PHIL 8670: Replication and Reproducibility in Science (Fall 2021, 3 units)

September 1, 2021

Teaching Staff, Meeting Times, and Communication

Instructor: Prof. Samuel C. Fletcher (scfletch@umn.edu). Preferred address in person and by email: "Sam" (he/him/his).
Seminar: Tu 4:00–6:30 in Heller 731
Office Hours: Mo/Tu 2:30–3:30, and by appointment in Heller 754 or via Zoom

Course Website: `https://canvas.umn.edu/courses/265727`. Please check Canvas often for course updates.

Timely Communication: Outside of class meeting times and office hours, I prefer that you contact me via Canvas Inbox or email, and will endeavor to respond within two business days. I expect the same of any email or Canvas messages to you.

Course Requirements

Prerequisites: Students are expected to have an undergraduate background in science or philosophy of science, with some exposure to experimentation and statistical testing.

Required Texts: The following text will be available at the bookstore:

- H. M. Collins, *Changing Order: Replication and Induction in Scientific Practice*, University of Chicago Press, 1992 ed.

All other course readings will be available on the course Canvas site, either directly or through a library link.

Other Required Materials: Please bring to every lecture and discussion section paper and either a pencil or a pen in blue or black ink.

Description and Objectives

This seminar will be on reproducibility and replication in science. Drawing from sources in the history, philosophy, and sociology of science, we will investigate questions such as: Why, or under what circumstances, is the replication of an experiment or the reproducibility of its result important in science? What scientific role do these concepts play? How are they defined? We will explore these sorts of questions (i) through Collins's challenge to the justification of experimental repliation, called the experimenters' regress, in his monograph, *Changing Order*; and (ii) through reactions to it, and attempts to define replication and characterize its role in science.

Then we will turn to a contemporary malaise, sometimes called the "replication" or "reproducibility crisis," afflicting especially parts of the psychological and biomedical sciences (and perhaps beyond) over the past decade. We will discuss, for instance: What, exactly, is this crisis? Is it a real problem for science? How can we measure its extent? Are its causes to be found among the statistical methods commonly used? Or in the incentives within science towards fraud, questionable research practices, and publication and other biases? And, how might we intervene on these causes or otherwise act to resolve the crisis? This part will also draw on scholarship by scientists working in the fields affected by the crisis and the community self-identifying as "meta-scientists," who apply tools from statistics and the social sciences to study scientific institutions.

Because of the diversity of topics, seminar participants should expect to be unfamiliar with some of them, but different participants will be unfamiliar with different ones. One objective of the seminar is to maintain a weekly community of discussion through which we can all learn from each other; accordingly, I am not planning on lecturing, in general. Instead, everyone in the course will lead discussion for one or more of the seminar meetings. (Those taking the course for a grade will lead two; those auditing, one.) That can include creating a slide presentation, or a handout, or can even be done using the whiteboard. The goal is to guide everyone through the important ideas of the readings, raising questions, facilitating discussion, etc. I will only play a consulting role before and during each seminar meeting.

You should expect to spend, on average, about 300 minutes per week outside of class completing reading assignments and, if applicable, preparing your class presentation. In any given week, you may spend more or less than this. Spending more or less time does not necessarily indicate that you are achieving less or more, respectively.

The reading assignment for the first class meeting provides two classes of considerations:

1. An introduction to the topics for the rest of semester. This consists in a book review of *Changing Order*, and a review essay on philosophy of science and replication crisis. Those attending the course should use this information to select their seminar presentation preferences, for which a Doodle poll will be sent after class.

2. The introduction and first chapter of *Changing Order*, in which Collins presents the theoretical context for the rest of his investigation.

Although some of the topics we will encounter during the seminar will have technical aspects, we will try to focus on the conceptual underpinnings of those aspects in discussion.

Assessment

Basis for Evaluation

Discussion Participation (15%) Students should attend all seminar meetings when possible and make some contribution to the discussion during those meetings.

Seminar Presentations (40%) Each student taking the course for a letter grade will lead seminar discussions for two class meetings on the readings assigned for that day. (Auditors will lead one.) This can include creating a slide presentation, or a handout, or can even be done using the whiteboard. Grading will be based on clarity, accuracy, judicious comprehensiveness, explaining any needed or helpful background ideas, and raising and facilitating interesting topics for discussion. Each presentation will be worth 20% of one's final grade.

Term Paper (45%) Students taking the course for a letter grade must submit by December 21st a 4,000–8,000-word term paper developing a novel argument on a topic derived from the course material.

Understanding Your Letter Grade

How to Compute Your Letter Grade

	$90 > \text{B+} \geq 87$	$80 > \text{C+} \geq 77$	$70 > \text{D+} \geq 67$	
$\text{A} \geq 93$	$87 > \text{B} \geq 83$	$77 > \text{C} \geq 73$	$67 > \text{D} \geq 63$	$\text{F} < 60$
$93 > \text{A–} \geq 90$	$83 > \text{B–} \geq 80$	$73 > \text{C–} \geq 70$	$63 > \text{D–} \geq 60$	

Grades in the following ranges represent the following corresponding levels of achievement relative to the level necessary to meet course requirements:

A: Outstanding.
B: Significantly above.
C: Adequate in every respect.
D: Worthy of credit despite not fully meeting course requirements.
F: Not meeting enough course requirements to be deserving of credit.

Students taking this course "pass/fail" will receive an "S," representing satisfactory achievement, for any standard final letter grade of "C–" or higher that he or she would have been assigned. Such students will receive an "N," representing unsatisfactory achievement, for any standard final letter grade of "D+" or lower that he or she would have been assigned.

For additional information about University policies about grading and transcripts, please refer to: `http://policy.umn.edu/education/gradingtranscripts`.

Policies

Student Conduct Code

The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University.

Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.

As a student at the University you are expected adhere to the Board of Regents' Student Conduct Code. Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor's ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities." The conduct code includes adherence to University COVID policies, such as wearing a face covering while indoors, when such policies are in effect.

Use of Personal Electronic Devices in the Classroom

The University establishes the right of each faculty member to determine if and how personal electronic devices are allowed to be used in the classroom. In this class, the use of laptops, tablets, and other electronic devices is permitted as long as it would not reasonably be a distraction to others. Reasonable distractions include movies, games, and social media. Students violating this policy will be asked to put their offending device away for the rest of the class session. Using personal electronic devices in the classroom setting, especially in these ways, can hinder instruction and learning, not only for the student using the device but also for other students in the class.

Writing Resources

Student Writing Support (SWS) offers free writing instruction for all University of Minnesota students at all stages of the writing process. In face-to-face and online collaborative consultations, SWS consultants help students develop productive writing habits and revision strategies. SWS consultants are teachers of writing: graduate and undergraduate teaching assistants and professional staff. Some consultants specialize in working with multilingual writers, and others have experience with writing in specific disciplines. Consulting is available by appointment online and in Nicholson Hall, and on a walk-in basis in Appleby Hall. For more information, go to writing.umn.edu/sws or call 612-625-1893. In addition, SWS offers a number of web-based resources on topics such as avoiding plagiarism, documenting sources, and planning and completing a writing project.

Scholastic Dishonesty

You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. According to the student conduct code, "scholastic dishonesty" includes: plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards,

or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis. If it is determined that a student has cheated, he or she may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see the UMN policy library.

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty. If you have additional questions, please clarify with your instructor for the course.

Make-up Work for Legitimate Absences

Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include illness (inclusive of dependents), medical conditions related to pregnancy, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, religious observances, and participation in formal University system governance. Such circumstances do not include voting in local, state, or national elections. For complete information, please see the UMN policy library.

Under such legitimate circumstances leading a student to be absent for any graded assignment, that student must contact me about it at least two weeks in advance, or as soon as possible if the circumstances are known later, to schedule a make-up assignment or an extension on the assignment deadline, as I deem appropriate.

Appropriate Student Use of Class Notes and Course Materials

Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community. For additional information, please see the UMN policy library.

Sexual Harassment

The University prohibits sexual misconduct, and encourages anyone experiencing sexual misconduct to access resources for personal support and reporting. If you want to speak confidentially with someone about an experience of sexual misconduct, please contact your campus resources including the Aurora Center, Boynton Mental Health or Student Counseling Services. If you want to report sexual misconduct, or have questions about the University's policies and procedures related to sexual misconduct, please contact your campus Title IX office or relevant policy contacts.

Instructors are required to share information they learn about possible sexual misconduct with the campus Title IX office that addresses these concerns. This allows a Title IX staff member to reach out to those who have experienced sexual misconduct to provide information about personal support resources and options for investigation. You may talk to instructors

about concerns related to sexual misconduct, and they will provide support and keep the information you share private to the extent possible given their University role.

For additional information, please consult the Board of Regents' policy on the matter.

Equity, Diversity, Equal Opportunity, and Affirmative Action

The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. To this effect, please notify me if you have a preferred name or pronoun not indicated in your official enrollment data. For more information, please consult the Board of Regents' policy on the matter.

Disability Accommodations

The University of Minnesota is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center (DRC) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations. If you have, or think you may have, a disability (e.g., mental health, attentional, learning, chronic health, sensory, or physical), please contact the DRC at 612-626-1333 to arrange a confidential discussion regarding equitable access and reasonable accommodations.

Students with short-term disabilities, such as a broken arm, can often work with instructors to minimize classroom barriers. In situations where additional assistance is needed, students should contact the DRC as noted above. If you are registered with the DRC and have a disability accommodation letter dated for this semester or this year, please contact me as early in the semester as possible to review how the accommodations will be applied in the course. If you are registered with the DRC and have questions or concerns about your accommodations, please contact your access consultant or disability specialist. For more information, please see the DRC website.

Mental Health and Stress Management

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website.

Academic Freedom and Responsibility

Academic freedom is a cornerstone of the University. Within the scope and content of the course as I have defined it, this includes the freedom to discuss relevant matters in the classroom. Along with this freedom comes responsibility. Students are encouraged to develop

the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study, but they are responsible for learning the content of any course of study for which they are enrolled. Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help, including me, the Philosophy Department Chair Prof. Peter Hanks (pwhanks@umn.edu), your adviser, or College of Liberal Arts Associate Dean for Arts and Humanities Josephine Lee (jolee@umn.edu).

Tentative Course Schedule

As the section title indicates, the course schedule is open to (reasonable) modification in light of the class's progress. Texts other than *Changing Order* (CO), which is listed by chapter, will be linked in the Canvas site. You are required to have the reading assigned for a particular day done before that day's seminar; in any case, prioritize readings in the order listed. If you are not used to reading a certain sort of text (e.g., philosophical, scientific), you may also find it helpful to re-read the text a second time after reading it first quickly for the gist. Reading averages 40–50 pages per class period. This does not include any readings labeled as supplemental, which you are not expected to read.

7 September: Introduction to the Course Topics

- Course Syllabus (12 pages)
- Bazerman, Charles (1989). Changing Order: Replication and Induction in Scientific Practice. *Philosophy of the Social Sciences* 19(1): 115–118.
- Romero, Felipe (2019). Philosophy of science and the replicability crisis. *Philosophy Compass* 14(11): 1–14.
- CO Introduction & Ch. 1 (28 pages)

The Experimenters' Regress

While you are reading CO in the following weeks, it may be helpful at points to read the relevant sections of the following essay review as a counterpoint:

- [SUPPLEMENT] Hesse, Mary (1986). Changing concepts and stable order. *Social Studies of Science* 16(4): 714–726.

14 September: The Idea of Replication & TEA-Laser Case Study

- CO Chs. 2–3 (50 pages)

21 September: The Experimenters' Regress

- CO Chs. 4–5 (50 pages)

28 September: Networks, Expertise, and Scientific Method

- CO Ch. 6, postscript, afterword (51 pages)

5 October: Avoiding and Reconsidering the Experimenters' Regress

- Franklin, Allan (1994). How to avoid the experimenters' regress. *Studies in History and Philosophy of Science* 25(3): 463–491.
- Feest, Uljana (2016). The experimenters' regress reconsidered: Replication, tacit knowledge, and the dynamics of knowledge generation. *Studies in History and Philosophy of Science* 58: 34–45.

12 October: Robustness and Stability

- Culp, Sylvia (1995). Objectivity in experimental inquiry: Breaking data-technique circles. *Philosophy of Science* 62(3): 438–458.
- Radder, Hans (1996). Reproduction and Nonlocality in Experimental Science. Ch. 2 (pp. 9–44) in his *In and About the World: Philosophical Studies of Science and Technology*. SUNY Press. [Skip section 2.7. 30 pages]

The Meaning and Role of Replication and Reproducibility

19 October: Historical Perspectives

- Schickore, Jutta (2011). What Does History Matter to Philosophy of Science? The Concept of Replication and the Methodology of Experiments. *Journal of the Philosophy of History* 5(3): 513–532.
- [SUPPLEMENT] Schickore, Jutta (2011). The Significance of Re-Doing Experiments: A Contribution to Historically Informed Methodology. *Erkenntnis* 75(3): 325–347.
- Steinle, Friedrich (2016). Stability and replication of experimental results: A historical perspective. Ch. 3 (pp. 39–63) In Harald Atmanspacher and Sabine Maasen, eds., *Reproducibility: Principles, problems, practices, and prospects*, Wiley.

26 October: The Function of Replication

- Schmidt, Stefan. (2009). Shall we really do it again? The powerful concept of replication is neglected in the social sciences. *Review of General Psychology* 13(2): 90–100.
- Leonelli, Sabina (2018). Re-Thinking Reproducibility as a Criterion for Research Quality. *Research in the History of Economic Thought and Methodology* 36(B): 129–146.
- Fletcher, Samuel C. (2021). The role of replication in psychological science. *European Journal for Philosophy of Science* 11(1): 1–19.
- [SUPPLEMENT] Goodman, S. N., Fanelli, D., and Ioannidis, J. P. (2016). What does research reproducibility mean? *Science Translational Medicine* 8(341): 341ps12.
- [SUPPLEMENT] Machery, Edouard (2020). What Is a Replication? *Philosophy of Science* 87(4): 545–567.
- [SUPPLEMENT] Fletcher, Samuel C.; Jones, Galin; and Rothman, Alexander. Discussion: What Is a Replication? Preprint.

The Replication Crisis

2 November: Measuring and Monitoring the Crisis

- Fidler, Fiona; and Wilcox, John (2021). Reproducibility of Scientific Results. In Edward N. Zalta, ed., *The Stanford Encyclopedia of Philosophy*, Summer 2021 Edition. `https://plato.stanford.edu/archives/sum2021/entries/scientific-reproducibility/`. [Read only section 2–2.1.]

- Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science* 349(6251): aac4716. (9 pages)

- Gilbert, Daniel T.; King, Gary; Pettigrew, Stephen; and Wilson, Timothy D. (2016). Comment on "Estimating the reproducibility of psychological science." *Science* 351(6277): 1037b. (1 page)

- Anderson, Christopher J. et al. (2016). Response to Comment on "Estimating the reproducibility of psychological science." *Science* 351(6277): 1037c. (1 page)

- Baker, Monya (2016). 1,500 scientists lift the lid on reproducibility. *Nature* 533(7604): 452–454.

- [SUPPLEMENT] Anderson, Samantha F.; and Maxwell, Scott E. (2016). There's more than one way to conduct a replication study: Beyond statistical significance. *Psychological Methods* 21(1): 1–12.

- [SUPPLEMENT] Fabrigar, Leandre R.; and Wegener, Duane T. (2016). Conceptualizing and evaluating the replication of research results. *Journal of Experimental Social Psychology* 66: 68–80.

- Fletcher, Samuel C. (2021). How (not) to measure replication. *European Journal for Philosophy of Science* 11(2): 1–27.

9 November: Was It All Falsity and Fallacy?

- Ioannidis, John P. A. (2005). Why most published research findings are false. *PLoS Medicine* 2(8): e124. (6 pages)

- Goodman, Steven; and Greenland, Sander (2007). Why most published research findings are false: problems in the analysis. *PLoS Medicine* 4(4): e168. (1 page)

- Ioannidis, John P. A. (2007). Why most published research findings are false: author's reply to Goodman and Greenland. *PLoS Medicine* 4(6): e215. (1 page)

- [SUPPLEMENT] Moonesinghe, Ramal; Khoury, Muin J.; and Janssens, A. Cecile J. W. (2007). Most published research findings are false—but a little replication goes a long way. *PLoS Medicine* 4(2): e28. (4 pages)

- Stroebe, Wolfgang (2016). Are most published social psychological findings false? *Journal of Experimental Social Psychology* 66: 134–144.

- Bird, Alexander (2018). Understanding the replication crisis as a base rate fallacy. *The British Journal for the Philosophy of Science* forthcoming: 1–31.

16 November: HARKing

- Kerr, Norbert L. (1998). HARKing: Hypothesizing after the results are known. *Personality and Social Psychology Review* 2(3): 196–217.
- [SUPPLEMENT] Leung, Kwok (2011). Presenting Post Hoc Hypotheses as A Priori: Ethical and Theoretical Issues. *Management and Organization Review* 7: 471–479.
- [SUPPLEMENT] Hollenbeck, John R.; and Wright, Patrick M. (2016). Harking, Sharking, and Tharking: Making the Case for Post Hoc Analysis of Scientific Data. *Journal of Management* 43(1): 5–18.
- Rubin, Mark (2017). When does HARKing hurt? Identifying when different types of undisclosed post hoc hypothesizing harm scientific progress. *Review of General Psychology* 21(4): 308–320.
- [SUPPLEMENT] Rubin, Mark (2019). The Costs of HARKing. *The British Journal for the Philosophy of Science* forthcoming: 1–30.
- [SUPPLEMENT] Murphy, Kevin R.; and Aguinis, Herman (2019). HARKing: How badly can cherry-picking and question trolling produce bias in published results? *Journal of Business and Psychology* 34: 1–17.
- Mohseni, Aydin (2020). HARKing: From Misdiagnosis to Misprescription. Pitt PhilSci Preprint: `http://philsci-archive.pitt.edu/id/eprint/18523`. (25 pages)

23 November: Questionable Research Practices and Researcher Degrees of Freedom

- Nuzzo, Regina (2015). How scientists fool themselves—and how they can stop. *Nature* 526: 182–185.
- Simmons, Joseph P.; Nelson, Leif D.; and Simonsohn, Uri (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science* 22(11): 1359–1366.
- John, Leslie K.; Loewenstein, George; and Prelec, Drazen (2012). Measuring the prevalence of questionable research practices with incentives for truth telling. *Psychological Science* 23(5): 524–532.
- Gelman, Andrew; and Loken, Eric (2014). The statistical crisis in science—a "garden of forking paths"—explains why many statistically significant comparisons don't hold up. *American Scientist* 102(6): 460–465.
- Rubin, Mark (2017). An evaluation of four solutions to the forking paths problem: Adjusted alpha, preregistration, sensitivity analyses, and abandoning the Neyman-Pearson approach. *Review of General Psychology* 21(4): 321–329.

30 November: Power and Significance Testing

- Button, Katherine S.; Ioannidis, John P. A.; Mokrysz, Claire; Nosek, Brian A.; Flint, Jonathan; Robinson, Emma S. J.; and Munafò, Marcus R. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience* 14: 365–376.

- Maxwell, Scott E.; Lau, Michael Y.; and Howard, George S. (2015). Is psychology suffering from a replication crisis? What does "failure to replicate" really mean? *American Psychologist* 70(6): 487–498.

- Wasserstein, Ronald L.; and Lazar, Nicole A. (2016). The ASA Statement on p-Values: Context, Process, and Purpose. *The American Statistician* 70(2): 129–133.

- Benjamin, Daniel J.; et al. (2018). Redefine statistical significance. *Nature Human Behaviour* 2(1): 6–10.

- Lakens, Daniel; et al. (2018). Justify your alpha. *Nature Human Behaviour* 2(3): 168–171.

- [SUPPLEMENT] Amrhein, Valentin; and Greenland, Sander (2018). Remove, rather than redefine, statistical significance. *Nature Human Behaviour* 2(1): 4.

- McShane, Blakeley B.; Gal, David; Gelman, Andrew; Robert, Christian; and Tackett, Jennifer L. (2019) Abandon Statistical Significance. *The American Statistician* 73(sup1): 235–245.

- [SUPPLEMENT] Crane, Harry (2018). The impact of p-hacking on "redefine statistical significance". *Basic and Applied Social Psychology* 40(4): 219–235.

- [SUPPLEMENT] de Ruiter, Jan (2019). Redefine or justify? Comments on the alpha debate. *Psychonomic Bulletin & Review* 26: 430–433.

7 December: Bias and Self-Correction

- Ferguson, Christopher J.; and Heene, Mortiz (2012). A vast graveyard of undead theories: Publication bias and psychological science's aversion to the null. *Perspectives on Psychological Science* 7(6): 555–561.

- Ioannidis, John P. A. (2012). Why Science Is Not Necessarily Self-Correcting. *Perspectives on Psychological Science* 7(6): 645–654.

- Romero, Felipe (2016). Can the Behavioral Sciences Self-correct? A Social Epistemic Study. *Studies in History and Philosophy of Science* 60: 55–69.

- Bruner, Justin P.; and Holman, Bennett (2019). Self-correction in science: Meta-analysis, bias and social structure. *Studies in History and Philosophy of Science* 78: 93–97.

- [SUPPLEMENT] Romero, Felipe; and Sprenger, Jan (2020). Scientific self-correction: the Bayesian way. *Synthese* forthcoming: 1–21.

14 December: Incentives, Rewards, and Labor

- Bakker, Marjan; van Dijk, Annette; and Wicherts, Jelte M. (2012). The rules of the game called psychological science. *Perspectives on Psychological Science* 7(6): 543–554.

- Nosek, Brian A.; Spies, Jeffrey R.; and Motyl, Matt (2012). Scientific utopia II. Restructuring incentives and practices to promote truth over publishability. *Perspectives on Psychological Science* 7(6): 615–631.

- Heesen, R. (2018). Why the reward structure of science makes reproducibility problems inevitable. *Journal of Philosophy* 115(12): 661–674.

- [SUPPLEMENT] Romero, Felipe (2018). Who Should Do Replication Labor? *Advances in Methods and Practices in Psychological Science* 1(4): 516–537.

- Romero, Felipe (2020). The Division of Replication Labor. *Philosophy of Science* 87(5): 1014–1025.

- [SUPPLEMENT] Miller, Jeff; and Ulrich, Rolf (2016). Optimizing Research Payoff. *Perspectives on Psychological Science* 11(5): 664–691.