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Honorary Authorship Practices in Environmental Science Teams: Structural and Cultural Factors and Solutions

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ABSTRACT

Overinclusive authorship practices such as honorary or guest authorship have been widely reported, and they appear to be exacerbated by the rise of large interdisciplinary collaborations that make authorship decisions particularly complex. Although many studies have reported on the frequency of honorary authorship and potential solutions to it, few have probed how the underlying dynamics of large interdisciplinary teams contribute to the problem. This article reports on a qualitative study of the authorship standards and practices of six National Science Foundation-funded interdisciplinary environmental science teams. Using interviews of the lead principal investigator and an early-career member on each team, our study explores the nature of honorary authorship practices as well as some of the motivating factors that may contribute to these practices. These factors include both structural elements (policies and procedures) and cultural elements (values and norms) that cross organizational boundaries. Therefore, we provide recommendations that address the intersection of these factors and that can be applied at multiple organizational levels.

KEYWORDS

honorary authorship; inclusive research practices; interdisciplinary teams; research ethics; team science

Introduction

For many years, inappropriate authorship practices have been a central concern of scholars studying the responsible conduct of research (see e.g., Rennie and Flanagin 1994; Resnik 1997; Shamoo and Resnik 2015). One of the most significant problems is honorary authorship (sometimes also called courtesy, gift, guest, or prestige authorship), which occurs when an individual who did not make adequate contributions to be included as an author

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on a paper is listed as an author anyway (da Silva and Dobránszki 2015; Greenland and Fontanarosa 2012).[1] A contrasting problem is ghost authorship, which occurs when an individual who contributed significantly to the paper—often by writing the manuscript—is not listed as an author (Moffatt and Elliott 2007; Sismondo 2007). Additional ethical problems related to authorship include deciding how to assign responsibility when errors are uncovered and determining how to order multiple authors (Claxton 2005). Many of these problems have been exacerbated by the increasing number of large, interdisciplinary research projects being performed by teams that include many coauthors who may have different norms surrounding authorship (Cronin 2001; Greenland and Fontanarosa 2012; Smith and Williams-Jones 2012).

Despite widespread discussions about problematic authorship practices, there has been little qualitative research designed to uncover the range of pressures and motivations that contribute to these problems. A systematic review performed by Marušić, Bošnjak, and Jerončić (2011) indicated that most studies of authorship practices have consisted of surveys or literature analyses; very few have involved qualitative research to uncover potential motivations behind the observed behaviors (e.g., Birnholtz 2006; Louis et al. 2008; Street et al. 2010). Moreover, the vast majority of studies have examined the health sciences and social sciences, with less attention to the natural sciences, and particularly the environmental sciences (Marušić, Bošnjak, and Jerončić 2011). Smith and Williams-Jones (2012) have called for more empirical research across a range of academic disciplines to develop a more accurate understanding of different authorship practices. Marušić, Bošnjak, and Jerončić (2011) also emphasized that there has been little research to identify the solutions that are most effective at resolving problematic authorship practices.

In order to address some of these major knowledge gaps about authorship practices and the factors that influence them, we conducted a qualitative analysis of authorship practices used by environmental science teams. We explored the motivations, personal experiences, and pressures that contributed to the teams' authorship practices by interviewing a lead principal investigator (PI) and an early-career member from six National Science Foundation (NSF)-funded interdisciplinary environmental science teams. We asked a series of questions about formal policies and informal practices related to authorship. Invoking the desire to be inclusive and generous, most teams engaged in problematic overly-inclusive authorship practices that fit the definition of honorary authorship (i.e., including authors who do not meet the criteria described in authorship policy statements

[1]Gift authorship and guest authorship are sometimes distinguished, with gift authorship focusing on the addition of authors in order to improve the appearance of their research output and guest authorship focusing on the addition of authors in order to increase the likelihood for a paper to be published (da Silva and Dobránszki, 2015). For the purposes of this paper, the term "honorary authorship" will be used to describe any circumstance in which authors are added to a publication despite not fulfilling the criteria for authorship.

produced by journals or scholarly societies). A number of factors appeared to contribute to such honorary authorship practices, and several of these factors involved "cultural" aspects of the teams. For example, team members desired to avoid conflict, team leaders had minimal training for managing large teams, and early-career team members had limited power to influence team decisions. Given these cultural factors that may contribute to honorary authorship practices, we argue that comprehensive approaches for alleviating these practices should not be solely structural (such as creating more explicit authorship policies), but rather ought to simultaneously address both cultural and structural aspects of interdisciplinary science teams.

Challenges related to honorary authorship

There are many different ethical issues associated with authorship (e.g., deciding how and when to disclose potential conflicts of interest and avoiding deceptive practices such as falsification or plagiarism), but the allocation of appropriate credit and responsibility is a particularly high-profile issue (Claxton 2005; da Silva and Dobránszki 2015; Seeman and House 2010). This allocation has become a challenge in part because there are many different tasks involved in producing a scientific research paper and because the number of authors on scientific papers has been increasing (Cronin 2001). Thus, it is not always safe to assume that all authors are playing the more traditional role of writing large portions of the manuscript (Borenstein and Shamoo 2015; Marušić, Bošnjak, and Jerončić 2011). Contributing to this problem is the fact that author lists frequently do not provide enough information for readers to determine the precise role that each author played in the development of the research project (Borenstein and Shamoo 2015; Dance 2012). Therefore, it is often difficult for research teams to decide who deserves to be included as an author on a research article, and it is confusing for readers to determine how much credit to give to all the authors.

Honorary authorship is one of the major problems that have arisen as a result of these allocation ambiguities. It can happen because supervisors pressure their subordinates to include them as authors on papers even when they have not contributed or when the authors of a paper try to add a prominent individual as an author because they think it will make the paper more likely to be accepted (Greenland and Fontanarosa 2012). The results that we present here indicate that honorary authorship can also occur when research teams decide to err on the side of including extra people as authors to promote team cohesion or to avoid difficult decisions about who deserves to be an author. In several recent analyses of medical and nursing journals, rates of honorary authorship appeared to be exceptionally high, ranging from approximately 20% to 50% of published articles (Eisenberg, Ngo, and Bankier 2013; Eisenberg et al. 2011; Kennedy, Barnsteiner, and Daly 2014; Kornhaber, McLean, and Baber 2015; Wislar et al. 2011).

A challenge closely related to honorary authorship is assigning authorship order and author credit (Borenstein and Shamoo 2015). Even if all authors meet the minimum authorship criteria, some may deserve much more credit than others. In many fields, the first and last authors are given particularly significant credit, but this is not always the case (Dance 2012). The authors in between first and last place are often listed in descending order of their contribution, but in some fields, such as economics, authors are typically listed alphabetically (Waltman 2012). Not only are the implicit norms surrounding the ordering of authors often opaque, but research teams may run into conflict about how to apply those rules (Dance 2012). This difficulty can become especially acute when interdisciplinary teams incorporate large numbers of authors from different disciplines that vary in typical authorship practices (Smith and Williams-Jones 2012).

It is complicated to address these problems in part because professional societies and journals have different authorship policies (Claxton 2005), and authorship expectations vary across countries and disciplines (da Silva and Dobránszki 2015). In many cases, these differences are not particularly significant, but there are some noteworthy differences. For example, according to the American Chemical Society, authors should be "those persons who have made significant scientific contributions to the work reported and who share responsibility and accountability for the results" (ACS 2015). This policy does not require that an author be involved in drafting the paper. In contrast, the International Committee of Medical Journal Editors (ICMJE) specifies that authors should not only make substantial contributions and take accountability but should also be involved in "drafting the article or revising it critically for important intellectual content" (ICMJE 2016). This does not appear to be an isolated difference; a recent review of journal guidelines and society ethics codes found that almost all journals required all authors to be involved in both research and writing, whereas two-thirds of society ethics codes required only involvement in research (Bošnjak and Marušić 2012).

In order to develop more complete solutions for addressing authorship problems, it is important to understand why the members of scientific teams make the authorship decisions that they do. Large-scale surveys of scientists can reveal the frequency of practices such as honorary or ghost authorship, but they are not ideal for uncovering the underlying motivations that generate these practices. Previous qualitative research has helped to discover some of these motivational factors, such as implicit norms, the complexities of working on large teams, and problematic reward and career structures (Birnholtz 2006; Street et al. 2010). However, only a very small portion of the existing literature on authorship practices has involved this sort of qualitative research (Marušić, Bošnjak, and Jerončić 2011). Our study provides a deeper understanding of the factors that contribute to inappropriate authorship practices, with the goal of developing a more comprehensive set of solutions to these problems.

Methods

We present data gathered from 12 interviews conducted with individuals who were members of interdisciplinary environmental science teams. We randomly selected six teams from three NSF environmental science funding programs, and interviewed two individuals from each team—a project PI and an early career (EC) member (e.g., graduate student, post-doc, or assistant professor). All six PIs were White men who were senior scholars (average age = 54.14 years, *SD* = 8.67 years), five of whom were U.S. citizens. The EC participants were comprised of 3 White women, 1 woman of color, 1 White man, and 1 man of color. They were graduate students (n = 2), post-docs (n = 2), or assistant professors (n = 2) at the start of the project (average age = 35.29 years, *SD* = 8.10 years), and four were U.S. citizens.

Using Zoom virtual meeting software, we conducted audio- and video-recorded one-on-one interviews that lasted 1–1.5 hours. All PIs were interviewed by a faculty member in Psychology, and all EC participants were interviewed by a graduate student in Education. The interview questions examined team policies, practices, and norms regarding authorship, data/materials sharing, and mentoring. The authorship questions that provided the basis for the current study included: "Does your team have any formal policies (or informal guidelines) regarding how you assign authorship?" "Do you think that formal policies about authorship are/would be helpful?" "Has your team experienced any tensions or difficult decisions related to authorship practices?" "What are your experiences with honorary authorship on this team?" and "Have you given honorary authorship or received it?"

Interviews were transcribed verbatim from the audio/video-recordings, checked by a graduate research assistant, and identifying information was removed. The data were coded by two graduate student research assistants using an inductive, thematic analysis (Braun and Clarke 2006; Gibbs 2007) and NVIVO qualitative data analysis software. We began with broad concept-driven codes based on the existing literature and our research questions (e.g., Do teams engage in honorary authorship?). However, from the relevant text related to the concept-driven codes, we engaged in open coding of participant responses, assigning meaning to phrases and sentences. From these open codes, we developed broader categories comprised of similar or related codes. Finally, the categories were organized into higher-order themes. In the results, we first describe the authorship policies and practices of each team. Second, we present the categories that emerged for our two main themes: "Nature of Honorary Authorship Practices" and "Factors Contributing to Honorary Authorship." Quotes are presented with minor edits (i.e., removing false starts, "um," "like," "you know") for the sake of clarity.

Results

Our interviews revealed important information about the *content* of the policies and practices employed by these six environmental science teams, the *nature* of honorary authorship practices they engaged in, and the motivating *factors* that appeared to contribute to honorary authorship practices. To some extent, the content of the policies and practices was intertwined with the factors that motivated honorary authorship, so some shared elements are described in those sections below.

Content of team authorship policies and practices

Three of the six teams (Teams 1, 2, and 4) had formal, written policies regarding authorship. The written policy for Team 1 divided papers into two categories based on whether all team members were included as authors (and could remove themselves) or whether a subset of team members were included as authors (and others could add themselves). For the latter type of paper, the lead authors formulated a list of people they thought should be included, and then others could ask to be added if they thought they deserved to be authors. For the former type of paper, everybody on the team was included unless they asked to be removed because they did not feel they had contributed enough to warrant authorship. The PI handled conflicts or questions related to authorship.

Team 2 developed its written policy in response to a conflict that emerged when one team member submitted a conference talk based on data collected by others on the team and failed to notify them. According to the team PI, they developed a written policy that required the lead author of a paper to assign authorship based on contribution. They described it as a general policy that "focuses on the spirit rather than letter." However, the early-career interviewee from the team did not seem to realize that the team had a written policy.

Team 4 had a written policy that focused primarily on determining first and last authorship. The team PI said, "Roughly, the guideline would be that if you write the paper, you're the first author (laughs) … If you're the main director, you're the last author. And then everybody else goes in between …" If two individuals on the team both felt that they were first authors, they would share first authorship and flip a coin to determine who would be listed first. However, the guidelines outside of the first and last author positions were vague; those who felt they contributed significantly to the project were included, sometimes in a random order. When it was unclear whether or not a student should be an author, the student was asked whether or not they understood the paper or whether they contributed to a figure or dataset used in the paper.

For the three teams without written policies, we asked about informal authorship practices. The PI for Team 3 said they were fairly informal, that "things just sort of function naturally," and that they "err on the side of

generosity." The PI of Team 5 said that authorship was based on order of involvement, and they aimed to agree on an appropriate order when they began to work on each paper and would alter the order if circumstances changed. The PI of Team 6 also indicated that they ordered authors by their level of contribution to the paper.

Nature of honorary authorship practices

Many interviewees made comments that hinted at honorary authorship practices. For example, the PI for Team 3 said, "I think we're … fortunate in that regard, that we don't have to have all these official rules that there are six things that you must have to be an author on a paper and if you meet three of those six criteria, then we'll consider—I mean, we try to avoid that kind of stuff, and whether it's considered ethically appropriate or not, we err on the side of generosity." The early-career interviewee from Team 1 described a paper she led that included all team members as authors, but was really written by three team members, with many of the other people on the team giving little or no feedback before it was submitted. Similarly, the early-career interviewee from Team 2 said, "I've included people who have hardly done anything on papers as authors." The post-doc from Team 5 noted, "I think there've been times where we disagreed, where I don't think someone has contributed at all but just for the- keeping everyone happy (laughs), they've been included." The PI for Team 5 said, "I'm trying personally to be as inclusive as possible, which means when it's my papers I tend to involve more people than others would."

The PI for Team 6 described a somewhat different authorship situation that is still closely related to honorary authorship. He claimed that there were times when he allowed a collaborator at another university to be the corresponding author instead of himself, even though most of the work was done in his lab. He explained, "I know maybe this is not absolutely right, but I do it a few times … I want to be more nice to the collaborators and help them because I think that returns back to me in the long term." Thus, while none of the interviewees acknowledged engaging in honorary authorship when explicitly asked if they had ever done so, they consistently described practices that appeared to fit its definition (i.e., including individuals as authors even if they did not contribute sufficiently to merit that designation).

One of the most striking findings from the interviews was the frequency with which teams responded to difficult authorship decisions by attempting to be "inclusive." Without any prompting from the interviewers about the topic of inclusion, four out of the six PIs claimed that they attempted to be "inclusive" or "generous" when deciding who should be included as an author on their team's publications. Three of the early-career interviewees also used these terms or recommended inclusive practices. However, this emphasis on inclusivity appears

to have gone too far, insofar as five of the six teams described practices that extended more credit to authors than would be expected based on the authorship policies created by scientific societies and journals. Although it is laudable for teams to promote genuine inclusivity by including a wide range of individuals in work that leads to authorship, our participants describe overly-inclusive practices that grant authorship to those who do not meet established criteria for doing so. These practices resulted in honorary authorship motivated by desires for inclusion, which is somewhat distinct from typical descriptions of gift or guest honorary authorship practices (Greenland and Fontanarosa 2012). Admittedly, it is often difficult to decide in a particular case whether or not an individual has actually met the criteria described in authorship policies, but the quotations above indicate that in many cases the team members we interviewed acknowledged that they were including authors who had probably not met these criteria.

Factors contributing to honorary authorship

One of the most significant advantages of the qualitative approach that we employed in this study is that it provides an excellent opportunity to uncover a range of factors that appeared to contribute to the interviewed teams' honorary authorship practices. We identified the following seven major factors: (1) confusion over what counts as a 'significant' contribution; (2) lack of formal team authorship policies or unclear formal policies; (3) efforts to promote positive team dynamics and avoid conflict; (4) lack of training in personnel management and conflict resolution; (5) lack of concern about honorary authorship by mid-/late-career PIs, insofar as it did not harm them; (6) deference or lack of power on the part of early-career scientists; and (7) informal or formal mentorship by scientists who engaged in honorary authorship.

(1) The starting point for honorary authorship in these teams was the complexity of defining what constitutes a "significant contribution" that merits inclusion as an author. When individuals contributed to the research in only a limited way (e.g., contributing to data collection or making the research possible through funding or intellectual contributions to proposals), it was often unclear to the team whether they should be included as authors. Although most journals require all authors of published articles to be involved in the writing process, this stipulation is not present in many ethics codes promulgated by scholarly societies (Bošnjak and Marušić 2012). This discrepancy may contribute to the confusion expressed by these teams. In accordance with most authorship policies for scholarly societies and journals, the interviewees for all six teams referred to "contribution" as central to deciding who should be included as a manuscript author. Nevertheless, many interviewees noted the ambiguities involved in deciding what sort of contribution was needed to justify authorship. For example, the PI from Team 3 described a postdoc who started out playing the role of a

technician for two years. He noted that even though the postdoc did not help to analyze data or write papers, he anticipated including the postdoc on two or three of the first papers to come out of the project as a reward for "getting the infrastructure in place." Similarly, the PI of Team 4 claimed that their data were very difficult to collect, and that data collectors were often included on the papers even if that was the only role they played in the project. He referred to a graduate student who was not part of the project but who spent a year collecting an important data set; as a result, he insisted that "one of the things in the … rules for … these data sets is … you have to ask him if he wants to be an author because he spent so much time doing that part of it." The PI for Team 6 also described situations in which all the PIs who wrote a big collaborative and multi-institutional grant proposal might be included as authors on a paper that described a small piece of the work done only at one particular institution, because they all played an important role in conceptualizing the overall project and obtaining the funding. The graduate student from Team 4 also noted that they sometimes included as authors those people who provided the funding to make data collection possible. The variety of authorship criteria described here demonstrates how these teams struggled to specify criteria for authorship and how their responses to this challenge varied. The discrepancy between the requirements of academic journals (involvement in the writing process) and ethical guidelines posed by scholarly societies (significant contribution; Bošnjak and Marušić 2012) may contribute to the lack of clarity in determining what, specifically, warrants authorship.

(2) This confusion about what constitutes a "significant contribution" was exacerbated by a second factor, namely, that only half of the teams had their own written authorship policies. As noted previously, Teams 1 and 4 had written authorship policies at the beginning of their collaborations. Team 2 developed a written policy after dealing with a conflict in which a member of the team submitted a conference paper based on team data without consulting with other members of the team. The other three teams did not have written policies. According to the PIs for Teams 3 and 5, they avoided formulating a written policy because they wanted to avoid seeming overly rigid or dogmatic. Interestingly, even the formal policies were unable to clear up all the confusion about appropriate authorship assignment.

(3) A third factor contributing to honorary authorship was the desire of team members to either promote positive team relationships or prevent conflict. For example, the PI from Team 6 indicated that he allowed other people to be the corresponding author, "… not necessarily because they really deserve to be the main corresponding author, but more like to be inclusive and to help them and I think that then helps me because there's always positive things coming out from something like that." He elaborated, "I believe right now without collaborations, you cannot do well, I'm quite convinced. Giving up some of the authorship, like corresponding authorship, I have done it a couple times in order to facilitate more

future collaboration, although maybe it wasn't the absolutely most fair decision out there." The emphasis on avoiding conflict also appeared frequently throughout the interviews, as described by the PI for Team 1: "There's two kinds of authorship mistakes that I think you could make. You could have someone included in the paper that didn't really do that much .... That's one type of error. The other type of error is, 'I should've been on that paper.' That a much more divisive kind of error and I think people are very keen to avoid that one .... The second error is a source of great unhappiness." These concerns accord very well with the limited body of previous qualitative research on authorship, which has also revealed concerns among scientists about promoting positive relationships and avoiding conflict (Street et al. 2010, 1461).

(4) A fourth factor that we infer to have contributed to honorary authorship on these teams was a lack of training for the team members in organizational management and team dynamics. This may have contributed to their fear of team conflict and their willingness to include team members with marginal contributions as authors rather than confronting difficult decisions. Of the twelve team members interviewed, only two (the PI from Team 5 and the early-career member from Team 6) had received any training specifically on collaboration or leadership in a research context. In addition, the PI for Team 2 noted that as a Department Head, he had received leadership training in an administrative context that was somewhat helpful but not geared specifically toward research collaborations. The interviewees also indicated that they knew of very few other team members who had received any training for effective collaboration as part of scientific teams. The interviewees for Team 1 indicated that some colleagues at one of their universities had participated in an Aldo Leopold leadership program, and the PI for Team 2 noted that another team member had received leadership training as an administrator. Otherwise, the interviewees indicated that they depended on their practical experience working with teams and occasionally reading a book or journal article on the topic to guide their actions.

(5) A fifth factor that appeared to contribute to honorary authorship on these teams was that the PIs, who set the tone for the teams' authorship policies, were at a career stage where they were not disadvantaged by overly inclusive practices. As the PI for Team 3 explained, "You get to a certain stage in your career where you can be a little more generous with certain aspects of where you fall into authorship and all of that." Similarly, when the PI for Team 6 reflected on his willingness to give others the corresponding author position even if they didn't really deserve it, he noted, "I say it's the career stage too. I think I'm transitioning more now to—I have published enough, people can recognize the work I'm doing in the paper, even if I'm not the corresponding author."

(6) Despite the PIs' self-awareness concerning their own career stages and the latitude it allowed them in regards to authorship, a sixth factor contributing to honorary authorship appeared to be a lack of awareness about the power differential between these PIs and the early-career team members. This power

differential resulted in the ECs' inability to exert influence over team authorship practices or norms. For example, the early-career interviewee for Team 1 described writing a paper and wanting it to fall into the team's more selective category (i.e., a subset of team members would be chosen as authors and others could request to be included), but was overruled. Ultimately, this EC and another team member wrote the paper, and most of the other authors gave minimal input or none at all. Similarly, as noted earlier, the EC from team 5 expressed disagreement with the team's authorship practices in some cases but ultimately deferred to others and claimed to still be learning "the nuances and realities of working with a group."

(7) In line with this last point, our interviewees consistently reported that their approaches to authorship were learned as a result of training from their own mentors or from the experiences of other team members. For example, the PI for Team 6 explicitly said that he developed his authorship practices from his PhD and postdoc training. He said about his past mentors, "They operate in a similar way and they were both big labs, so this is even a bigger lab … and so, I think I follow more or less my mentors in what they are doing. And I didn't have to reinvent the wheel here I think because it's working effectively." In the case of Team 1, they adopted their policy of two categories of papers because a co-PI on their project had experience with it on another team. In fact, the ECs interviewed indicated that they were learning to follow the authorship practices modeled by their current teams. After the EC from Team 5 expressed disagreement with some of the team's authorship decisions, the EC continued in a manner that illustrates the gradual adoption of the standards of the team: "Yeah. So … I think it really, it resonates with me the inclusiveness and putting people on there …" A similar experience is reflected by the EC from Team 4 who said, "If you're the first author, you're the first author. It doesn't matter who's, you know, author three through n." The EC went on to say, "I had no idea how authorship would work and being on this project, I'm grateful that I learned it this way as opposed to a more cutthroat way of doing authorships (chuckles)." Thus, these trainees appear to be adopting their teams' perspectives that inclusion is a priority that overrides concerns about engaging in honorary authorship.

Recommendations

Our study included interviews from six randomly selected interdisciplinary environmental science teams. Given this small sample size, it is unclear whether our results reflect common practices and motivating factors in environmental science generally, in other types of large teams, and in other disciplines. Nevertheless, our results suggest some ways in which the desire to be inclusive can contribute to honorary authorship practices and some of the reasons this may be the case. To the extent that other teams have similar policies, practices, and norms, the findings from our interviews indicate that solutions to the complex problem of honorary

authorship will require both structural changes (policies, procedures, etc.) and cultural changes (norms and values of scientists). Some of the motivating factors identified in our interviews were primarily structural, such as the lack of written authorship policies for scientific teams and differences among policies about what constitutes a significant authorship contribution. Other factors involved team culture, such as concerns about avoiding conflict and lack of power on the part of early-career team members to influence authorship practices. It is also important to recognize that many of the structural and causal factors identified in our interviews were interdependent (Figure 1). For example, the lack of leadership training programs for team members (a structural factor) seemed to contribute to difficulties handling conflict in appropriate ways (a cultural factor). Conversely, when early-career team members did not have adequate power to exert their perspectives (a cultural factor), it diminished the effectiveness of team authorship policies (a structural factor).

Further studies are needed to clarify the generalizability of these factors, the ways they interact in different contexts, and the best ways of positively influencing them. Nevertheless, our interviews suggest some lessons and recommendations that merit further investigation. Because of the interdependency between structural and cultural factors observed in our interviews, we recommend that

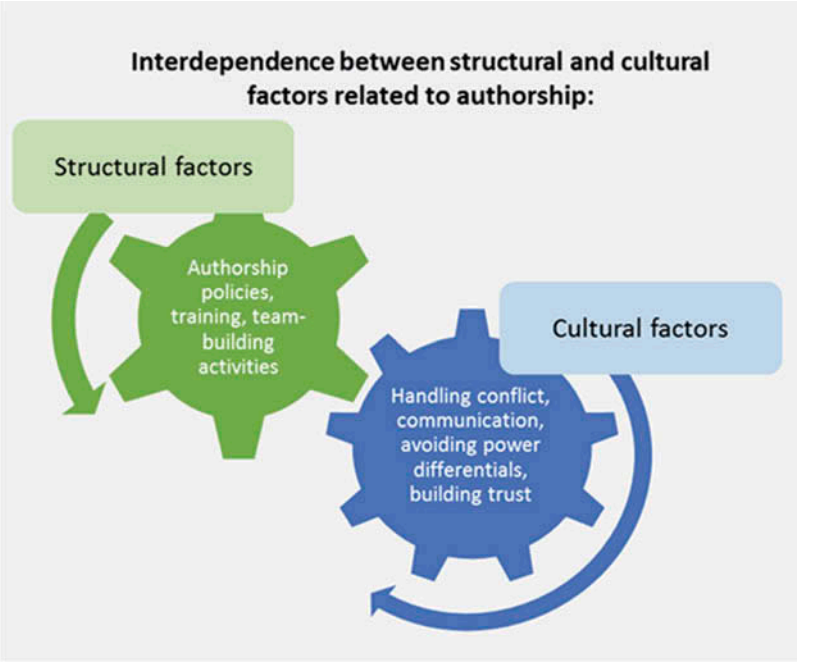

Figure 1. The interdependence between structural and cultural factors related to authorship. Listed within the two cogs are recommended policies and procedures (structural factors) and behaviors and values (cultural factors). The cogs represent the interdependency between these two types of factors.

both types of factors be considered by those seeking to promote meaningful change in authorship practices (Figure 1). Better policies and procedures are needed (e.g., Greenland and Fontanarosa 2012; Macrina 2011), but these structural reforms should be accompanied by cultural reforms to ensure that they are implemented and followed (Barrett, Funk, and Macrina 2005; Eastwood et al., 1996). Without changes to the climate at the team level, any top-down approach developed at the level of the institution is likely to be limited in its effectiveness, because all reform measures rely on leaders and individual members of interdisciplinary teams to apply, enforce, and report deviations from such policies. Moreover, without an inclusive climate, voices of dissent will not be heard and challenges to problematic practices will be muted. Alternatively, positive cultural change depends on the development and implementation of appropriate policies and procedures. For example, team members need appropriate training to promote effective communication and to alleviate power dynamics. Thus, this interplay between structural and cultural factors deserves more emphasis in scholarship on honorary authorship.

In an effort to address the problem of honorary authorship, we propose seven recommendations that together address both structural and cultural factors. Many of the recommendations address the two factors together, insofar as they involve policy changes that can improve team culture or cultural changes that can promote better implementation of authorship policies. In addition, these recommendations address multiple organizational levels, ranging from journals, funding agencies, and universities to individuals and teams. In order to facilitate more thoughtful implementation of the recommendations, we also identify potential structural and cultural barriers or difficulties that may need to be addressed.

(1) We argue, along with a number of other scholars, that many authorship problems could be alleviated if journals adopted some form of "contributorship model" that requires authors to delineate more precisely the roles they played in creating the paper (see, e.g., Borenstein and Shamoo 2015; Rennie, Yank, and Emanuel 1997; Resnik 1997). These models require teams to explicitly report each author's contributions to the manuscript. Along these lines, Clement (2014) recently proposed the use of an "authorship matrix" that provides precise assignments of the effort each author contributed to the ideas, work, writing, and stewardship associated with a research paper. Quantitative Uniform Authorship Declaration (QUAD) is another system for quantifying authorship contribution (Annunziata and Giordano 2014; Feeser and Simon 2008). Contributorship statements may help alleviate honorary authorship practices in at least two ways (Weltzin et al. 2006). First, they would encourage teams to examine each person's role to determine whether they made a significant contribution to the project. Second, they would create greater public accountability and therefore discourage attribution of authorship to those who had not made a significant contribution.

Nevertheless, efforts to implement contributorship-based approaches effectively will require attention both to structural and cultural barriers. For example, one potential barrier is that it may be difficult to enact contributorship-based policies, given that journal editors are likely to be reluctant to adopt more requirements for authors. Moreover, especially in interdisciplinary research with large teams, it is likely to be difficult to quantify the relative contributions of all authors in a precise fashion. Drawing attention to efforts by high-profile journals such as *Proceedings of the National Academy of Sciences* and *Nature* to enact contributorship policies may help to alleviate some of these structural concerns (Weltzin et al. 2006). Our interviews also highlighted the fact that contributorship-based approaches are likely to achieve their full potential only if scientific teams engage in a good faith effort to employ them regularly and accurately, with honest input from all team members. For example, if early-career and other vulnerable team members do not feel comfortable voicing their perspectives, then much of the potential for contributorship statements to lessen honorary authorship practices could be lost. Thus, the effectiveness of this approach depends on creating a team culture that supports open discussion and productive responses to conflict.

(2) Funding agencies could also take steps to incentivize the development of team authorship policies by requiring that they be included with grant proposals, much like the National Science Foundation requires the inclusion of data-management and post-doctoral mentoring plans. It appears from our interviews that many teams might not otherwise be motivated to develop authorship policies, even though they can help promote transparency and encourage behavior that accords with the policies developed by journals and scholarly societies.

As in the case of journal editors who are considering the implementation of contributorship policies, however, a barrier to implementing this proposal is the concern that grant proposals are already onerous and become even more so with the proliferation of additional requirements. In particular, newly formed teams with authors from different disciplines could find it particularly challenging to develop authorship policies before having worked together. As these policies became more widespread and scientists became more familiar with them, however, it would likely become less difficult for new teams to formulate policies. Moreover, new techniques are being developed to help team members talk across disciplines and improve team culture at the beginning of interdisciplinary collaborations (e.g., O'Rourke and Crowley 2013). However, to ensure that team authorship policies are not largely ignored after their initial development, it would be important for teams to reevaluate policies on a regular basis, such as annually or bi-annually, and to use them for every team manuscript.

(3) Universities can play an important role in addressing honorary authorship as well. Our interviews highlighted the fact that many team leaders and individual members receive little or no training on team management from their

institutions or professional societies and thus lack the knowledge required to effectively create and participate in inclusive, interdisciplinary, and productive scientific teams. We found that this lack of training can contribute to honorary authorship, because team members are tempted to include people as authors on papers solely to promote positive team relationships and avoid conflict. Universities can help to alleviate these cultural problems by creating professional development workshops and graduate courses for the current and next generation of scientists. Important training topics include handling team conflict (Yong, Sauer, and Mannix 2014), being reflexive about how teams are functioning (Janss et al. 2012), and incorporating activities and policies to promote equitable authorship practices (Bennett, Gadlin, and Levine-Finely 2010). Such workshops would improve team culture by helping team members lead in a way that incorporates the input of all team members, particularly early-career or otherwise underrepresented individuals who may feel they lack voice within the team. To make these efforts effective, however, universities will have to find the necessary funds and staff to provide adequate training, and faculty will need to be incentivized to participate.

(4) Scientific teams can also take the initiative to create written authorship policies, even if they are not required to do so by funding agencies. By promoting transparency and clear expectations surrounding authorship, these policies can be helpful not only for clarifying rules but also for promoting positive team culture. A cultural challenge identified in our interviews is that team leaders are likely to worry that the creation of authorship policies could appear overly rigid or prescriptive. Nevertheless, these concerns could be partially addressed by treating the policies as "living documents." As mentioned above, we would recommend that teams draft a policy at the start of their project and then revisit and revise it frequently, especially when team members change. Articulation of the rationale behind creating and revising authorship policies by team leaders could also help alleviate such perceptions and change team culture to one that encourages fair process and transparency. To help address concerns about power differentials among team members, early-career team members could be encouraged to play a significant role in the revision process.

(5) Teams could also take the step of creating an authorship committee to ensure implementation of the authorship policy and to help navigate disagreements among team members. Ideally, a committee of this sort would help foster transparency about authorship decisions and also address the lack of power felt by early-career team members; over time, this would hopefully result in changes in the team culture around voice and openness. Although the committee could itself perpetuate problematic power dynamics, this problem could be alleviated by rotating team members on and off the committee and by ensuring that it includes a diverse range of members.

(6) In order to ensure that teams do not become overly focused on structural solutions, thereby neglecting cultural factors that can contribute to honorary authorship, we also recommend that teams engage in team-building activities that promote positive dynamics and trust (Cheruvelil et al. 2014). While these sorts of activities are not focused explicitly on preventing honorary authorship, they create an environment in which team members are more likely to be able to confront difficult decisions head-on rather than resorting to questionable authorship practices. While team members may be hesitant to spend time on team-building activities that seem peripheral to performing science, our findings suggest that developing positive team dynamics is in fact important for generating and disseminating good science in an ethical fashion.

(7) Finally, at the individual level, we recommend that lead authors on papers make the criteria for authorship clear as early as possible during the development of their publications. This change would promote transparency within teams and allow team members to take the steps needed to merit inclusion as authors. Admittedly, power dynamics could still make it difficult for early-career team members to challenge the expectations or demands of senior team members when they serve as lead authors or try to influence the decisions of lead authors. Authorship committees could play an important role in addressing these concerns.

Conclusion

Inappropriate authorship practices such as honorary authorship continue to be important problems for the scientific research community. Most previous research on these issues has focused on quantitatively determining the extent of the problem and proposing potential solutions, but it has not focused on the motivations and experiences that contribute to authorship decisions. This study attempted to address this gap by interviewing members of large, interdisciplinary teams in environmental science, which is an area of science that has not been well represented in previous studies of authorship. Half the teams interviewed had written authorship policies, and the other teams had informal policies. All teams referred to "contribution" as an important factor for determining who should be included as an author, but they struggled to determine what counted as an adequate contribution. The teams tended to respond to difficult decisions about authorship by being overinclusive, in the sense that they included participants who may not have contributed significantly to the research as authors, thereby granting honorary authorship.

To the extent that our results reflect practices and motivating factors in other large interdisciplinary teams, they suggest that solutions to honorary authorship should take account of the interplay between structural issues (i.e., policies and procedures) as well as cultural ones (i.e., norms and values). The motivating factors that appeared to contribute to ethically questionable authorship practices

in our interviews included not only lack of clear policies and confusion about what constituted "significant" authorship contributions, but also concerns about maintaining positive team dynamics, lack of training in team management, and lack of power for early-career team members to challenge questionable practices. To address this array of interconnected structural and cultural factors, we provide seven recommendations that cover multiple organizational levels: (1) journals should develop contributorship policies, (2) funding agencies should require authorship policies to be included with grant proposals, (3) universities should provide training in personnel management and collaboration skills for researchers, (4) teams should draft written authorship policies at the beginning of their projects and revise them regularly, (5) teams should develop authorship committees, (6) teams should engage in team-building activities to promote positive dynamics, and (7) lead authors should be clear about authorship qualifications as early as possible in the research process.

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