

## INAPPROPRIATE AUTHORSHIP IN COLLABORATIVE SCIENCE RESEARCH

Robert T. Pennock

A recent statement from the National Academy of Sciences, the Institute of Medicine and the National Academy of Engineering decried the lack of progress in instituting ethical standards for scientific research, and among the sorts of misconduct they mentioned was "inappropriately assigning authorship to research papers" (Hilts 1994).

Kristin Shrader-Frechette terms this unethical practice "loose authorship" in her *Ethics of Scientific Research* and defines it as "inserting or removing names of persons who may or may not have helped with the work", but she does not discuss it beyond noting that it is a "controversial" form of deception or fraud (Shrader-Frechette 1994, p. 52). In this paper I take up this issue of inappropriate authorship in collaborative scientific research and examine it in detail. The first section presents the current situation in which this sort of misconduct has become problematic and analyzes specific forms that it can take. The second section discusses three major ethical principles—truthfulness, responsibility and justice—that are violated in inappropriate authorship and lays out what they demand for proper attribution. Next, I review current attribution conventions and show how they make it difficult for even well-intentioned researchers to satisfy the ethical principles. I propose two alternative attribution strategies that may help avoid some of these problems, and defend them against possible objections. In the final section I summarize the conclusions and make some additional recommendations that could facilitate change. My central contention in the paper is that the authorship model itself, with its vague and conflicting tacit conventions, is to blame for many of the ethical difficulties and that many of these difficulties could be avoided if scientific associations endorsed and scientific journals adopted an explicit and more carefully differentiated set of attribution conventions.

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To illustrate the current situation in science in which the problem of inappropriate authorship has come to the fore, let us review a few telling statistics. The Institute for Scientific Information noted in 1994 there were 37 papers in the life-sciences published with over 100 authors, compared to almost none in the 1980's. In physics, papers with over 100 authors totaled almost 140. For the last few years a dozen or so papers have had over 500 authors! These represent the extreme, but in 1994 there were almost 400 papers published with over 50 authors (Regalado 1995). Even for papers with a dozen or so names, one wonders whether all these people deserve authorship credit.

Of course, most cases are ethically unproblematic. Scientific research has increased in complexity, leading to a greater need for collaboration and this has naturally resulted in an increase in multi-authored papers. Indeed, most of the heavyweight papers come from high-energy physics and multi-center medical clinical trials, which require dozens or hundreds of researchers for the implementation, if not the design, of an experiment. So, probably in most cases most of those listed do deserve some credit. Unfortunately, in many cases we know that authorship is given improperly. A 1993 survey of faculty in chemistry, civil engineering, microbiology and sociology revealed that almost one-third of faculty members knew of inappropriate assignment of authorship credit of research papers by their peers (Swazey and others 1993). No doubt some of these were referring to the same incidents, but, even so, the statistic indicates that the problem is not insignificant.

What sorts of behavior fall under the heading "inappropriate authorship credit" and why are they thought to be unethical? Of course, merely including a large number of names is not unethical if a large number of people in fact made significant contributions. Ethical problems arise in three ways: when people who contributed in a significant manner are not properly recognized, when those whose contribution was minimal or nil are included as co-authors, and, the general case, when researchers are not properly recognized for their actual contributions.

The first sort of case may appear as plagiarism, but there are other ways to fail to give proper credit. What probably occurs most commonly is that a person in authority takes credit as the main author while an underling who played the more significant role, perhaps in the conception and execution of the experiment, merely appears as one of the subsidiary authors. Completely omitting mention of someone who played a significant role is the most flagrant sort of violation, but occurs rarely.

These days the trend seems to be to include too many people, and this second sort of case is what is most typically thought of under the heading

of inappropriate authorship credit. Again, it may occur in a variety of ways. For example, a researcher may include a colleague as an author either to curry favor or with the tacit understanding of being listed in return in the colleague's articles. Or researchers may use the briefest of conversations to rationalize inclusion of a "big name" scientist among the authors to heighten the prestige of a paper and the chance that readers will take it seriously; at the very least this increases the likelihood that the article will be found and read when someone does a literature search. In other cases the impetus may come from the other side: someone may agree to provide a bit of information or a sample to a researcher only on condition of receiving authorship credit.

Sometimes the motivation is less self-serving, but practices that give recognition out of proportion to input or fail to properly recognize actual contributions are still ethically problematic. The job market is tight even for researchers with a Ph.D. and one or more post-doctorate degrees, and professors may feel a need to help their graduate students by including all their lab members as authors on papers when only a subset actively collaborated in the particular project. Students who benefit from this practice may not complain, but it is clearly unfair to other students on the job market who earned their credits by their own labors. Also, conferring authorship is sometimes the only way that a project leader can publicly recognize those who were helpful in some way. According to Curt Furberg, chair of the publication committee for the Women's Health Initiative at N.I.H., "If you give credit, you give it to everyone" (Regalado 1995). The point seems to be that anyone who contributed at all gets to be an author, even if their only contribution was to solicit a few patients for the study. Although one can sympathize with the difficulties that researchers face that would lead them to adopt this sort of maxim, it is hardly an equitable solution. For one thing, it is false—how often are the names of lab technicians, nurses, and other supporting staff included, even though they were essential to the execution of a study? Second, it is unfair in that those included as "authors" for some minor consultation or service receive equal credit to those who contributed in a substantial manner. To confer "honorary authorship" in these ways is to abdicate one's responsibility to make fair and honest judgments, rather like a teacher who gives any student a grade of 'A' who was a personal favorite or who turned in at least one assignment.

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If one were to adopt the model that ideas and other sorts of intellectual input are kinds of property, then one could argue that the various forms of inappropriate authorship mentioned are all forms of theft. When some-

one who contributed is not included as author or when someone's ideas are used without attribution, then these clearly would be cases of stealing. One could argue that theft occurs in the other sorts of case as well; for example, by including as authors people who made little or no contribution one indirectly takes something of value—the exclusivity of property—from those who did contribute. However, the notion of intellectual property is controversial and I do not believe that it should be endorsed generally in scientific research, so I will not use it as part of the ethical argument here, and will instead appeal to a few more basic ethical principles. In particular, I want to argue that there are three major ethical principles that are violated in cases of inappropriate authorship: truthfulness, responsibility and justice. Let us consider them in turn.

The first ethical principle that applies to the question of appropriate authorship is that of simple truthfulness or honesty. A commitment to truth is an especially important virtue in science, given that a central goal of research is to search for empirical knowledge, which necessarily requires truth. We should naturally expect the virtue of truthfulness to hold generally and not to stop with the reporting of experimental results but also include honest attributions of contribution.

One might object that reporting authorship is not comparable to reporting experimental data, because the latter is evidentially significant to the investigation whereas the former is not. Even if we were to accept the purported difference this would not justify a departure from the principle of truthfulness, but in any case we should not grant the premise for it ignores the possibility of an indirect form of evidential relevance of authorship. For instance, if a researcher has been found to be negligent or to commit fraud in a particular instance, that information would cast doubt upon that person's other work as well, and in this way turn out to make a difference to one's evidential assessment. On the positive side, it may also make an evidential difference to know that someone who is particularly skilled or trustworthy was in charge of a particular aspect of a research project. Clearly, who did what can be evidentially relevant, so it is not merely that ethics demands honesty in general that supports accurate, objective reporting of researcher input.

A second general ethical principle that stands behind proper authorship attribution is that of responsibility—we attach the names of researchers to a report to indicate that they were responsible for the work. The idea of *bearing responsibility* is a basic concept in any framework of moral action. Moral agents are accountable for their actions and consequences thereof, and failure to take responsibility and recognize responsibility is a serious omission.

Critics should not minimize the idea of responsible action as merely an abstract philosophical notion, nor think that proper attribution is simply a

matter of etiquette, because with responsibility may come reward. In the case at hand there are tangible benefits that can accrue from authorship. Authorship determines not only reputation in the field, but also salaries, tenure, promotion, bonuses and grant funding. Other things being equal, researchers who author no or only a few papers typically find themselves receiving fewer of these benefits than those who publish more because administrators who divvy up the rewards do so largely on the basis of numbers of publications. As a sign of responsibility, authorship lets us know who is deserving and so whom we ought to reward.

The other side of the coin of responsibility is responsibility for wrongdoing or error. In legal terms we might think of this as liability; we need to know who to blame when there is negligence or fraud. On the current system of co-authorship, it would follow that all the named researchers would be liable for wrongdoing in the same way that they are all claiming and would receive credit if that is due. But how many scientists are willing to accept responsibility for "someone else's" negligence or fraud? One sometimes sees a subset of authors of a report publishing a retraction and distancing themselves from their co-authors when there has been a charge of data-fabrication or some other wrongdoing. If someone is willing to accept credit as an author, it is reasonable to expect them to accept blame as well.

On the other hand, it is also important that we not hold responsible for some outcome someone who had no control over it. For persons to have moral responsibility requires that they have a role that gives them the ability to choose and to take one course of action rather than another, and thus potentially to make a difference to the outcome. Those who could take no action (or no significant action) in a situation bear no responsibility and so cannot properly share either the blame or the credit. Therefore, what we should expect to see in ethically grounded attribution is a report of those researchers who were in a position to act and make a difference and who take responsibility for the same.

A third ethical principle that applies to authorship is that of justice. We mostly speak of justice in contexts of political or social rights, but the ethical notion properly has a much broader scope. Aristotle's formal principle of justice tells us we should treat equals equally and unequals unequally. (This is a "formal" principle in the sense that it describes the logical structure for just judgment and action, but does not provide the content.) Justice demands "discrimination" in the positive sense that those who deserve greater reward should receive greater reward and those who deserve less should receive less. In the case at hand, justice requires that recognition be given to whom it is due by virtue of their contributions to the research and not to others who do not deserve it (and similarly for blame).

To try to counter the justice argument, one might appeal to a sports model and argue that differentiation is inappropriate in science because successful collaborative research is necessarily a team effort. Scientists undertake joint research in part because there are problems that cannot be tackled by an individual. So, given that a project could not have succeeded without everyone's contribution, everyone deserves equal credit. However, there are two problems to note about this argument. In cases in which every participant's contribution was necessary it is certainly true that they all deserve credit, but that does not imply that they all deserve equal, undifferentiated credit. That is, keeping with the sports analogy, the fact that the team as a whole was responsible for the win does not mean that we should ignore the members' individual roles—kicker, receivers, quarterback and so on. A second problem is that one of the main issues at hand is that in extreme cases individuals are being included as authors even when they were not "on the team." Here the injustice is clear: people whose contribution was minimal or nonexistent are included as "equals" with those whose contribution was essential and significant.

To summarize, we can say that inappropriate authorship is attribution that does not honestly report the researchers' true roles, give proper assignment of responsibility, or justly apportion differential contributions, and that ethically proper attribution should do these things. Of course, there is little that the scientific community can do to prevent willful misconduct beyond setting up policies that make it difficult and costly, and then being diligent about oversight and enforcement. However, I suspect that egregious cases of willful misconduct are rare, and I want to suggest that many of the ethical problems involving inappropriate authorship arise inadvertently, because of the authorship model itself and the simplistic modes of attribution that are available. If we examine the authorship conventions now used we will see that they make it difficult to adequately follow these ethical principles even when one tries. Indeed, it is remarkable that the scientific enterprise, which is based upon precision and clarity, should allow such a vague and internally-conflicting "system" of credit attribution as we now find.

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When a research report lists a single person as author, the reader knows that this person is to get full credit, but otherwise the division of responsibility is unclear. If two or more names appear it is difficult to know whether they are to share credit equally or whether some differentiation is intended because there are some tacit ranking conventions—ordinal position, alphabetization, and correspondence priority—that may (or may not) come into play and that lead to ambiguous or conflicting rankings.

The most common tacit convention in scientific research reports that may differentiate responsibility is that major credit supposedly goes to the person who is "first author," that is, whose name comes first in the list. Sometimes this pride of place gets emphasized when the subsequent names stand alone in alphabetical order, as in (Yellin and others 1995). In more complex cases one finds the first two or three names listed in some order, followed by the rest alphabetized, as in (Boujrad and others 1995). In such cases, if the initial names are also alphabetized one might conclude that these are meant to be of equal "first author" status, and if not that some ranking of importance is implied. Of course, none of this will work if the primary investigator happens to have a surname that comes first in alphabetical order. Indeed, if all the names are in alphabetical order, then one may not give any special credit to the first author, on the assumption that the order was not meant to be indicative of credit. In other cases one finds a list without any alphabetization, as in (Endrizzi and others 1995). Such cases are especially unclear. One probably would tend to credit the first author, but was the intention to indicate descending order of credit or were the names arranged at random to de-emphasize this?

A second main strategy—the "starred author"—gets around some of these problems. In this approach, an asterisk by a name refers the reader to a footnote that usually indicates that this is the author "to whom correspondence should be addressed." The unspoken convention here seems to be that the person from whom one would request reprints or direct inquiries would be the key figure. However, sometimes one finds more than one starred author to whom correspondence should be addressed, occasionally with the names at different places in a list that may or may not be alphabetized. (For example: "T.C. Shen,\* C. Wang, G. C. Abeln, J. R. Tucker, J. W. Lyding, Ph. Avouris,\* R.E. Walkup" (Shen and others 1995)) Is this a sign of equal contribution or is some ranking implied? Some researchers are explicit that stars indicate credit—in a few cases multiple identical asterisks lead to a footnote that says specifically that those authors contributed equally to the work, as in (Karlovich and others 1995). More and more often one finds papers with several sorts of footnote marks by names—stars, daggers, crosses, etc.—some indicating correspondence precedence, others shared credit, and others alternative addresses, as in (Mougeau and others 1995). How are these and other such mixed signals to be interpreted?

Things get especially confusing when the two conventions clash. For example, often the starred author is not the same as the first author, as in (Hsieh and Hayward 1995). In such cases one might judge that the starred author runs the lab or was project leader and that the first author played the main role for this particular result, but it is doubtful that this

is a general rule. Except in the cases in which footnotes explicitly mention contribution, the reader mostly must guess how to assign credit and responsibility, because the various signs of differentiation are inconsistent.

I will not multiply examples. This brief review is enough to show that although current attribution strategies make some attempt to address the need for differential attribution as required by the ethical principles, they are structurally inadequate to the task. They make it difficult to honestly report the researchers' true roles, they do not allow proper assignment of responsibility, and they do not justly apportion differential contributions.

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Despite the national calls for attention to inappropriate authorship and the studies that show that it is a real problem, I do not think it common that scientists are intentionally flouting the demands of truth, responsibility and justice when they assign authorship credit. While there are certainly instances of misconduct of this sort, I believe that most violations are unintentional—the inadvertent result of accepting without question a standard, but archaic and flawed, model of attribution. Indeed, it is of little help that a scientific report writer understands and conscientiously attempts to follow what ethics demands for appropriate standards of authorship, if there is no adequate mechanism for implementing them.

To be adequate, a set of attribution conventions must make it possible to fulfill the ethical principles we have noted. Primarily, they must allow honest and just differential attribution of credit and responsibility. They should recognize essential, though perhaps minor, contributions while discouraging unearned authorship. They should reflect the ethical ideal while still being grounded in the practical realities of the work structure within the laboratory and the social reward (and punishment) structure without. Let me now propose a couple of possible attribution models that science could adopt to accomplish these goals.

One approach would be to keep an authorship model, but to abandon the ambiguous "first author" convention in favor of an extended method of explicit "starred" crediting. Rather than vague mention of correspondence priority, footnotes could note researchers' actual contributions and especially should indicate those who had primary responsibility. Those who had only consulting or supporting roles should not be included in the author list at all. For example, someone who merely provided samples or subjects should be credited in a different manner, perhaps by a citation within the report in the same way that information from another published work is referenced. Similarly, someone who provided expert advice on a particular point deserves recognition for that but not as co-author, and

instead could be acknowledged in a footnote. We already have a precedent for this sort of credit attribution in the long-standing method of bibliographic referencing, which gives targeted credit for background information in published or unpublished forms. This approach has the advantage of resolving some of the ambiguities of credit without making a radical change; it simply extends a current trend in attribution. However, it may be that we need to break with the current model in a more significant way.

A second approach is for science to do away with the very notion of authorship, which is, after all, a completely inappropriate category to use to describe the scientist's work. Scientists are researchers, experimentalists, theoreticians and investigators first, and authors only incidentally. Scientists should take their actual roles and responsibilities seriously and attribution conventions should reflect this. I therefore propose that science journals institute a section in research reports devoted to delineation of contributions, following the model of "the credits" in a film. Rather than a generic or vaguely differentiated list of "authors" the credits should name the participants together with their scientific responsibilities in the research project. I will not here offer a specific list of such responsibilities because most categories will depend upon the field of research. We might expect to see roles such as Statistician, Laser Spectrographer or Subject Interviewer, or categories that list responsibilities such as instrument design, equipment engineering, computer simulation programming, and so on. Perhaps there ought to be a spot for an ethicist! Of course, individuals may have more than one role, and the level of detail that is appropriate will vary depending upon the actual division of responsibilities in any given project, so these examples should be taken merely as possibilities. The significant point is that by signing off on a role a scientist accepts credit for that function and possible blame in the case of negligence or fraud.

I do propose one cross-disciplinary category, that of "Principal Investigator," a title that is already generally recognized, though not in published reports. This key role is to be reserved for those who conceived and oversaw execution of the research and who thus bear overall responsibility. These are the scientists who had the theoretical insight, formed the hypothesis, designed and implemented the protocol, analyzed the data. We should expect relatively few people to be listed as principal investigators for any given research report. Even the mammoth projects with over 500 authors that we saw in physics and medicine would probably have fewer than a dozen principal investigators, and the vast majority of projects would have only one, two or three. The title should identify just those scientists who had the primary positions of design and general oversight of the research being reported and who will sign off on all the steps

of the process and take responsibility for the accuracy of its results. The principal investigators should receive primary overall credit and if error or fraud is discovered they will be the ones to hold accountable. Listing just a few scientists as principals is not meant to deny credit to those who played other roles—such people deserve specific credit for their specific roles (and specific blame if they violate their responsibilities). Again, the point is to reflect the actual contribution of the participants, and typically there are only a few scientists in any given project who are really exercise overall design and control.

Finally, I suggest that there be a second generally recognized role—perhaps “Consulting Scientist” would serve—that would allow a way to credit those auxiliary contributors who provided some expert advice or professional service, for example, but who were not actively involved as researchers on the project. This provides a way for the Primary Investigator to recognize important professional help from other scientists without having to inappropriately elevate such contributors to the status of an “author.”

The general strategy behind these proposals is to make attributions of differential responsibility explicit. Besides permitting researchers to be given credit for their true contributions as scientific investigators (rather than as “authors”), an explicit system of attribution will also make it harder to inappropriately tuck in “honorary” researchers as is now so easily done in the generic author list.

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Let us now consider possible arguments against these proposals and try to rebut them in turn.

First, we may dismiss some rather self-serving reasons one might offer in favor of the status quo. The undifferentiated author list might make it easier to evade responsibility and duck blame if there are accusations of fraud or negligence. The current system also makes it easier to claim credit if the project turns out to be a major success. Moreover, if the paper simply sinks into the morass of uncited papers, the authorship credit still helps increase the length of one's publication list. The ethical cynicism here should be obvious, but even the supposed benefits are not unadulterated. Innocent researchers may be tarred in a case of research fraud by having appeared as an equal author when they had no knowledge or control over the fraudulent aspect of the research. Also, multiple authorship will eventually dilute the benefits of authorship in the same way that grade inflation has decreased the value of B's and A's. The impression one has now upon seeing reports of the “most published” researchers, often with hundreds of articles, is not of their quality in

scholarship. Instead, one suspects that it is mostly a sign of their ability to network politically. Nevertheless, we must admit that these “reasons” will continue to have some unfortunate practical force unless institutional and administrative attitudes change. When universities emphasize number of publications over content and quality when making judgments about tenure or promotion it is not surprising that people will be tempted to find ways to increase their “output” quantity. Concomitant with the proposed change in attribution policy, we should expect administrators to become more sophisticated in their judgments and more careful and consistent in dividing rewards based upon a scientist's record of work.

Second, one might offer some practical arguments against the proposals. For example, one may argue that it is difficult or impossible to categorize the various contributions individual scientists make to a research project. Credits in films are possible because responsibilities are mostly pre-defined by unions, but someone could argue that no such categories are available in scientific research. It is true that research roles are not contractually defined as they are in films, but it is not correct to say that divisions of responsibilities do not exist. In some cases roles may indeed be quite clearly laid out in job descriptions or grant applications, and in other cases differential responsibilities are understood informally within a lab or research group, with the participants well aware of who conceived and/or oversaw implementation of a given experiment or provided the key elements of a theoretical analysis, and who served the various supporting roles. Except for the role of Principal Investigator, I do not propose that there be a pre-set classification either between or within disciplines, but simply one that accurately reflects the divisions of responsibilities as they occurred in the particular research project that is being reported.

Another pragmatic argument against these attribution proposals is that they will unduly focus attention upon the participants' places in the research hierarchy. Instead of regarding all the participants as co-operative seekers of knowledge we now will be concerned about whose name goes where on the marquis. This point has some merit. Unlike the case of creative works of art in which our interest is often as much in the artist as in the work, in science the content of an article is what is important—what knowledge has been gained—and the identity of the researchers is of little importance and so should not be emphasized in this way. On the other hand, we have already mentioned a way in which researcher identity may be indirectly evidentially relevant. Furthermore, although we might find the notion of the “abstract researcher” who is interested only in advancing knowledge to be an appealing ideal, the argument is somewhat disingenuous given that we already do pay attention to the place of the researchers' names on the author billboard as we

have earlier seen. Given limited funds for research support and the competitive nature of the scientific career, individual achievement must be recognized and documented, and it is not right to expect researchers to give up the possibility of distinguishing themselves. The attribution methods that I propose have the advantage of making recognition and documentation explicit and "above board."

There is one more serious practical consequence that could result from changes to the present system, namely, they could have a chilling effect upon collaboration in general. Anecdotal evidence from research departments in which authorship is shared as a matter of policy shows greater interaction and sharing of information, high productivity, and better morale. If we remove the incentive of co-authorship, researchers may be less willing to co-operate with other scientists, especially in supportive roles. Such a result would be detrimental to the advancement of science, so the change is ill-advised. If such a chilling effect would indeed occur as the result of the proposed changes, then this would be a good argument. Of course it would take an empirical study to check the claim, but given general knowledge of human psychology it does not seem unreasonable to think that removing the co-authorship incentive to co-operation would have that effect. At this point one might argue that thorough-going competition is more productive than co-operation, and dismiss the argument by granting the second premise while rejecting the first. For example, Philip Kitcher, in a different context, has argued that competition among scientists is an important impetus to science's continued success and advancement (Kitcher 1993). However, although a certain level of competition is healthy, substantial co-operation is also required, so we should encourage or at least not discourage it. Nevertheless, I would claim that there is little danger that collaborative research will be unduly discouraged for the simple reason that, as was mentioned, most scientific research today is sufficiently complex that it simply cannot be done alone. Furthermore, the proposed attribution schemes will continue to reward collaboration by making scientists' contributions explicit. Some self-serving co-operation will no doubt be lost, but that may be the price to be paid for ethical attribution.

Finally, we must consider an ethical argument that is the most persuasive reason for not adopting the proposals, namely, that in the established research culture authorship is the accepted coin of the realm. Although the final goods may be research funds or promotions, the immediate unit of payment for the researcher is authorship, and from this is derived recognition, reputation and reward. In such a culture the proper way to recognize someone's contribution to a research project is to confer authorship. One can argue this point from a Contractarian theory of ethics, reasoning that the present system of co-authorship is moral because it is

what professional scientists have agreed to or would agree to under some fair decision-making procedure. This viewpoint also would explain why lab technicians and other support staff are not typically included as authors. Hired technicians have chosen a career in which they hone their ability to carry out assigned technical tasks without needing to understand the conceptual protocol in which those procedures are embedded, and their primary, accepted remuneration for this limited but essential role is the wage they receive. For the professional, on the other hand, who has devoted years of effort and resources to reach a high level of both practical knowledge and theoretical understanding, "payment" for contributions to a research project is not wage but recognition, and in the present system this can only come from being listed as an author.

We may admit that it is certainly proper that professionals receive credit for their contributions by providing them with recognition, given that this is the accepted form of "payment." Nevertheless, it does not follow that everyone should receive equal recognition, which calling everyone an "author" does. To stay with the currency analogy, it would be as if the only monetary denomination were the hundred dollar bill so one could not be paid less than that no matter how large or small one's contribution. The situation is in fact a bit worse than this, because neither can one be paid any more than this. The current attribution strategies attempt to refine things a little in that the "first" or "starred" authors could be thought to be more equal than the other authors, but, as we saw, these tacit conventions are vague and inconsistent. The arguments from truthfulness, responsibility and justice show that more fine-grained acknowledgment is required. My proposed attribution methods that depart from the simple authorship model are possible solutions in that they keep the special sort of credit that research professionals expect, but also allow us to respect the ethical need to differentiate levels and varieties of contributions.

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We may now summarize our conclusions. Inappropriate authorship in scientific research occurs when one or more of the principles of truthfulness, responsibility and justice are not respected when reporting researcher contribution in a published report of a scientific investigation. Some cases of loose authorship are the result of willful misconduct, but often problems arise because of the authorship model itself and the vague and conflicting conventions that are available to differentiate responsibility among "authors." Alternative attribution conventions that can more accurately reflect the actual roles and contributions of scientists are ethically preferable and should be pursued.

Two further recommendations may facilitate the proposed change to a more ethically sound system of attribution. First, professional journals (or perhaps scientific societies) should adopt a convention of explicit responsibility attribution such as I have defended in the same way that they adopt stylistic conventions, thus providing a consistent model that researchers can follow and readers can use to make judgments. Second, administrators should review their institutional policy for judging and rewarding researchers; as long as administrators continue to emphasize quantity and simply count numbers of "authored papers" to determine reward, scientists will have little practical incentive to change the present system.

Of course, even if the proposed attribution procedures are adopted, they do not by themselves solve the problem of intentionally unethical actions; they cannot prevent researchers from engaging in outright fraud. What they will do is mitigate many of the ethical problems of credit attribution that the current authorship model exacerbates. They provide a way to honestly report and justly differentiate the particular contributions that individuals actually made. They allow a way to indicate who bears responsibility for what. And they provide a structure in which consultants and others who provide important auxiliary support may be given credit for their contributions without improperly exaggerating their role to that of co-author. In the end, however, it will still be up to researchers to choose to do the right thing.

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