

A missing component of research integrity pedagogy: expanding RCR education to include writing scientific prose

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Abstract

Even in cases in which RCR curricula exceed minimal government or regulatory requirements, they remain out of date, limited and incomplete.

Writing is not merely an addition or supplement to the RCR curriculum, but, rather, underpins all aspects of empirical inquiry and therefore should be regarded as a core component of research integrity.

Writing and Science

Scientific writing is not merely “the bare transmission of determinate facts”¹ but rather an essential part of scientific understanding and progress, and an integral part of the practice of research.

This work clearly establishes the links between writing and science, including medicine, and that writing is not separate from, but part of, the scientific enterprise. The growth of knowledge depends in part on the way we communicate those ideas.

Writing contributes to science as a necessary condition of scientific communication, data and information sharing, and reproducibility.

The Challenge of Scientific Replication

- Causes are not well established but may include methodologic sloppiness, failures of rigor or frank misconduct.
- I hypothesize that a ubiquitous and practical feature of scientific inquiry also has a role in failures to replicate studies: writing prose

Scientific writing

Scientific writing is often of low quality.

Scientists are usually not taught to write as part of their training.

Weaknesses or flaws include vagueness, opaque prose, excessive use of passive voice, hedging and boasting, and excessive use of positive words.

Poor writing leads to lack of clarity, misrepresentation of ideas, obfuscation, and, ultimately, inaccurate reporting of results.

Good scientists are good writers

Rigor and Reproducibility

The NIH has recently added reproducibility to its RCR/training requirements.

“Two of the cornerstones of science advancement are rigor in designing and performing scientific research and the ability to reproduce biomedical research findings. The application of rigor ensures robust and unbiased experimental design, methodology, analysis, interpretation, and reporting of results. When a result can be reproduced by multiple scientists, it validates the original results and readiness to progress to the next phase of research.”

Rigor and Writing

“...the strict application of the scientific method to ensure robust and unbiased experimental design, methodology, analysis, interpretation, and *reporting of results...*”

Rigor requires good writing.

For example:

hedging
emphasis
clarity
obfuscation
word choice

Hedging and Emphasis

Striking the right balance between hedging and emphatic may be the most difficult challenge in clear writing.

Words such as “usually,” “often,” “sometimes,” “perhaps,” “may,” “might,” “can,” “could,” “(it would) seem,” “suggest” are all **hedging** words.

Emphatic words are good, but we rarely see them because we are not that sure: “clearly,” “very,” “obviously,” “indeed,” “undoubtedly,” “certainly,” “major,” “primary,” “essential” are all **emphatic** words

Clarity

Inhalation of vapor phase particulate matter chemical contaminants from biomass combustion in domestic settings is a significant contributor to local disease burden.

or

Domestic wood smoke causes local health problems.

Obfuscation

Still not significant ...

“...if your p-value remains stubbornly higher than 0.05, you should call it ‘non-significant’ and write it up as such. The problem for many authors is that this just isn’t the answer they were looking for: publishing so-called ‘negative results’ is harder than ‘positive results’.

[Often] the solution is to apply the time-honored tactic of circumlocution to disguise the non-significant result as something more interesting, e.g. ‘a trend towards significance’...”

Word Choice

Box 1: Words used in PubMed search queries and Google books search engine

Positive words

Amazing, assuring, astonishing, bright, creative, encouraging, enormous, excellent, favourable, groundbreaking, hopeful, innovative, inspiring, inventive, novel, phenomenal, prominent, promising, reassuring, remarkable, robust, spectacular, supportive, unique, unprecedented

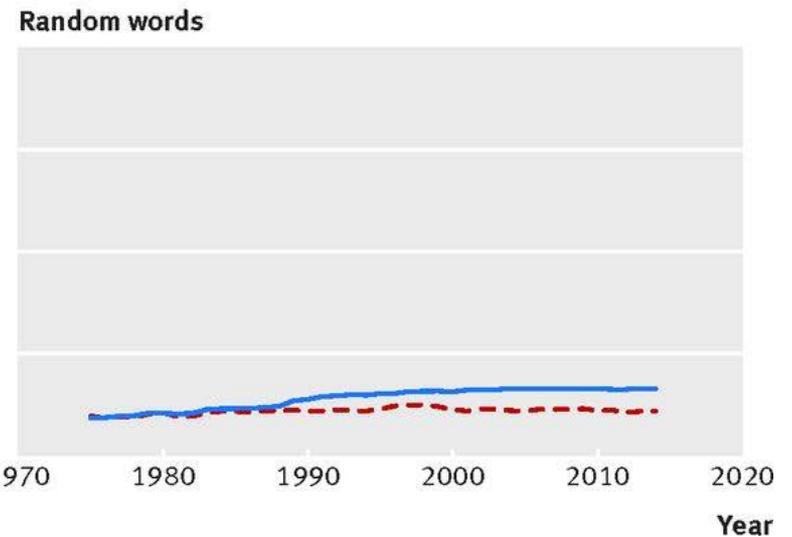
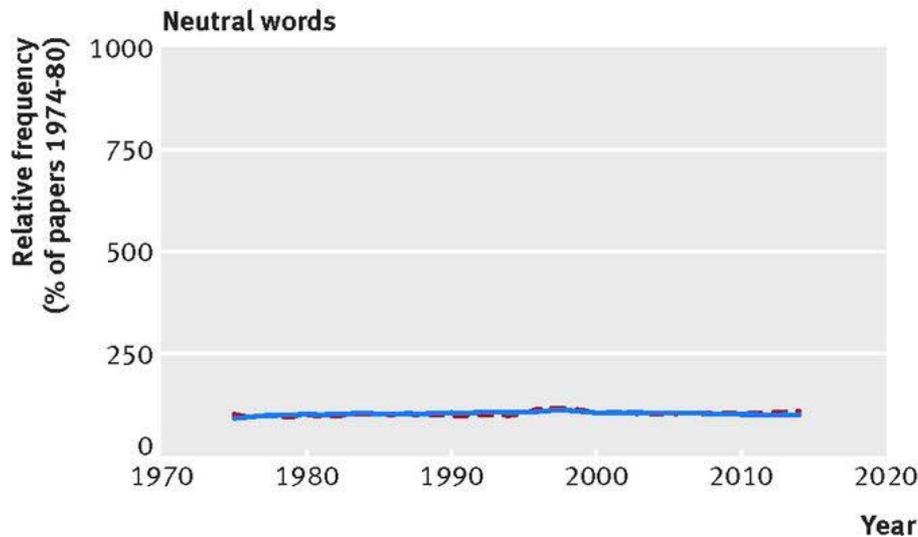
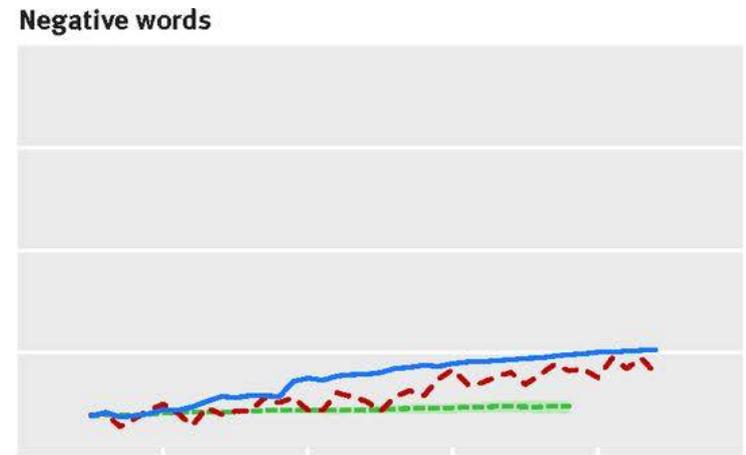
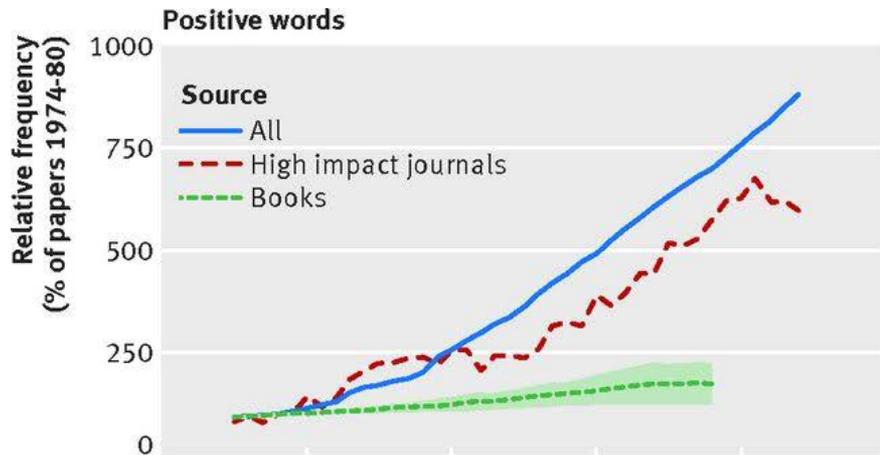
Negative words

Detrimental, disappointing, disconcerting, discouraging, disheartening, disturbing, frustrating, futile, hopeless, impossible, inadequate, ineffective, insignificant, insufficient, irrelevant, mediocre, pessimistic, substandard, unacceptable, unpromising, unsatisfactory, unsatisfying, useless, weak, worrisome

Neutral words

Animal, blood, bone, brain, condition, design, disease, experiment, human, intervention, kidney, liver, man, men, muscle, patient, prospective, rodent, significant, skin, skull, treatment, vessel, woman, women

Positive words have increased 880% over 40 years



And these words...

- robust
- novel
- unprecedented
- innovative

...show a relative increase of up to 15 000%

Conclusion

- There is a need for fuller understanding of, and response to, the causes of failures of scientific replication. Writing should be added to other hypothesized causes, and studied as such.
- This unrecognized source of reproducibility failure should be a component of the RCR curriculum.
- We recommend that academic and corporate scientific entities take up this initiative.
- At the University of Miami, we have modified our institutional RCR training to include prose writing and code writing in addition to traditional components of the curriculum.

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