs the function of supervisor/advisor of the research. When limited to the respondents (21) that answered that the order of the authors reflects their role and function in the development of the article, this understanding is even more prevalent, given that 86% of the authors (18) selected the option of the supervisor. These results are similar to White (2001), Yang et al. (2017), and Weber (2018), who pointed out that the position of last author in the byline corresponds to those authors that are more established scientifically and thus perform the function of supervising the research. In addition, another function that was attributed significantly to the last author was the conceptual contribution, selected by 30% of the respondents (9).

Going back to the question of the difference between authorship and scientific collaboration, we believe that being a co-author requires an active involvement in the development of research, so the mere supervision of the work should not be considered co-authorship. Notwithstanding, on the other hand, only 1 respondent answered that the position of the last author in the byline corresponds to the function of the main author. Still, in relation to the results from Table VII, it is worth noting that few respondents indicated that the role or function of the last author is not associated with the order in which they are listed in the byline. In addition to the selected answers, the participants' comments show that the last position in the byline is reserved for senior authors, heads of departments or coordinators of research groups, and, in the case of alphabetical ordering, the researcher who contributed to less substantial activities. Another aspect considered by one of the respondents was the case of articles co-authored by large research teams, in which the last author tends to have the function of guarantor and validator of the contents.

4. CONCLUSION

The results presented in this study show that, in general, the author's contributions to the fundamental activities of the development of research are not manifested equally, especially in studies with larger numbers of co-authors. In relation to our first objective, we have shown that in the field of the metric studies of information, the list of co-authors followed a decreasing order (from the most participative to the least participative) of the total contributions to the fundamental activities, presenting a special significance for the contribution of the first listed author. This result answers the research question we posited, by revealing that there is an association between the order of au-

thors in the byline, the type of activity performed by the author, and the regularity of their participation in the fundamental stages of the development of the paper, with special significance for the stages of conceptualization and design of the study and the analysis of the results for the main position - first author - with a percentage higher than 67% in all activities, even for those cases in which the co-authors were listed in alphabetical order.

By presenting the perception of the authors of the JOI articles regarding the role of the authors and the ordering of authorship, the second specific objective was fulfilled. We identified that, in fact, co-authors perceive different functions in the article according to their position in the byline (or, in other words, the perception of the position in the byline is conditioned by the different functions performed by the co-authors). For the majority of respondents, the co-author listed first tends to be the main author of the study. Middle authors tend to be considered technical and conceptual contributors, being this position the one with the least visibility and preference for the respondents. Finally, the co-author listed last is perceived to occupy a supervisory or advisor role, being this position generally reserved for senior researchers, coordinators of research groups, and department heads.

Perhaps due to the diversity of education levels of the authors who were invited to answer the questionnaire, the main perception of the role of the corresponding author was split between the main author (the function that the majority of respondents selected) and the supervisor of the study (selected by 25% of the respondents). Thus, the perception of the researchers here can be noted although it is not unanimous.

We also observed that the greater the number of co-authors listed, the more difficult it is to guarantee that all co-authors would be able to undoubtedly defend all the content present in the article, nor would they be responsible for it. In this context, it is noteworthy that the attribution of authorship and ordering already represent an indicator of relative productivity, given that the regularity in the participation of the fundamental activities of the development of the article and the perception of the authors in relation to their function seem to be associated with the order in which they are listed. However, for the proposal of an indicator to be consolidated, the following aspects are necessary: the validation of the authors' contributions in practical terms and the authors' agreement on whether the listed order represents the relative contribution of each study.

Finally, we acknowledge some limitations of our research are related to the relatively limited dataset size and focus on a single discipline and one year in one journal. The nature and role of co-authorship and author order may also change over time, particularly as research team sizes continue to grow, which would need to be studied with longitudinal data. We believe, however, that this study still sheds light on this important issue and helps to inform future, larger-scale research on the topic. The present study also provides a framework for how this may be studied. Future research should investigate if there are disciplinary differences in the rationale used for determining author order, if the reasons have changed over time as research team sizes have grown, the possible influence of the national evaluation agencies' policies and the country of affiliation of the authors, and the influence of the field of the authors that publish on bibliometrics considering that authors from different fields might present different patterns of co-authorship and perceptions about the concept of authorship (see for instance Silva et al., 2017). Although these aspects should be developed in future research, we believe that the methodology and discussions presented in our present paper can be of great help and interest to develop those ideas.

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APPENDIX 1. SURVEY ON THE UNDERSTANDING OF THE AUTHORSHIP ORDER IN SCIENCE

Q1 - Do you believe that the authorship order reflects different roles and functions in the development of a paper?

Yes, I do.

No, I do not.

I have no opinion on this matter.

I do not wish to comment on this matter.

Use this space to clarify your answer if necessary.

Q2 - Do you believe that the order in which the authors are listed in the article's byline reflects their contribution (either quantitatively or qualitatively) in the development of the article?

Yes, I do, but only quantitatively.

Yes, I do, but only qualitatively.

Yes, I do, in both ways.

No, I do not.

I have no opinion on this matter.

I do not wish to comment on this matter.

Use this space to clarify your answer if necessary.

Q3 - Do you believe that the first author listed in an article performs the function of:

The main author;

A conceptual contributor;

A technical contributor;

A supervisor or advisor;

I believe the role or function of the first author is not related to his/her order in the article's byline.

I believe the order of the authors (all authors) is not related to their order in the article's byline.

I have no opinion on this matter.

I do not wish to comment on this matter.

Use this space to clarify your answer if necessary.

Q4 - Do you believe that the intermediary author(s) listed in an article perform(s) the function of:

The main author(s);

Conceptual contributor(s);

Technical contributor(s);

Supervisor(s) or advisor(s);

I believe the role or function of the intermediary author(s) not related to their order in the article's byline.

I believe the order of the authors (all authors) is not related to their order in the article's byline.

I have no opinion on this matter.

I do not wish to comment on this matter.

Use this space to clarify your answer if necessary.

Q5 - Do you believe that the last author listed in an article performs the function of:

The main author;

A conceptual contributor;

A technical contributor;

A supervisor or advisor;

I believe the role or function of the last author is not related to his/her order in the article's byline.

I believe the order of the authors (all authors) is not related to their order in the article's byline.

I have no opinion on this matter.

I do not wish to comment on this matter.

Use this space to clarify your answer if necessary.

Q6 - Do you believe that the corresponding author listed in an article performs the function of:

The main author;

A conceptual contributor;

A technical contributor;

A supervisor or advisor;

I believe the corresponding author does not perform any special function different from the other authors

I have no opinion on this matter.

I do not wish to comment on this matter.

Use this space to clarify your answer if necessary.
