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REVIEWS

Scientific Life

The Citation Diversity Statement: A Practice of Transparency, A Way of Life

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Appending a Citation Diversity Statement to a paper is a simple and effective way to increase awareness about citation bias and help mitigate it. Here, we describe why reducing citation bias is important and how to include a Citation Diversity Statement in your next publication.

We, like so many, are troubled by the gender and racial disparities that have existed in academia for far too long. What will be required to right these wrongs against our trainees, in our fields, and throughout our world? What would a world of recognized minority leadership and scholarship look like? How can we contribute? While we certainly do not have all the answers, here we present a simple, though no less significant tactic, that is relatively easy for anyone to adopt.

The Story Behind the Citation Diversity Statement

It all started with a curious man. His name is Jordan Dworkin, then a graduate student at the University of Pennsylvania with R. Taki Shinohara. He had recently read Ed Yong's piece in *The Atlantic* on the gender imbalance in journalism [1]. The story resonated with Dworkin's own observations of papers and conferences, as well as his informal discussions with women colleauges, and led him to a robust literature on gender biases in academic publishing [2,3]. In his free time, he decided to investigate the existence, extent, and drivers of gender imbalance in neuroscience reference lists. He looped in Bassett (physicist, neuroscientist, and network scientist) and Zurn (philosopher, ethicist, and gender theorist) and, joined by coauthors Shinohara, Linn, and Teich, the team completed and published the work in *Nature Neuroscience* [4].

The study reports a marked gender imbalance in the reference lists of articles published between 1995 and 2018 in *Nature Neuroscience*, *Neuron*, *Brain*, *Journal of Neuroscience*, and *NeuroImage*, with papers first- and last-authored by men being cited 11.6% more than expected given the proportion of such papers in the field and papers first- and last-authored by women being cited 30.2% less than expected. The imbalance: (i) remained after controlling for author seniority, publication year, and research subfield, (ii) was driven largely by the reference lists of papers first- and last-authored by men, and (iii) is increasing over time, particularly in the reference lists of papers first- and last-authored by men. The latter finding is only partially explained by homophily in coauthorship networks. The findings are consistent with reports in political science, international relations, communications, and astronomy [2,3,5,6].

Is gender imbalance indicative of gender bias? If the imbalance is statistically unexpected were gender not a factor, then yes, the gender imbalance is indicative of gender bias [7] (Box 1). The undercitation reported in the paper reflects explicit and implicit bias against authors known to be women, as well as explicit and implicit bias against authors with a first name common to women. To increase awareness of this bias, and to combat the authors' own implicit bias, Dworkin developed a Citation Diversity Statement and appended it to the paper [4].

What Is a Citation Diversity Statement?

A Citation Diversity Statement is one way to mitigate citation bias. It is simultaneously a simple statement of fact and a consciousness-raising tool. Rust (neuroscientist, psychologist) and postdoc Vahid Mehrpour were not involved in the original work, but adopted the Citation Diversity Statement with enthusiasm. After consulting with Bassett's team, they incorporated their own statement into a review article for *Trends in Cognitive Sciences*, which became the first published article to do so [8].

As developed to date, the Citation Diversity Statement is a short paragraph, included before the References section, in which the authors consider their own bias and quantify the equitability of their reference lists [4]. It states: (i) the importance of citation diversity, (ii) the percentage breakdown (or other diversity indicators) of citations in the paper, (iii) the method by which percentages were assessed and its limitations, and (iv) a commitment to improving equitable practices in science. The statement of importance provides authors with the opportunity to note diversity issues unique to the paper's (sub)field. In turn, the percentage breakdowns can be generated either through algorithmic calculations[i] or manual curation such as by gathering pronouns from websites. Identifying method and limitations enhances transparency and the nod to future work indicates a certain humility. Each portion flags a recognition of the value of developing new methods and means for supporting citation diversity and diversity in the profession overall. With all four elements together, the Citation Diversity Statement is an important annotation, as much as an expression of ethos. See the References section for a sample statement concerning gender bias.

Why Is the Citation Diversity Statement Important?

Despite its ubiquity, few of us appreciate just how insidious implicit bias can be or know how to counteract it effectively. We manifest bias without even realizing it, even those of us who are already hard at

Box 1. Types of Bias

Bias may be either individual or structural, buried in disciplinary habits and social customs. The relevant types of individual bias here are at least fourfold. First, we can have explicit bias against a person's known gender. This type of bias is exemplified by the all-too-common statement: 'But men are just better scientists than women'. Second, we can have implicit bias against a person's known gender. This type of bias is exemplified when we treat men as better scientists than women, even though we do not consciously believe men are better scientists than women. Third, we can have explicit bias against someone who has a gendered name. This type of bias is exemplified by an overt disdain for people bearing names that are gendered in particular ways. Fourth, we can have implicit bias against someone because of their gendered name [13-15]. This type of bias is exemplified when we act differently toward someone with a name commonly used by women than someone with a name commonly used by men.

The methods used in Dworkin's study are sensitive to all four types of bias. Using two publicly available probabilistic databases, the label 'woman' was assigned to authors whose first name had a probability ≥0.70 of belonging to someone: (i) assigned female at birth, or (ii) identifying as a woman on social media; likewise, the label 'man' was assigned to citing authors in the dataset whose name had a probability ≥0.70 of belonging to someone (i) assigned male at birth, or (ii) identifying as a man on social media. Those authors assigned the label 'woman' therefore approximate: (i) people that the citing authors in the dataset may know to be women (either cisgender or transgender) from personal friendships, professional relationships, or websites; and (ii) people whose names are commonly used by women.

work diversifying our fields. Imbalanced citations are real, quantifiable proof of continued bias in neuroscience. Moreover, the fact that citation imbalance is not only persisting but increasing yearly is a marked call to action. The question is simply what to do about it. The Citation Diversity Statement is a relatively simple and highly effective way to shine a light on the issue and cultivate a more equitable future (Box 2).

While the problem of citation bias is real, it is more significant than mere bean counting [9]. Citations serve several major functions. They are a kind of currency, used to obtain career advancement in the form of jobs, tenure, promotion, grants, or other academic opportunities. They represent an existing architecture, or distribution network, of the resources and relationships that constitute science itself. They serve as a record of what has counted for science and the persistence of revolutions in scientific thought. And they are resources from which new scientific directions can be drawn. When citations are imbalanced in such a way that minority scholars' career advancement is disadvantaged, this is an injustice. But the more fundamental injustice lies elsewhere. If citations direct the trajectory of scientific discovery, shaping the very formulation of our research questions, then an imbalance in citations is an imbalance in whose questions get heard, repeated, investigated, and ultimately answered. Citation imbalances bias the research itself. Scientific inquiry at its best will proceed via optimal foraging, canvassing and curating questions for their essential worth and the diversity of their contributions.

Box 2. What Are Common Objections to the Citation Diversity Statement?

Preparing a Citation Diversity Statement is not always easy. Authors may have to navigate conceptual or practical challenges. Here, we provide helpful solutions to two common concerns.

i. I'm an Expert! I Cite What I Need to Cite

We are, indeed, experts in our field. But those fields are always changing and our expertise must grow with them. Moreover, we are always more than experts. We are, most fundamentally, not those who know but those who seek to know. We are investigators. The Citation Diversity Statement is an invitation to pause, an invitation to reflect, an openness to see our own tendencies, and a willingness to correct course. To learn new literatures, meet new scientists, romance new questions. Evaluating our reference lists is a practice of holding ourselves accountable but also of teaching ourselves about our fields and increasing awareness for others. We have found repeatedly that certain claims are often better supported by papers authored by minority scholars than famous papers, by majority scholars, arriving first at our pen-tip from the muddy recesses of our mind.

ii. There Aren't Any Women in My Subfield! My Hands Are Tied

If there is a dearth of women or other minority scholars in your subfield, what do you do? Do you publish a Citation Diversity Statement with low numbers or forego it and save face? We find at least two viable responses here. First, given the hourglass shape of a paper, if nothing else, you can easily diversify the citations in your introduction and discussion sections, framing your main contribution in dialogue with minority scholarship. Second, if in fact the situation in your subfield is unusually dire, you can identify this problem in section (a) of your Citation Diversity Statement, indicating regretfully that your paper follows field-specific percentages. Doing so signals a wider problem that the subfield ought to address by building new pipelines, mentoring underrepresented scholars, diversifying conference speakers, publication invitations, research collaborations, etc.

Creating Your Own Citation Diversity Statement

Already, the Citation Diversity Statement is being changed and fine-tuned, as any true scientific or social justice endeavor must. In early examples [4,8,10], the Citation Diversity Statement is composed of differing elements and divergent methods. We emphasize that while we have suggested what a Citation Diversity Statement might look like, this should not be taken as a rigid or final suggestion about the precise form that other Citation Diversity Statements should take. Rather, we encourage all authors to implement the version that they think is most beneficial for the cause of mitigating citation bias. It is important for all of us to critically engage in revising and improving these practices, and to do so in conversation and collaboration with the marginalized scholars they aim to support. Ultimately, what is more important than a Citation Diversity Statement itself is the reflexive processes in which it invites us to participate. For our current suggestions on best practices,

see Zhou *et al.*, 'Genderdiversity statement and code notebook v1.0'[i].

Beyond the Citation Diversity Statement

The Citation Diversity Statement is not an end in itself. It is a means toward not only social justice, but good, clean science. While the Citation Diversity Statement is a useful tool along the way, commitment to diversifying science requires moving: (i) beyond the gender binary, (ii) beyond the axis of gender itself, and (iii) beyond citations.

Beyond the Gender Binary

We regret that the current methodology of probabilistically linking names with binary genders cannot account for or appreciate the diversity that intersex, non-binary, and/or transgender scientists bring to the field. Due to the variety of ways in which these populations negotiate gendered names, we suspect self-attestation to be the most reliable indicator. To that end, we would welcome the expansion of 500 Queer Scientists[ii] as a complement to Anne's List[iii].

Beyond Gender

A commitment to diversity must stretch beyond gender to also include race, ethnicity, socioeconomic status, disability, and other dimensions of disparity. Scholarship has consistently diagnosed inequities along these axes and such inequities are exacerbated at their intersections [11]. Notably, recent grass-roots efforts seek to present the identities and scholarship of under-represented minorities in growing databases[iv]. It behooves each of us to use these data to educate ourselves about the scientific questions posed by all and to #CiteBlackWomen[v] among other minority groups. To quote Maya Angelou, 'No one of us can be free, until all of us are free'.

Beyond Citations

Committing to a Citation Diversity Statement is one way of committing to citation diversity and ultimately the diversification of science. While the algorithmically generated statement is uniquely poised to assess large reference lists composed of authors with whom the writer is currently unfamiliar, it cannot take the place of conscious efforts to familiarize oneself with the work of minority scholars. Such familiarization can occur while editing a manuscript, but it is even better undertaken in the conceptualization and design of a research project.

Concluding Remarks

Ethical research practices are a way of life. And diversifying science is a task for the long haul. The Citation Diversity Statement is but one tool in a larger project. Science changes every day. And each of us changes it with every paper we write, every reference list we publish, every collaboration we initiate, every class we teach, and every mentee we welcome [12]. How do we want to make that change?

Resources

[i]https://github.com/dalejn/cleanBib/
[ii]https://500queerscientists.com/
[iii]https://anneslist.net/
[iv]https://dscnatl.org/speakers-list/
[v]www.citeblackwomencollective.org/

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Citation Diversity Statement

Recent work in several fields of science has identified a bias in citation practices such that papers from women and other minorities are under-cited relative to the number of such papers in the field [2–6]. Here we sought to proactively consider choosing references that reflect the diversity of the field in thought, form of contribution, gender, and other factors. We obtained predicted gender of the first and last author of each reference by using databases that store the probability of a name being carried by a man or a woman [4][i]. By this measure (and excluding self-citations to the first and last authors of our current paper), our references contain 42.9% woman(first)/woman(last), 28.6% man/woman, 7.1% woman/man, and 21.4% man/man. This method is limited in that: (i) names, pronouns, and social media profiles used to construct the databases may not, in every case, be indicative of gender identity, and (ii) it cannot account for intersex, non-binary, or transgender people. We look forward to future work that could help us to better understand how to support equitable practices in science.

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Science & Society

Of Viruses, Vaccines, and Variability: Qualitative Meaning Matters

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Deaths from COVID-19 depend on millions of people understanding risk and translating this understanding into risk-reduction behaviors. Although numerical information about risk is helpful, numbers are surprisingly ambiguous, and there are predictable mismatches in risk perception between laypeople and experts. Hence, risk communication should convey the qualitative, contextualized meaning of risk.

Amidst the COVID-19 crisis, it is crucial to understand how people think about risk and how this determines their risk-reduction behaviors [1]. As in other public health problems, outcomes hinge on people's choices: whether to practice social distancing to prevent the spread of COVID-19, safer sex to prevent HIV/AIDS, or vaccination to prevent seasonal influenza. However, there is a fundamental mismatch between how most people think about risk and the assumptions experts make about actual and ideal human thinking. That is, most people think about risk in terms of qualitative meaning, called gist, as opposed to the precise details of risk information [2]. This mismatch produces predictable pitfalls in risk communication that are avoidable.

Why Numbers Are Ambiguous

The mismatch between gist and precise representations of risk goes beyond merely rounding off numbers, lumping rather than splitting, or innumeracy – the numerical equivalent of illiteracy [3]. To be sure, numeracy is a good thing. Popular numeracy tests ask respondents about probabilities and risks, such as questions about how to convert frequencies into probabilities, order different probabilities, and discriminate lower from higher risks. Other tests ask people to estimate the values displayed in a bar graph [4]. It is important to be able to read a graph and to know that a 0.10 probability of contracting COVID-19 is higher than a 0.01 probability. Every day during the pandemic, graphs and numbers hurl past the public.

However, numeracy is not sufficient to understand risk. In fact, numbers are ambiguous in the way that words are ambiguous, perhaps more so [5,6]. Suppose that a person hears that the number of deaths in the USA has surpassed 80 000, that the risk of transmission of COVID-19 is 2–3 times greater than that of the seasonal influenza, and that the mortality rate is about 3% of reported cases (Box 1). Decisions to act depend on the meaningful essence of this information. A simple linear transformation of numbers to categories does not capture the essence of risk. A nonlinear transformation of numbers does not suffice either. For example, a probability of 3% of rain would be low, but a probability of death of 3% from COVID-19 is high. Context matters for meaning.

Much research in the decision sciences has been devoted to demonstrating that context biases risky decisions, even making people who are risk-avoiding become risk-seeking just by changing how the same underlying facts are described [7]. These biases illustrate the human tendency to focus on changes relative to a reference point [8]. For example, a woman consulting the Breast Cancer Risk Assessment tool online (https://bcrisktool.cancer.gov/) is likely to be relieved to discover that her risk of cancer is below average because it is less than that of the population rate of about 13%, but how should she interpret these numbers? The numbers do not tell her the most important thing, namely, whether her risk is low or high. Her actions, whether to be screened more often than the average woman, and emotions, whether to feel calm or anxious, hinge on her interpretation of the gist of the risk: What does this information mean in context?

Meaning in context does not mirror literal reality. Typically, people do not think using what are called 'verbatim representations' of information. They think in fuzzy imprecise ways that interpret reality. For example, during a recent meeting I attended, public-health experts pointed out that those who test negative for a genetic mutation that increases breast-cancer risk technically do not have the same probability of developing breast cancer as members of the general population. But what is the gist of their risk? Testing negative does not mean that they have zero risk. Rather, their risk is less than the population average but remains in the same ballpark – the bottom line is that they could still develop cancer and need to take measures to reduce their risk (e.g., screening). For those who test