



An Ethical Exploration of Increased Average Number of Authors Per Publication

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Abstract

This article explores the impact of an Increase in the average Number of Authors per Publication (INAP) on known ethical issues of authorship. For this purpose, the ten most common ethical issues associated with scholarly authorship are used to set up a taxonomy of existing issues and raise awareness among the community to take precautionary measures and adopt best practices to minimize the negative impact of INAP. We confirm that intense international, interdisciplinary and complex collaborations are necessary, and INAP is an expression of this trend. However, perverse incentives aimed to increase institutional and personal publication counts and egregious instances of guest or honorary authorship are problematic. We argue that whether INAP is due to increased complexity and scale of science, perverse incentives or undeserved authorship, it could negatively affect known ethical issues of authorship at some level. In the long run, INAP depreciates the value of authorship status and may disproportionately impact junior researchers and those who contribute to technical and routine tasks. We provide two suggestions that could reduce the long-term impact of INAP on the reward system of science. First, we suggest further refinement of the CRediT taxonomy including better integration into current systems of attribution and acknowledgement, and better harmony with major authorship guidelines such as those suggested by the ICMJE. Second, we propose adjustments to the academic recognition and promotion systems at an institutional level as well as the introduction of best practices.

Keywords Scholarly authorship · Authorship ethics · Authorship inflation · Publication ethics · Research integrity

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Introduction

This article aims to analyze ethical issues associated with an Increase in the average Number of Authors per Publication (INAP). Although INAP is not, in of itself, a concept with pejorative connotations, we aim to show that it can have negative side effects that threaten the integrity of research, necessitating precautionary measures and the adoption of best practices by researchers and institutions. Some proposals to deal with INAP, e.g., putting a cap on the number of authors per article seem rather extreme and may result in group authorships that do not list individual authors (Weeks et al., 2004). However, as we shall demonstrate, other less radical initiatives and developments are available (e.g., CRediT taxonomy, institutional best practices), which, if adequately revised and widely employed, could enable research stakeholders to address some of the ethical issues associated with authorship to which INAP continues to contribute.

The paper begins by describing six factors that have contributed to INAP. Subsequently, by referring to the most common ethical issues associated with scholarly authorship (Hosseini & Gordijn, 2020),¹ we analyze and explain the ways in which INAP could exacerbate these ethical issues at some level. Finally, in the discussion section we explore the long-term impact of INAP on different parties involved in academic research and provide suggestions to address the long-term impact of INAP on the reward system of science.

INAP and Its Contributing Factors

Scholarly authors are involved in efforts that result in creating texts such as articles, chapters, or monographs (Shamoo & Resnik, 2015, p. 122). When collaborative research was not as prevalent as today, almost all scientific publications were attributed to a single author.² The researcher who conducted the experiment or had ideas to share, would also draft, revise, and finalize a text for dissemination (Gross et al., 2002). Consequently, there would be little or no ambiguity in relation to authorship credit, ownership of original claims, or accountability with regard to the content of a publication (Rennie, 2001; Shamoo & Resnik, 2015, pp. 122–123). However, with the development of collaborative research, a continuous increase in the average number of authors per publication is noticeable across all disciplines since the 1980s (Fanelli & Larivière, 2016). In the areas of the natural sciences and engineering, INAP and subsequent hyperauthorship, — “multiple authorship,

¹ Hosseini & Gordijn define ethical issues related to authorship as “questions and/or concerns about obligations, values or virtues in relation to reporting, authorship and publication of research results” (2020, p. 274). This understanding is broader than a traditional interpretation of ethics of authorship that mainly concerns “who deserves author status, authorship order, and abusive authorship practices” (ibid.).

² For instance, “in a sample of 2,101 scientific papers published between 1665 and 1800, Beaver and Rosen found that 2.2% described collaborative work. Notable was the degree of joint authorship in astronomy, especially in situations where scientists were dependent upon observational data” (Cronin, 2001, p. 560).



Fig. 1 Factors contributing to an Increase in the average Number of Authors per Publication (INAP)

in extremis”— (Cronin, 2001, p. 562) is more pronounced than in other disciplines (*ibid.*). However, this analysis will not focus on disciplinary differences and will explore the trend of INAP more broadly.

Across various research areas, at least six different factors are believed to have contributed to INAP (see Fig. 1). The first three factors could be considered as ethically unproblematic as they are inevitably related to the increased complexity and scale of modern science. The fourth and fifth factors are ethically questionable as they are due to perverse incentives. The sixth factor, however, is based on noncompliance with codes of conduct and a lenient approach to authorship guidelines and is considered to be unethical.

1. The methodological and technological complexities of contemporary science are often seen as one of the driving forces of INAP. Researchers with different skill-sets from diverse disciplines are required to tackle the complexities of answering multifaceted research questions (Zietman, 2017) or analyzing big data sets (Hammer & Miaskowski, 2017). Collaboration across disciplines constitutes a positive development, but it inevitably results in more diversity in terms of author roles and increases the number of authors (Feng & Kirkley, 2020; Oliver et al., 2018; Zhang et al., 2018).
2. Increased importance and frequent recognition of various technical roles that warrant authorship status (e.g., because they make a substantial contribution to projects) has also been a contributing factor to INAP (Shapin, 1989; Welker & McCue, 2007). The role of technology (notably of large and complex technologies that require a range of technicians to operate) explains why INAP is more pronounced in research areas that are highly dependent on expensive machinery used by large teams (Birnholtz, 2008), such as high-energy physics (CERN) or genomics (high-throughput sequencing).
3. Due to the transformation of scientific practice into a “large-scale” international enterprise (Zwart, 2008 p. 287), driven by, for instance, industry funding (Resnik, 2007) and economic instrumentalization (Radder, 2010, pp. 7–8), collaborative projects necessitate, and have more resources to recruit, greater numbers of inter-

- national researchers from a broader range of academic disciplines (Gibbons et al., 1994, p. 146). Simultaneously, the coordination of ever-larger, increasingly internationalized, and more diverse project groups demands greater numbers of project coordinators, supervisors, project managers and principal investigators (Alberts, 2010; Charlton, 2008), all of whom are potential co-authors.
4. Institutional pressures exemplified by performance assessment criteria (Du & Tang, 2013), as well as the push to increase institutional publication-counts, are also seen as contributing to INAP (Larivière et al., 2015). Among other factors, institutional publication records are often linked to higher education research assessments and institutional rankings, which can directly affect public and private funds received by universities (van Raan, 2005). As such, it is *pro tanto* rational for universities to prefer to hire prolific researchers and push their current researchers to be more productive.
 5. The achievement of most (if not all) personal and professional objectives in academia, including funding acquisition and resource allocation (Bornmann et al., 2008), tenure, promotions, salary increases and enhancements in academic status, requires publications (Biagioli & Galison, 2003, p. 2). In this environment, although the sheer number of publications is not the only important factor for success,³ academics who publish more papers (especially as first authors) are more likely to succeed (Resnik, 2010). Senior researchers are reported to be aware of this dynamic and prone to push graduate students to get first-authored publications “to be competitive for postdoctoral positions and then for their careers as faculty members or other scientists” (Louis et al., 2008, p. 103). Hence, it is *pro tanto* rational for more researchers to prefer to become equal first authors (Conte et al., 2013) or to make smaller contributions to more publications involving more co-authors than larger or more time-consuming contributions to fewer publications involving fewer contributors (Mongeon et al., 2017).
 6. In general, crediting those who do not meet authorship criteria (Drenth, 1995; Kapoor et al., 2015; Kumar, 2018), including those who should be mentioned in the acknowledgement section (Rennie & Flanagan, 1994), is an unethical practice that has contributed to INAP. Among other unethical practices, crediting “senior faculty members who had little or no contact with the work” (Kastor, 1984, pp. 7–8) with authorship status is believed to distort a healthy academic environment (Greenland & Fontanarosa, 2012).

Among studies that have analyzed INAP, some have focused their attention on specific disciplinary contexts, measuring, for instance, the growth in the average number of authors in a specific discipline or among certain journals (Kapoor et al., 2015; Papatheodorou et al., 2008; Tilak et al., 2015). Whilst these studies have quantified INAP, they have not adequately analyzed the ethical implications of

³ Although peer reviewed publications remain the marker of academic accomplishment, recent research shows that there are nuances in terms of evaluation of researchers in various disciplines. Other factors include departmental journal lists (Bales et al., 2019), impact factor (McKiernan et al., 2019), the number and amount of funded grants (Moher et al., 2018).

this phenomenon beyond the claim that it represents authorship inflation and could have resulted from increased pressure for publication as well as honorary and guest authorship practices.

By contrast, others have investigated INAP within the broader context of the changing dynamics of research environments, raising concerns about the implications of this phenomenon for the ethical conduct of science and the integrity of research. For instance, Biagioli (2003) highlights the challenges of using authorship definitions in large-scale collaborative research. Whilst acknowledging that INAP is a (natural) side-effect of the modern conduct of research, he notes its effects on individual responsibilities and the ways in which these are diffused when more researchers are credited with authorship for a single publication (Biagioli, 2003, pp. 261–264).

In the following section, we extend Biagioli's analysis by exploring the impact of INAP on a range of known ethical issues related to scholarly authorship.

INAP's Impact on Known Ethical Issues of Authorship

The most recent review of the literature regarding ethical issues related to scholarly authorship (Hosseini & Gordijn, 2020) provides a list of ten common issues. In what follows, INAP's impact on each of these issues is explored. It should be noted that these explorations and provided examples are not meant to suggest that various ethical issues related to authorship are *caused* by INAP. Our main argument is that these ethical issues could be *exacerbated* by INAP and we show this using various examples and logical inferences.⁴ The rationale for this ethical exploration is that in virtue of being aware of the possibility of transgressions, researchers and research institutions can take precautionary measures and adopt best practices to minimize their likelihood.

Attribution of Credit

Discussions about the attribution of credit pertain to the recognition of contributions, the requirements for authorship status and explicit acknowledgement. Whether credit should take the form of authorship status or acknowledgement often depends on the type of contribution (e.g., data analysis versus administrative support) and/or the degree of contribution (e.g., significant versus insignificant). Authorship definitions that require substantial contributions to specific tasks (e.g., data analysis) to warrant authorship status demand that contributors who do not fulfil these conditions to be recognized as deserving of acknowledgement (Hosseini & Lewis, 2020). In the presence of more collaborators conducting diverse roles, the process of clarifying whether a contribution is

⁴ As one of the anonymous reviewers noted, in some cases, increased number of authors reviewing a paper could reduce biases and help identify mistakes by increasing the likelihood of having more 'good apples'. That said, Borenstein and Shamoo argue that INAP "diminishes the likelihood that the respective contributions of each collaborator have been reviewed by other research team members" (2015, p. 270).

directly related to tasks deemed to deserve authorship and whether individual contributions are “substantial” is likely to be more complex and prone to tensions. For example, it is not immediately clear whether data curation or data visualization should be considered as part of data analysis and, accordingly, whether they qualify their contributors for authorship. Furthermore, since various tasks might take dissimilar amounts of time or involve different types of effort/risks, the extent of contribution would always be a contentious subject between those who contribute to the same task at different times and to varying degrees. For example, in terms of substantial contributions to the task of data collection, while collecting samples in various subdisciplines of earth sciences might involve months of fieldwork, sleeping in rough conditions and hard manual labor, tasks such as planning, supervising or facilitating sample collection (arguably as vital to the completion of data collection processes) are more glamorous and involve less physical effort.

For projects that involve numerous members contributing to different tasks to different degrees, contributions to task types (e.g., data curation or data visualization), which are neither explicitly mentioned as deserving of authorship nor decisively a task that should be acknowledged, will generate a *grey area* between authorship status and acknowledgement credit. As the number of contributors increases and more researchers contribute to ever more specialized tasks to various extents, the grey area will expand, thereby complicating a fair attribution of credit.

Violations

Discussions about the violations of the norms of authorship are centered around two main issues: (1) the difference between severe violations (e.g., fraud) and questionable practices (e.g., the exploitation of junior researchers); and (2) the means to prevent these violations. According to Youtie and Bozeman (2014), INAP complicates and exacerbates violations of the norms of authorship in three distinct ways. First, it increases the likelihood of having a “bad apple” in the team (*ibid.*, p. 958). Second, it necessitates greater levels of monitoring and, thus, strains the trust-based dynamic of science. Third, it increases the likelihood of interpersonal conflicts. In turn, the presence of more authors complicates the implementation of proposed solutions to address these issues. For instance, the increased likelihood of ‘bad apples’ and conflicts will require greater levels of research monitoring and supervision as well as greater levels of involvement from human resource departments, research ethics committees and research integrity offices if and when violations occur. In addition, promoting and enforcing authorship guidelines (Lissoni & Montobbio, 2015) and educating researchers on good authorship practices (Cabral et al., 2015; Fang et al., 2012) will require more resources. Furthermore, if affiliated authors operate in institutions and countries where different regulations with dissimilar definitions (e.g., of misconduct) apply, violations may prove to be more difficult to investigate and resolve (Desmond & Dierickx, 2021).

Bias

Ethical issues related to bias in authorship tend to be framed as either financial or non-financial conflict of interests (COIs). The main type of ethical issues associated with financial COIs are so-called *value biases*. The values of funders—whether disclosed/ostensible or not—can influence any research project, from the research questions posed to the way they are framed, from decisions about what data to collect to methods of gathering and processing that data, and from the inferences drawn to the reporting and dissemination of results (Douglas, 2014; Lewis, 2020). To the extent that INAP increases the likelihood of the receipt of funds from different funding organizations, it exacerbates the difficulties of tracking the sources of funds (IWCSA Report, 2012), and in cases where “the effectiveness of funding restrictions is varied in extraterritorial regulation” (Skene, 2007, p. 244), it fosters conditions for the exploitation of legal loopholes. For example, in the US, “if the research is supported *solely* by federal funding, the US regulations must be obeyed; if scientists receive non-federal funding, they can do research that would otherwise be prohibited” (ibid. [emphasis added]). Furthermore, the presence of more authors means that funding negotiations, processes for attributing funding acquisition responsibilities, and plans for budget expenditure become more complex and contentious.

In terms of non-financial COIs, Borenstein and Shamoo (2015) have argued that INAP most visibly affects the use of language. Contributions to the writing process can vary significantly, with different contributions occurring at different times. While junior and early-career researchers often perform a substantial role in the creation of the initial drafts in large-scale projects, the review and revision process is slightly more disorganized as some contributors may only leave relatively few comments, whilst others may provide substantial additions, revisions and suggestions. Thus, as the number of individuals specifically involved in developing a manuscript increases, it can become more challenging to identify which individuals contributed to specific parts or (problematic) words within the text. This ambiguity could be particularly problematic in terms of instances of language bias (e.g., exaggerated or equivocal phrasing of claims). In addition, according to Borenstein and Shamoo, INAP “diminishes the likelihood that the respective contributions of each collaborator have been reviewed by other research team members” (ibid., p. 270), potentially undermining the reliability or coherence of claims and leading to the miscommunication of ideas. Furthermore, to the extent that power imbalances exist between junior and senior researchers in large-scale projects, more junior researchers can find that they have relatively less authority to determine the expression of ideas and claims in their final form. Therefore, not only can INAP facilitate conditions for the unequal distribution of power such that a relatively small number of the contributors disproportionately influence the expression of ideas and claims, but also an absence of equitable engagement with the writing process can generate issues regarding responsibility and accountability for published claims, as we shall now explore.

Responsibility and Accountability

In authorship debates, ethical issues about responsibility and accountability are focused on ambiguities in relation to individual and overlapping responsibilities in collaborative projects and challenges of clarifying mentors' supervisory responsibilities. Research ethics experts stress that authors of scientific papers need to be held accountable for their part in the work and the paper as a whole (Resnik, 1997). This approach has been adopted within key guidelines for authorship, issued by, for instance, the International Committee of Medical Journal Editors (ICMJE). When more authors are listed in the byline, it is more difficult to hold individuals accountable for the content of publications (Mongeon et al., 2017; Resnik & Master, 2011), because individual responsibilities are diffused when more authors contribute to the same tasks, thereby leading to overlapping responsibilities (Institute of Medicine, 1993). In other words, with an increase in the average number of authors, it is more likely that no single person will be able to assume full responsibility for a specific claim in relation to a specific task (e.g., research design, data collection, data analysis, literature review), or in relation to a specific section of the paper (e.g., introduction, results, discussion, concluding remarks). If responsibilities for published claims are diffused across a number of individuals, then such claims cannot be explicitly associated with unique names or defined in "strictly individual terms" (Biagioli, 1999, p. 12). Similarly, in the presence of more authors, holding researchers accountable for the social consequences of research would be much more complicated. The point is that the association of claims and their consequences to individual names is needed for accountability purposes, so that if applicable, specific individuals can "act as spokesperson[s] in the face of a liability suit" (Cronin, 2001, p. 562). However, when more researchers contribute to different tasks, it becomes increasingly difficult for individual researchers to assume responsibility for the published work as a whole (e.g., as required by the ICMJE guidelines).⁵

Senior researchers, project coordinators and principal investigators also have responsibilities for the guidance, mentoring, and training of early-career researchers during the process of authorship (Bozeman & Youtie, 2016; Syed et al., 2015), the supervision and monitoring of individual and collective tasks and the development of effective collaborations between involved parties (Kremenak, 2010; Ludvigsson et al., 2018). In the presence of more co-authors, especially when they are based in different institutions across different countries, the coordination of these tasks becomes more challenging.

⁵ ICMJE's fourth criteria for becoming an author requires authors' "Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. In addition to being accountable for the parts of the work he or she has done, an author should be able to identify which co-authors are responsible for specific other parts of the work. In addition, authors should have confidence in the integrity of the contributions of their co-authors" (ICMJE, 2019, p. 2). When there are more authors who conduct a diversity of tasks, the likelihood that all authors would know/understand what others in their team have done is significantly lower. Accordingly, one can claim that the willingness to take responsibility for tasks conducted by researchers whom they hardly know (if at all) would also be lower.

Authorship Order

Although different disciplines have different conventions for listing authors' names, "certain positions such as first, last, and the corresponding author are highly coveted and considered more valuable" (Smith & Master, 2017, p.2).⁶ Consequently, determining the order in which authors are listed is particularly important, so much so that in some contexts authors may share first or last positions, calling themselves equal co-authors (Hosseini & Bruton, 2020). With more authors, ranking them becomes more troublesome because more researchers would be interested in occupying prime positions (Strange, 2008). Since credit and status vary depending on the occupied position, the byline is an *irregular* continuum, whereby the extreme ends of the scale are considered to be the most valuable, and the status of the positions in between the two poles varies in relation to their degree of proximity to the most coveted positions. INAP leads to an increase in the shades of grey on the continuum of authorship order, making it more difficult to specify which place should be occupied by each co-author.

Citations and Referencing

In terms of citation practices, excessive self-citation (Fong & Wilhite, 2017), involvement in so-called citation cartels (Zietman, 2017) and self-plagiarism (Vasconcelos & Roig, 2015) are among ethical issues that can be exacerbated by INAP. Longer bylines and international collaborations increase the likelihood of self-citation at a document level because more authors can cite their previous publications to improve the (international) visibility of their work (Costas et al., 2010). Although the average number of authors vary per discipline and overall have a moderate effect on self-citations (Glänzel & Thijs, 2004), research areas such as nuclear and particle physics, astronomy and astrophysics, which produce papers with a high number of co-authors, are shown to have significantly higher number of self-citation averages (Noorden & Chawla, 2019). Involvement in citation cartels (i.e., teaming up with a set of co-authors to cite each other's publications) is arguably more likely to occur within larger groups of co-authors because "papers which tend to cite collaborators will also tend to cite collaborators of collaborators" (Wallace et al., 2012, p. 9).

It should be noted that self-citations and citation cartels are explored cautiously in the literature, because there might always be legitimate reasons to cite one's own work (e.g., continuity) or that of specific authors (e.g., collaborative networks working on particular research questions) without any malicious intent. Although the extent and prevalence of self-plagiarism vary across disciplines (Sun, 2013), by creating the conditions for more overlapping authors and supervisors to recycle text from their previously published material (Anson & Moskovitz, 2021), INAP could increase the likelihood of self-plagiarism and text-recycling.

⁶ Disciplines where alphabetical ordering is the norm are an exception (e.g., economics).

Definition of Authorship

INAP has triggered complicated questions about the definition of authorship and has made these definitions problematic to use in practice (Claxton, 2005). The complexities of generating a single, common and widely accepted definition that can be consistently employed to award authorship status to those involved in specific tasks (e.g., conceptualization, data collection and analysis) has contributed to the development of inconsistent definitions with different prerequisites for authorship status (Hosseini & Lewis, 2020). Although various authorship definitions have been developed to tackle broader ethical issues associated with research, many experts consider these criteria as appropriate means to reduce INAP and mitigate abusive practices such as gift/honorary authorship (Baerlocher et al., 2007; Bebeau & Monson, 2011; Eisenberg et al., 2018; Garcia et al., 2010).

First developed in 1988, the ICMJE guidelines were the first to achieve wide acceptance among various journals (Claxton, 2005; Leash, 1997). Despite continuous revisions to the ICMJE criteria in the past few decades (Huth & Case, 2004), it was found—through an analysis of 87,002 documents—that the requirements for authorship are rarely met by all co-authors (Larivière et al., 2016).⁷ It is argued that a strict application of the ICMJE criteria prevents the attribution of authorship credit for many types of contributions that are commonly seen as necessary for the conduct of research projects (Larivière et al., 2016). By contrast, too much leniency in the application of these criteria attributes authorship credit to those who do not deserve it (Cronin, 2001). The application of the definition of authorship is, in principle, much more complicated in projects where more authors are contributing to increasingly intertwined and interrelated tasks.

Publication Strategy

Strategic behaviors in publication can be best understood using Jürgen Habermas's notion of strategic communication, which describes forms of communication aimed at gaining power and domination (Habermas, 1996). In the authorship context, behaviors associated with strategic communication look to increase the chances of publication, enhance its visibility, drive metrics, claim priority, and prevent the competition from catching up (Hosseini et al., 2020), all of which are at odds with the prime goals of conducting research, that is, to extend certified knowledge (Merton, 1973) and improve understanding within the scientific community (Habermas, 1971).

Some of these behaviors may include partial disclosure of methodologies and results, rushed or delayed publication of results, publication in irrelevant journals (e.g., merely because of higher impact factor), and cherry-picking collaborators (e.g., based on their impact or demographic/institutional privileges instead of

⁷ These conclusions give rise to concerns claiming that the ICMJE criteria are not an ideal fit for modern research practices (Kornhaber et al., 2015; Moffatt, 2013; Nylenna et al., 2014) or worse, not operationalisable and ignored by research groups (Göttsche et al., 2007).

their expertise). These decisions are usually made to advance authors' interests. As a result of INAP, the interests of more authors are at stake. Consequently, it will be more difficult to align and accommodate these interests and in cases where the interests of some co-authors are not satisfied, project groups might take decisions that would have not been taken with fewer co-authors. For example, in terms of accommodating special authorship arrangements (e.g., equal-first authorships), since more authors bring in a wider gamut of situations and interests with them, project groups might simply change the publication outlet in cases where these interests are not fully accommodated by a relevant target journal (Hosseini & Bruton, 2020). The ethical issue being that personal interests and preferences about how names should appear in the byline could be prioritized over more significant issues such as the publication outlet. When it comes to the time of publication, some authors might prefer to delay the publication of life-saving data and results to retain claims of priority as was shown by some projects that worked on the COVID-19 virus (Marcus & Oransky, 2020). In relation to the disclosure of used data and methodologies, when more authors are involved, some who are funded by organizations of different nature (e.g., public, private) might have different preferences towards the full disclosure (e.g., some might prefer to limit availability and access to used methods or data, and consequently, hamper the likelihood of reproducibility) as was shown during the early 2000's rush to sequence the human genome (Resnik, 2007, p. 16) and in clinical trials to test the Russian COVID-19 Vaccine (Logunov et al., 2021).⁸

Originality

Discussions about originality are concerned with the noteworthiness of data and results as a prerequisite for publication. All other things being equal, greater numbers of authors affect how the claim to originality is perceived by readers and members of the scientific community. While team science researchers shows that smaller teams are more likely to produce radical and disruptive research (Azoulay, 2019; Osório & Bornmann, 2021), the presence of more authors could falsely imply that more work has gone into a paper or that the research and its overall conclusions are more significant. Alternatively, one might interpret the presence of greater numbers of authors as undermining the originality of individual contributions on the basis that the work has been divided between more contributors.

Furthermore, in cases of salami-publication or data-massaging, the presence of more authors can contribute to the inflation of authorship credit as more researchers can benefit from undeserved authorship status. In the context of INAP, these practices unfairly enlarge the scholarly record with potential implications for the

⁸ The data sharing statement provided by those who conducted clinical trials for the Gam-COVID-Vac (Sputnik V) notes: "Anonymous participant data will be available upon completion of clinical trials and publication of the results of the completed study upon request to the corresponding author. Proposals will be reviewed and approved by *the sponsor, security department, researcher, and staff* on the basis of scientific merit and absence of competing interests. Once the proposal has been approved, data can be transferred through a secure online platform after the signing of a data access agreement and a confidentiality agreement" [emphasis added] (Logunov et al., 2021, p. 681).

perceived professional and academic statuses of the authors involved (Smolčić, 2013). In addition, as result of the links between publication and institutional metrics (van Raan, 2005), INAP confounds university rankings in favor of those that have a strong focus on disciplines with high average number of authors (e.g., Physics), larger networks and more publications for reasons other than scientific merit (e.g., access to better sources of funding). As such, while some universities could be publicly perceived as being at the forefront of original science, this may not be always accurate.

Sanctions

Ethical discussions about sanctions focus on the appropriateness and proportionality of different forms of punishment in response to ethical transgressions. To the extent that INAP exacerbates the ethical issues related to violations of ethical norms, it complicates the sanctioning process in three ways. Firstly, an increase in the number of authors could lead to a more diverse range of violations, requiring a more diverse range of investigatory responses and, accordingly, more rigorous requirements and larger resources to enforce sanctions.

Secondly, since all co-authors have a collective responsibility for scholarly articles, there are increased complexities in sanctioning a larger group of authors. As stipulated by ICMJE's fourth criterion for authorship, all authors agree "to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. In addition to being accountable for the parts of the work he or she has done, an author should be able to identify which co-authors are responsible for specific other parts of the work. In addition, authors should have confidence in the integrity of the contributions of their co-authors" (ICMJE 2019, p. 2). However, since all authors are rarely *equally* engaged in, or informed about all tasks, processes and decisions, a broader spectrum of sanctions is required to deal with violations associated with publications with more authors.

While the norms surrounding author responsibility and accountability highlight the importance of linking specific contributions to individual names (Biagioli, 2003; Cronin, 2001), when it comes to sanctioning, spectrums of authority, engagement and access to information (which grow with INAP) impact authors' responsibilities, thereby complicating the determination of sanctions. Since international guidelines also demand that each author is responsible for the tasks conducted by their co-authors,⁹ in principle, all authors are liable for violations committed by their co-authors. Although co-authors might not always be sanctioned for misconduct committed by their collaborators (e.g., Gerald Schatten was charged with negligence, but he was declared innocent of misconduct committed by Woo Suk Hwang (Holden, 2006)), they might be negatively affected due to others' mistakes as a result of, for example, discontinuation of funding, retractions or loss of reputation.

⁹ For instance, the European Code of Conduct for Research Integrity notes that "all authors are fully responsible for the content of a publication, unless otherwise specified" (ALLEA, 2017, p. 7).

Thirdly, to the extent that INAP potentially increases the number of institutions associated with a publication, it exacerbates the inconsistent application of sanctions. The fact that cases of misconduct and sanctioning processes are dealt with differently in different institutions and countries (e.g., sanctions are suggested by governmental bodies in China and could take the form of “legal, administrative, disciplinary or academic sanctions, with the possibility to combine them” (Li & Cornelis, 2020, p. 305)), means that the same evidence could result in altogether dissimilar sanctions for co-authors with identical roles and responsibilities (Yeo-Teh & Tang, 2021). Moreover, a growing number of authors affiliated with two or more universities (Huang & Chang, 2018), further exacerbates the aforementioned complexities.

Discussion

After exploring the impact of INAP on known ethical issues of scholarly authorship, we now extend the discussion to its potential long-term effects on the reward system of science and different parties involved in scholarly publications. Our aim is to safeguard important ethical components of responsible authorship from erosion and inflation, focusing on concrete tools and options for best practice.

INAP and the Value of Authorship Status

In making the claim that INAP depreciates the value of authorship status, we invoke an economical interpretation of the term “inflation”.¹⁰ In the field of economics, inflation refers to a fall in the purchasing value/power of money, measured over a period of time.¹¹ For experts such as Biagioli (2003), who posit the idea that INAP does not directly affect the value of authorship, there is an important distinction to be made between inflation as understood by economists and inflation due to INAP:

“A coauthored scientific publication makes for a very unusual pie whose features resist, in different ways, what both the ICMJE and its critics would like to do to it. Surprising as it may sound, *cutting it in thin slices does not necessarily reduce the value of each slice*, but it also leaves that value undetermined. As a result, multiauthorship does not produce credit inflation (as the ICMJE fears), nor does it allow for a quantitative division of the ‘shares’ (as the critics would like)” [emphasis added] (Biagioli, 2003, p. 263).

¹⁰ By appealing to an economic interpretation of inflation, we do not wish to suggest that we are equating INAP with the concept of “authorship inflation”. As we have already mentioned, authorship inflation is commonly construed as unethical due to its association with, for example, guest and honorary authorship.

¹¹ Inflation is the rate at which the general level of prices for goods and services is rising and, consequently, the purchasing power of currency is falling. Source: <https://www.investopedia.com/terms/i/inflation.asp>

The key point for Biagioli is that INAP does not necessarily lead to credit inflation. We agree with Biagioli's specific claim that INAP does not determine the value of each authorship credit when a piece of research is first published. At the moment of publication or, indeed, in the development of a manuscript, authors will *not* be in a position to determine reliably the value of each authorship credit because the value is, in part, dependent on the reactions of the research 'market'. However, given that a co-authored publication grants each contributor an authorship credit, the value of a co-author's individual authorship credit will change *over time*. Indeed, the value of an authorship credit will become more apparent the longer the publication is circulated in the public and research domains. For instance, research conducted by Fox and colleagues (2016) shows that, in the field of ecology, papers with more authors are likely to receive more citations. In addition, citations in general tend to increase per each additional author, within the fields of economics and business studies (Didegah, 2014). Hence, given that citation rates, in part, determine the value of a publication, INAP, to the extent that it increases citation counts, increases the value of each co-author's authorship credit (*ceteris paribus*).

Nevertheless, due to INAP, researchers working predominantly in disciplines where multi-authorship is taken to be the standard for academic publishing will, over time, own ever greater numbers of authorship credits resulting from different publications. Some or, indeed, most of these researchers will assume mid-to-long-term positions in academia. The issue here is that because INAP leads to the distribution of more and more authorship credits for each researcher over time, a specific researcher will, relatively speaking, need more authorship credits to gain their desired commodity (e.g., a postdoc, tenure, promotion or full professorship). Thus, *ceteris paribus*, the value of each authorship credit relative to the total number of authorship credits arising from academic publications will depreciate over time. This economic dimension of INAP is best articulated by a scientist interviewed in a recent study, noting that "the inflation of publication expectations in my own field is so severe that job applicants [e.g., for Assistant Professorships] now need to have CVs comparable to the average Associate Professor 15 years ago" (Bruton et al., 2020, p. 1539). Due to the impact of INAP, an authorship credit does not have the same value that it used to have, which may also explain why sometimes authorship is credited too easily (e.g., in cases of honorary or guest authorship).

Furthermore, just as economic inflation does not have an equal effect on all socio-economic groups, INAP can have an unequal effect on researchers in different stages of their careers. It is safe to assume that if the number of authors in the byline increases, the perceived contribution of primary authors (i.e., those who contributed more) is likely to diminish (Vasilevsky et al., 2021). The perceived diminishment of the value of one's contribution may not be as important for established, professionally recognized and financially secure researchers when compared with others. However, those seeking promotion, progress on the academic ladder, or those who are subject to frequent performance reviews will be required to publish more and more as the value of each authorship credit diminishes. Consequently, although INAP may not, in itself, affect the overall value of a specific piece of research at the moment of publication, most of its negative effects will be shouldered by those on

lower levels of the academic ladder, because of its effect on the value of each authorship credit over time.

The Impact of INAP on Contributors to Non-Author Tasks

Since authorship status is still one of the most valued coins of the academic realm (if not the most valuable), it is extremely difficult to find a balance between over-crediting and under-crediting contributors to non-author tasks (e.g., supervisory, administrative and technical tasks). In the long run, the difficulty in finding a balance between the two extremes is likely to have a negative effect on researchers who make these contributions. As already mentioned, due to the difficulties with defining and employing a single, common and widely accepted definition of authorship, attribution of credit to those who contribute to perceived 'technical' (e.g., surveying a maritime channel to measure depth for geological studies) or administrative support is a complicated matter. Of course, this problem is not helped by diverse and competing guidelines for what constitutes the requirements for authorship (Hosseini & Lewis, 2020). Since contributors to non-author tasks often do not satisfy all the authorship requirements, attributing them with authorship credit is unfair to those who *do* satisfy the authorship requirements (whatever they may be). Hence, strictly speaking, although the attribution of authorship credit to non-author tasks is not as egregious as gift or honorary authorships, they are still unethical. By contrast, according to authorship criteria such as those provided by the ICMJE, supervisory, administrative and technical tasks require recognition in the acknowledgement section of publications (ICMJE, p. 3). However, this form of credit does not come with the sorts of professional benefits that would typically arise from authorship credit because acknowledgements are not collected and registered by common quantitative measures of individual performance such as h-index and citation counts.

So, in one scenario, contributors to non-author tasks receive authorship credit but are not perceived as deserving of this form of credit. In another scenario, they are mentioned in the acknowledgement section, which does not facilitate the same levels of recognition necessary for furthering an academic career. If the former scenario becomes the norm and the majority of these sorts of contribution receive authorship credit, INAP is exacerbated. Accordingly, all contributors to scholarly work including those who contribute to non-author tasks would need more and more authorship credits in order to progress on the academic ladder. If, however, the latter scenario becomes the norm, we are likely to see a two-tier system in the academic workforce, consisting of an elite group of researchers who receive authorship credit and those who are only recognized in the acknowledgement section without receiving major benefits for their work. In the long run, the continuation of this trend could be reflected in increasingly widening discrepancies in the treatment and perceived professional worth of individual researchers as a result of problematic and outdated attitudes towards the nature of certain contribution types. We suggest two approaches that might tackle this problem:

- (1) Further promotion of the CRediT taxonomy and improving how it is used.

CReditT subsumes a range of similar activities under 14 standard roles (e.g., methodology, project administration), thereby providing specific vocabulary to describe common contribution types (Brand et al., 2015). Currently, CReditT has been adopted by major publishers such as Elsevier, Sage, Springer and Wiley (CAS-RAI, 2020), and is also recommended by COPE experts (COPE, 2016, 2019). Furthermore, CReditT roles are formalized as an ANSI/NISO standard (Alves, 2021) and ready to be implemented by ORCID, thus, allowing ORCIDs to be directly linked to the roles specified for publications (Demain et al., 2021).

Since CReditT is currently being used in parallel with authorship lists, it seems to leave adopters and their users confused about author and non-author contributions. CReditT developers note that “roles are intended to apply to all those who contribute to research that results in scholarly published works, and it is recommended that all tagged contributors be listed, whether they are formally listed as authors or named in acknowledgements” (Brand et al., 2015, p. 153). However, since CReditT has not yet been incorporated into journals’ acknowledgement sections (Holcombe, 2019; O’Connell & Harp, 2017), it could, in the long run, reinforce INAP by facilitating the elevation of clearly ‘acknowledged’ contributors to authorship bylines. For instance, despite endorsing the ICMJE criteria for authorship, in explaining how to describe individual contributions, the journal of *PLOS Biology* requires each contributor to be linked to a “*minimum of one contribution*” regardless of whether that contribution was to—what the ICMJE takes to be—a task deserving of authorship.¹² The point is that the CReditT taxonomy is not incorporated into acknowledgement sections and also dovetails commonly-accepted non-author tasks (e.g., acquisition of funding and administrative support), with tasks that have been most consistently associated with authorship credit (e.g., data collection and analysis, drafting the manuscript) under a single *contribution* category. Thus, it could give the impression that (or be employed as if) all of its 14 roles are equally worthy of authorship credit (which is definitely not the case according to the ICMJE guidelines). In order to ensure that these ambiguities are minimized, improving harmony between CReditT and authorship definitions should be prioritized (given disciplinary differences in how research is conducted and published, this could be an opportunity to engage e.g., scholarly associations and societies that advocate for the interests of researchers in specific disciplines with a view to draft domain-specific guidelines). Furthermore, to ensure that author and non-author tasks are recognized appropriately and considered for academic assessments and evaluations, future developments should explore how mentioned contributions in the acknowledgement sections of publications could be captured by CReditT, or how ORCIDs could be incorporated in acknowledgement sections. To support such efforts, platforms such as Rescognito could be considered, which allow researchers to complete their contributor CReditT checklist for published items and ensure that these are linked to their ORCIDs and the DOI of the publication (Rescognito, 2021).

¹² In their instructions to authors, the journal of *PLOS Biology* note “You will enter all author contributions in the submission system if your manuscript is selected for peer review. Provide at minimum one contribution for each author, and use the CReditT taxonomy to describe each contribution. (PLOS Biology, 2020, Paragraph 4).

(2) Adjusting the academic recognition and promotion systems at an institutional level.

In parallel with the previous suggestion, hiring and promotion processes should become less reliant on authorship and, instead, be based on a more diversified set of features. An innovative approach has been suggested in Utrecht University's recognition and rewards vision, which aims to move away from purely quantitative measures. In this new vision, although "quantitative indicators are allowed, they should be supported by narratives and need to be meaningfully related and signal quality of the process and output in relation to the mission, vision and strategy of the team that is the point of reference" (Utrecht University, 2021, p. 6). Other best practices could include the incorporation of CRediT taxonomy into academic assessment workflows as implemented by, for example, the University of Glasgow (Casca & McCutcheon, 2019), or the application of focused tracks to recognize and reward a wide range of contributions, such as the Team Scientists faculty track at the Northwestern University Feinberg School of Medicine, wherein substantial collaborative contributions to the research and/or educational missions of the school are considered for the promotion process. This is facilitated by a "Critical References" form submitted by faculty across all tracks to report and reflect upon candidates' most significant contributions (Vasilevsky et al., 2021, p. 33).

Conclusion

This paper highlighted ethical challenges of the rather recent (relative to the long history of authorship) phenomenon of INAP. In solo-authored works, it is more or less evident what authorship entails. The author is responsible, both for the process and for the output(s) of academic work (e.g., publication), and, thus, is the one who takes credit for the work. In multi-authorship contexts, authorship is linked to a more diverse range of tasks and may entail multiple roles. In such contexts, co-authors may (or may not) make substantial contributions to all aspects of the process and/or output of the work in multiple ways. We notice that in response to an increase in pace, scale, and complexity of research, intense international, interdisciplinary and complex collaborations are necessary, and multiple authorship is an expression of this trend. However, perverse incentives aimed to increase institutional and personal publication counts are ethically questionable. Introducing guest or honorary authors to the byline is wrong and not in compliance with codes of conduct and the ethical norms of authorship. Whether or not it takes the form of authorship inflation, INAP intensifies ethical issues of authorship and depreciates the value of authorship credit in the long run.

From a conceptual perspective, authorship is, and perhaps will always remain in transition. For the scientific community, challenges of authorship (as a concept in transition) involve a dynamic learning process, in which a dialectical narrative curve can be discerned (Hermerén et al., 2019; Todorov, 1977): An initial situation of relative equilibrium (the first moment, the era of single authorship) is disrupted by emerging challenges (e.g., methodological complexities, internationalization), culminating towards a crisis (the second moment, ever-expanding authorship

bylines). Although INAP is not necessarily negative, by recognizing its possible disruptions, attempts could be made to contain and address its potential damage (to which this article aimed to contribute). Rather than deploring such developments, we should see them as the inevitable “second” dialectical moment and as an invitation to critically reconsider the function and meaning of authorship in the current era. Ultimately, the introduction and acceptance of some best practices results in the establishment of a new equilibrium (the third moment), but now at a higher level of complexity, reflecting the lessons learned, enabling the community to address the implications of the transitions that have occurred.

We suggest that although the CRediT taxonomy is more sensitive to the way research practices are evolving, it needs better integration in current systems of attribution and acknowledgement, more harmony with major authorship guidelines such as those suggested by the ICMJE, and better integration into institutional evaluation and assessment processes. Although CRediT is still in its early stages of development and its application in specific cases raises ethical and practical questions, it is reasonable to assume that further mutual learning and distributed reflection among CRediT’s stakeholders will overcome these issues. If it is improved and used correctly by project groups, journals and institutions, CRediT can perform a critical function in assisting with mitigating the practices that drive “authorship inflation”, including perverse incentives and guest and honorary authorship. Furthermore, we propose that adjustments be made to academic recognition and promotion systems at the institutional level with the introduction of best practices that emphasize the significance of qualitative factors in the support of an institution’s mission.

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Conflict of interests The authors declare that they have no conflicting interests.

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