Title: “Why MANToring is not the solution. A Rebuttal to ‘The association between early career informal mentorship in academic collaborations and junior author performance.’”

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The findings of AlShebli Makovi & Rahwan¹ highlight an endemic problem in science: co-authoring with men is associated with greater numbers of citations for junior scientists than co-authoring with women. The reasons for this likely stem from a long history and culture in science where White, straight, cisgender men are the dominant force. Under the authors' assumption that authorship is equal to mentorship (a notion we criticize below), the reported citation disparity by coauthor gender for junior scientists may simply reflect that under the current status quo there are more barriers for women to establish strong mentorship programs and secure resources to support their mentees compared to men. In other words, citation disparity is the problem, not the solution as proposed by the authors. We argue that the citation disparity is uncorrelated with mentorship and the quality of the publication. Unfortunately, AlShebli Makovi & Rahwan err in their publication in two ways: they define mentorship as co-authorship (albeit with conditions), and they prescribe the problem as a solution suggesting that junior scientists, especially women, ought to be mentored by men - a proposal we have aptly named "MANtoring". These faulty interpretations and conclusions reveal a broader problem in scholarship: failure to critically examine structural biases and assumptions when evaluating and interpreting data showing disparity. Much work is needed to improve the culture of science and to provide a more fair and equitable environment for individuals of any background (women in this case, but a similar reasoning would apply to people historically marginalized based on gender, race, sexuality, class, and other dimensions) to thrive². The AlShebli et al article is a wakeup call to authors in all disciplines to take greater care in interpreting and acting on their disparity data. Failure to do so could have catastrophic effects on science including the irony of exacerbating the very problems researchers are attempting to address.

Problems with the operationalization and measurement of mentoring

At the heart of the problem with this paper is that the authors define mentoring as the mere presence of co-authorship. Yet, there is so much more to mentoring. As defined by the National Academy of Sciences³, "*Mentorship is a professional, working alliance in which individuals work together over time to support the personal and professional growth, development, and success of the relational partners through the provision of career and psychosocial support.*" Moreover, equating co-authorship with mentorship is unsupportable due to the methods used. First, the authors fielded a survey which represents .00668% of their overall sample to assess mentorship relationships. The low response rate raises the question of selection bias, which is not appropriately addressed. Second, the non-validated measure of mentorship equated receiving advice on specific tasks with mentorship, which fails to achieve face validity. Third, the mentor quality measures (citation counts, 'hub') are themselves vulnerable to gender biases. Using an uninterrogated gender-biased metric to explain a gender-biased outcome limits the interpretive value of the work. Fourth, the explanatory scope of the work is limited because it samples on the dependent variable - using only the pool of successful pairs (i.e., those who published together) to evaluate so-called "mentoring" success. Fifth, the gender classification algorithm has limited success with non-Western/Anglo names and commits "trans erasure" (see supplement for more detailed explanations of each point). Lastly, there is evidence that even a single paper co-authored with a top-tier senior scientist boosts junior researchers' careers⁴, suggesting that AlShebli et al's finding that there is a correlation between having a man as a coauthor and having more citations later may be spurious, owing to the fact that men hold a greater proportion of a top-tier senior scientist positions than women.

Problems with Data Interpretation and Conclusions

We commend the authors on their careful processing and detailed documentation of the data they collected and analyzed. But, their suggestions for real-world implications fail to account for systemic gender biases in science, and thus reproduce the inequalities present in the status quo. The authors state, *“Our findings also suggest that mentors benefit more when working with male protégés rather than working with comparable female protégés, especially if the mentor is female.”* This explanation suggests that the causal path goes from gender of protégé to mentor benefit. To the contrary, if there are differences in outcomes between identity groups (e.g., men vs. women), it is essential to evaluate whether a 3rd variable - historical and contemporary manifestations of privilege and bias - drives the observed differences in outcomes. A more accurate interpretation is that men’s access to research-oriented roles in science⁵, gender biases against women⁶, and gender homophily and hegemony in favor of men, accrues the benefits that co-authoring with men (as a mentee or mentor) seem to confer greater numbers of citations. Moreover, men self-cite more than women⁷⁻⁹.

What we felt was most problematic of all is the conclusion that: *“Our gender-related findings suggest that current diversity policies promoting female–female mentorships, as well-intended as they may be, could hinder the careers of women who remain in academia in unexpected ways....More broadly, the goal of gender equity in science, regardless of the objective targeted, cannot, and should not be shouldered by senior female scientists alone, rather, it should be embraced by the scientific community as a whole.”*

We echo the authors’ statement that the pursuit of gender equity should not be shouldered only by senior women scientists, and suggest that to achieve this ideal, structural and cultural forces (including those producing the effects documented in this paper) must be considered. From this standpoint, it is not that women mentors are the problem and men mentors are the solution; the broader culture that rewards masculine defaults is the problem. We thus challenge any conclusion that steers scientists away from a collaboration with a woman, or preferentially toward a man, whether as mentor or protégé. Such a conclusion is not warranted by these data, and overlooks the gender (and other systemic) inequities that exist in academia, especially in STEM.

In summary, the authors have misrepresented their findings on *co-authorship* by concluding that men deliver better quality *mentorship* than women, and especially to women mentees. The authors should correct their characterization of the relationship they studied to be more accurate to the data¹: *“published coauthors at the same institution in the same discipline.”* Offering *MANtoring* as a solution is counterproductive because it reinforces a belief that (White, straight, cisgender) men are regarded as superior to women. Future work should aim to expose the mechanisms by which co-authorship by women seems to result in fewer citations for their protégés. Such knowledge could inform theory-driven interventions to remove obstacles to publication success for dual-women mentoring pairs. We suggest reconsidering the current findings in light of the documented gender bias (and bias against research on gender bias^{10,11}) in the literature. As long as we fail to measure the full spectrum of gender and omit trans and non-binary scientists from analyses, we will miss the full extent of gender bias that scientists face and therefore will be unable to address it. As we have pointed out elsewhere,¹² developing an inclusive and diverse culture that emphasizes multiple ways of knowing, metrics for successes, and forms of collaboration will ultimately advance discovery and knowledge production.

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Supplementary Information

(1) Methodological Issues in Claiming a Mentoring Relationship: Sample Selection Bias, Lack of Representativeness, Quality of Survey Instrument

Reviewers of the manuscript drew attention to the authors' assumption that the selected co-author relationships constituted mentorship. In response to the reviewer critique, the authors fielded a non-validated survey to confirm the existence of a mentoring relationship between selected co-authors. We note three problems with the authors' approach: sample selection bias, lack of representativeness of the co-authorship pairs under study, and use of a non-validated survey instrument.

The authors report survey data from 167 co-author pairs out of 2.5 million, and do not tell us how their small sample is different from those who did not respond. Is there a selection bias? Respondents (n= 167) represent 8.35% of their sample of 2000 junior scientists selected for the survey, a very low response rate. However, with regard to representing the population under study, the denominator is more appropriately the 2.5 million unique co-author pairs the authors characterized as mentor-protégé relationships. Therefore, only .00668% of their total sample responded to the survey. This amounts to less than half of an estimated sample size of 385 needed to represent the population at a 95% confidence level¹, which suggests that responses cannot be assumed to represent the broader group of junior scientists under study. Moreover, these survey data were not included in the statistical analyses of scientific impact. At a minimum, the authors ought to report indicators of representativeness of their sample².

In addition to problems of sample selection and sample bias, we question the content of the survey being used as evidence that the nature of the relationship is one of mentoring. The authors claim that mentoring relationships exist is predicated on a non-validated survey, "*A high percentage of [junior scientists who responded to the survey] agreed (strongly or otherwise) that they have received advice from the senior collaborator about that skill, with the percentage ranging from 72 to 85% depending on the skill.*" Although receiving advice about a skill may be one component of mentoring, receiving advice, in and of itself, is not equivalent to mentoring. Referring to Figure 1 panel (a) in the paper³, a coauthor who, for example, advises shortening the introduction, and adding in new references for the statistical analyses, would be counted as having given advice; but is that mentorship? Responses in Figure 1 panel (c)³ are more compelling at face value, but are still not validated indicators of a mentoring relationship. Instead, the authors would have done well to ask respondents directly, "Would you consider this person your primary/informal mentor?" and provided ratings of the degree of support within the mentoring relationship. The mentoring literature is deep, and it was a missed opportunity to adapt a published, validated, measure of mentoring. At the very least, the authors should acknowledge the limitations of their operationalization of "mentoring" and ensure that their conclusions do not overgeneralize to "mentoring" in general, which is likely to be multifaceted and include factors such as perceiving support from one's mentor.

(2) Mistaking Men's Social Capital as Measures of Mentor "Quality"

A second key concern is that the definition of "mentor quality" is problematic. The measures of mentor quality presented were: 1) how much others cite their work (i.e., average number of citations per annum for the mentor up to the year of their first publication with the protégé) – what the authors call the "big-shot" measure, and 2) how well connected the mentor is to other authors (i.e., the average degree of the mentors prior to mentorship) – what the authors call the "hub" measure. These measures reflect more about social network capital of senior authors than "mentorship quality". Research on the role of social capital on academic success, including "The Matthew Effect", posits that better-known scientists garner more recognition than lesser-known peers in spite of similar achievements⁴⁻⁶ (see also ⁷). Given gender disparities in scientific recognition, it is not surprising that men's scientific research gets more attention than women's ⁸⁻¹¹ and that co-authorship with senior men (more than senior women) will likely increase junior scientists' citation counts in the field.

Yet, research shows that citation counts are, themselves, a reflection of bias. Male scientists self-cite their own work 56% more often than women scientists, and men cite other men's research at far higher rates than they cite women's research, even when the work is published in the same journal (e.g., ¹²⁻¹⁴). As shown in Figure 3³, *"having more female mentors is associated with a decrease in the mentorship outcome, and this decrease can reach as high as 35%, depending on the number of mentors and the proportion of female mentors."* In this analysis, the authors controlled for: *"the protégé's average big-shot experience, number of mentors, gender, discipline, affiliation rank, and the year in which they published their first mentored paper."* The outcome for the protégé's "impact" defined as the number of citations accumulated 5-years post-publication, by a specified set of papers published without the mentor during the protégé's senior years. It has already been established that papers garner more citations when authored by men (vs. women). This inequity does not mean that women are inferior as mentors; rather, it illustrates the bias in under-citing women's work and, relatively speaking, over-citing men's work. Changes are needed to overcome cultural biases that exist in favoring men's research over women's research, as well as recognize the problems associated with using certain forms of bibliometrics to infer quality or impact of an author's research¹²⁻¹⁴.

(3) Authorship as Mentor Quality?

Because the sample of co-author mentor-mentee pairs was constructed from published research, the analysis is flawed in sampling on the dependent variable (publication which is an integral part of the way mentee "success" is defined). To study "mentor quality", one should not only look at success cases (those who published) and draw conclusions based on associations, because the same relationships could have been present in failure cases. In other words, to make inferences about the dynamics of gender and mentorship success, researchers would need to evaluate the full scope of mentorship success **and failure** across gender identities. For example, it could be that men mentor- women mentee pairs are more likely to dissolve, with no publications, than women-women pairs. If this were the case, it would meaningfully change our understanding of the current data (i.e., there is only a men mentor- women mentee advantage for the few who make it through to publication) and the implications for mentorship success.

(4) Limitations of Gender Classification Algorithms

The author gender classification algorithm used in this article, genderize.io, is fraught with two problems. First, it is heavily biased towards Anglo or Christian names, and may not accurately classify non-Anglo and/or non-Christian names (e.g., Asian names)¹⁵⁻¹⁷. Second, like much of the literature on

gender in science, the gender analysis by AlShebli et al. engages in “Trans erasure” by failing to measure or thoughtfully acknowledge gender alternatives to cis men and cis women. These authors are not the first or only ones that fail to approach gender analyses in an inclusive way, which we and others have noted as a problem elsewhere^{18,19}. We encourage scholars to both acknowledge the limitations of existing gender classification algorithms and strive to develop new measures, analyses, algorithms, and methods to include rather than erase trans and non-binary people. Therefore, we call on the authors of this paper, as well as the broader scientific community, to take on this important task to develop the resources to be more inclusive in our work.

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