A JOURNEY INTO OPEN SCIENCE AND RESEARCH TRANSPARENCY IN PSYCHOLOGY

JON GRAHE

A Journey into Open Science and Research Transparency in Psychology

A Journey into Open Science and Research Transparency in Psychology introduces the open science movement from psychology through a narrative that integrates song lyrics, national parks, and concerns about diversity, social justice, and sustainability. Along the way, readers receive practical guidance on how to plan and share their research, matching the ideals of scientific transparency.

This book considers all the fundamental topics related to the open science movement, including: (a) causes of and responses to the Replication Crisis, (b) crowdsourcing and meta-science research, (c) preregistration, (d) statistical approaches, (e) questionable research practices, (f) research and publication ethics, (g) connections to career topics, (h) finding open science resources, (i) how open science initiatives promote diverse, just, and sustainable outcomes, and (j) the path moving forward. Each topic is introduced using terminology and language aimed at intermediate-level college students who have completed research methods courses. But the book invites all readers to reconsider their research approach and join the Scientific Revolution 2.0. Each chapter describes the associated content and includes exercises intended to help readers plan, conduct, and share their research.

This short book is intended as a supplemental text for research methods courses or just a fun and informative exploration of the fundamental topics associated with the Replication Crisis in psychology and the resulting movement to increase scientific transparency in methods.

Jon Grahe is Professor of psychology and department chair at Pacific Lutheran University, USA. Other roles include managing executive editor of *The Journal of Social Psychology*, president of the Western Psychological Association, and former president of Psi Chi, the International Honor Society. He also led the design and administration of the Collaborative Replications and Education Project (CREP) and the Emerging Adulthood Measured at Multiple Institutions (EAMMi2) project, among other undergraduate crowd projects.

"In 2013, Jon Grahe convinced Mark Brandt and I of his dream to come along on his journey to teach replication projects across universities, which now has become widely known as the Collaborative Replication and Education Project. Jon's book provides an excellent introduction to the principles that convinced Mark and I to come along on his journey: to make the world a better place via high-quality research that does justice to the human condition. Jon provides an in-depth discussion that is partly historical, partly forward-looking in his characteristically story-telling way, drawing from his own journey covering research practices, statistics, ethics, writing, diversity, and even career advice. Read Jon's book to understand why this will become the go-to introduction to open science."

– **Hans Rocha IJzerman** *is an Associate Professor at Université Grenoble Alpes, France, and author of* Heartwarming: How Our Inner Thermostat Made Us Human

"Who knew that rock music, national parks, and replication could be woven together into an accessible narrative that introduces the reader to open science principles and practices? Grahe provides an effective introduction to research rigor and transparency with a perfect blend of conceptual instruction, concrete examples, and learn-by-doing. After completing A Journey into Open Science and Research Transparency in Psychology readers won't just know about open science, they'll be doing it themselves!"

– **Brian Nosek** *is co-founder and executive director of the Center for Open Science. He is also a Professor in the department of psychology at the University of Virginia, USA*

"Grahe's visionary textbook leverages the potential for psychology undergraduates not only to learn about research methods but also to do valuable projects themselves. Armed with cutting-edge tools for open, transparent, and reproducible research, a history of the recent upheavals in science, and an understanding of the relation between scientific and societal values, students will be prepared for the conceptual and technical scientific challenges of the future."

– **Barbara Spellman,** *Professor of psychology, University of Virginia, USA*

A Journey into Open Science and Research Transparency in Psychology

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PREFACE

This book invites readers to complete a journey through open science. Within the pages, I describe the open science movement and associated initiatives and outcomes at an introductory level aimed at supplementing student learning as they complete research methods and capstone courses. In fact, the book itself is a bit of a personal capstone project for me. Beginning in 2010, I was trying to convince my peers that we could do better research by pooling our resources and conducting research collectively. My efforts yielded little success until the Replication Crisis in 2011 jolted the field into making changes. At this point, the larger community's passion for replication coincided with my desire to create more and better research opportunities for undergraduates.

As I watched these events unfold, I quickly adopted the open science movement's goals as my own, though my own passion had been more about building a better science by becoming more efficient. I subsequently began championing undergraduate research opportunities and open science principles in every role and professional venue I could access. As I entered my next sabbatical, I wanted to share my experience and knowledge before transitioning my scholarship focus to something different. What came from that desire to share was the "Crisis Schmeisis Lecture or Music Tour," and this book transforms that experience into a narrative to introduce open science in a fun and informative way. The goal is not to replace the classroom text, which introduces basic methods, but rather to augment that material with the tools needed to present those methods transparently.

In this way, it is a capstone project for me. For students, capstone projects (also called senior research) represent the culminating educational experience that synthesizes (or attempts to) all the knowledge and learning to that point. An undergraduate capstone project ideally represents the summation and product of the student's experience. Though not every course or construct is included in the expansive project, the project comes from the collective experiences that make up that education.

In the same way, this book brings together multiple aspects of my personal and professional growth. The book includes four themes that propel the narrative forward. In the center are the open science movement and the goals of scientific transparency. However, my understanding of this content and my manifestation of its principles are influenced by the rest of me. As readers will soon recognize, the rest of me includes music, travel, and personal reflection. These extracurricular components guide me and keep me moving forward. By the time my sabbatical arrived, music, travel, and personal reflection were top priorities along with my need to produce scholarship from my work in the open science movement. And so I merged them. This integration of open science knowledge, music development, need for travel, and conviction to effortfully self-reflect represents a capstone to me. Here is a more expansive

explanation for how and why these merged at this moment for me. Afterward, I will more specifically point to how they are reflected in the text.

To start with, this is the only psychology textbook, supplemental or otherwise, that I know of that is framed around the lyrics of a concept album. You can watch and/or listen to the songs on the Purrfect Second Stringers YouTube channel. I encourage readers to learn the songs and play along. However, the book does not require musical interest. The lyrics might be read as poetry or even just an outline of a talk. The lyrics are not presented within the text themselves, but the reader can access them online as part of the book's appendix.

However, the music was critical for me. My passion for making crowd projects of undergraduates made it impossible for me to continue playing music for fun. By the time of my sabbatical, I could barely play songs I knew well. Sabbatical is a time in which there is a bit more time, and so I wanted to re-engage with music. After the "Replication Crisis" song came in a moment of inspiration and developed quickly, I decided to use my love of open science and my vocation as a professor to help me relearn music. By committing to writing a concept album of songs about open science that could be used in a classroom, I was committing to playing music again. To force myself to learn more in the process, I wrote songs with increasing complexity or difficulty so that I had known challenges. In the end, the 10 songs challenge the guitar player through a range of keys and styles. Though my limitations are revealed in the live performances, the practice value of the 52 minutes of music was certainly evident to me.

An interest in travel does not make me unique. However, it influences this book, because while I was writing that concept album of "Songs to Inspire Scientific Transparency," I was also committed to visiting as many US national parks as possible. Because we live within a couple hours of two national parks (Olympic National Park and Mt. Rainier National Park) and because hiking and camping are among our most favorite pastimes, my wife and I buy the yearly pass that allows access to all national parks. It is a matter of simple logic for us. The cost of the pass is equal to visiting three different parks. If we already know we will visit two as the matter of a normal year, it is highly likely that we will have an opportunity to visit a third sometime during the year. It turns out to be a remarkably economical way to recreate if you don't have to pay for lodging.

Rather than trying to make the reader jealous, I would encourage anyone with the same privileged status to take advantage of these wild spaces for their own well-being. In any case, the only limits to travel normally are cost, work, and family commitments. When on sabbatical, work commitments are no longer an excuse, and a loving and supportive wife who shares an empty nest removes the family-commitment limits. Because cost is still a limit for me, I took advantage of work-related travel to allow me to also enjoy personal time.

For the Crisis Schmeisis Lecture and Music Tour, I gave talks and workshops wherever I could get in. It started when a school hired me to do a capstone workshop for them; I drove instead of riding in a plane and turned a

three-day professional trip into a three-week professional road trip. Instead of just sharing open science with that one institution, I visited seven. Along the way, I drove through or visited seven national parks.

Over the course of the year, I traveled many times to professional conferences or meetings and, in each case, extended it to advance the tour. I traveled frugally, sleeping on couches or in the back of my van along the way. But I always sought another chance to bring the open science message forth. For example, when Psi Chi sent me to a conference in Texas, I rented a car and drove to Arkansas, turning a weekend trip into two weeks and visiting five institutions along the way. There were only two national parks on that trip, but they each made a lasting impact on me because they amplified my clarity regarding the third component of my personal development: personal reflection regarding diversity, social justice, and sustainability.

Across my adult life, I have tried to become a better person. What better means isn't always clear, but while serving on a committee in 2012, I found direction when my institution incorporated a commitment to advancing diversity, social justice, and sustainability in its long-range plan, called PLU2020. My direction came from the conversations that we had about them. The challenge was that there were proponents who argued the singular importance of each one compared to the other. For instance, they might argue that unless someone values diversity, there is no point to social justice or sustainability. Alternatively, without a livable planet, there is no possibility of social justice or diversity. The challenge was that all are equally important, and clarity came when all three were brought into a single focus. Rather than singularly considering diversity or social justice or sustainability, the institution would strive to acknowledge the trilogy as guideposts.

For me, this conflict and compromise represented the challenge and ideal in the larger social world. Certainly, the world includes a diverse array of values, including some that are quite contradictory to these, such as desires for autocracy, power, or greed. But for individuals driven toward a social good, these are values that are generally shared; "all people should be valued, all people should be treated equally, and decisions should be made that manage resources for the future." And yet there is inherent conflict between these value statements when enacted.

Following the challenge inherent in the institution's long-term plan, I concentrated on my own lens across these values. As I entered sabbatical, I still struggled with that clarity. As the fourth prong of my sabbatical plan, I decided to engage in deep personal reflection on the topics of diversity, social justice, and sustainability. Across the year, I accomplished this by reading books that were not part of my professional scope.

In keeping with the theme of the Crisis Schmeisis tour, I sought books within the context of national parks. At every national park visitor center bookstore, I looked for books that would help me expand my understanding of diversity, social justice, or sustainability. Often, I sought stories about or from individuals with minoritized backgrounds. Ideally, that book would put the person in an environmental conflict as well, such as *The Story of Luna*

or *African American Women in the Old West*. In some instances, the book came from another event in my life, such as *What Does It Mean to Be White?* which was part of a reading group at my home institution and seemed applicable to my personal needs. In one case, the book (*Proud Shoes*) was chosen as a substitute because I could find no book store in any of the visitor center areas at Hot Springs National Park. When seeking something about the area, I stumbled across the book and found the story compelling. In each instance, I read the book and tried to place myself in the context of the story. As I drove through these beautiful spaces, I also recognized pain and hardship that I had not seen before. There were certainly stories of triumph, but there were more stories of pain, broken promises, and even murder in the name of civilization and manifest destiny.

Increasingly, I could see connections between the messages of promise from open science and the calls for a better society from the trifocal lens of diversity, social justice, and sustainability. This book represents my closing one chapter and moving to the next. As I hoped, the sabbatical plan brought forth clarity for the next phase of my professional career with a nice byproduct of reminding my fingers how to move on the neck of a guitar. It also allowed me to crystalize my message to researchers unfamiliar with open science principles. And so I share this book in an effort to expand the reach of this message. I hope that the reader finds the journey both pleasurable and engaging in addition to being informative. To achieve this, I incorporate all the components of my experience into each chapter.

As I mentioned earlier, each song was written following an intention that they would be successive and somewhat cumulative. The book is framed around these 10 songs. The title of each chapter matches the song title, and an "about the song" section follows the chapter abstract and objectives. These about-the-song sections explain the creative connection between the song and the chapter. There is also at least one "Crisis Schmeisis Book Review" in each chapter. These books were not read in any particular order, and they are not all directly or clearly tied to the content of each chapter. Instead, I chose books in each chapter that were the best fit after the book was completed. Throughout the book, the national parks are connected by the hypothetical Book Research Example about how many miles people hike at national parks. Additionally, the concepts of open science are often introduced through metaphors considering one or more national parks. Though this book is intended primarily for psychology or social science audiences, the national park context helps connect the topics without the need for any disciplinary expertise. At the end of each section are a few chapter exercises intended to help the reader further advance their own ongoing projects.

Across the book, readers will learn about the (Chapter 1) causes, consequences, and some responses to "The Replication Crisis." In Chapter 2, "Go Forth and Replicate" helps put the idea of replication into the context of science and suggests some ideas about doing it on a big scale. Chapter 3 explains all the issues that should be considered when preregistering research with a title intended to bring smiles; "Preregistered." Chapter 4 explains the competing

approaches to statistical decisions with the metaphorically titled "Decision Heavyweights." In Chapter 5, "An Ode to p-Hacking" reflects on the many decisions researchers make and where they are represented in a manuscript with a title ironically lamenting questionable research practices. The title of Chapter 6, "You Can't Plagiarize Yourself," speaks to one aspect of research in ethics while the chapter explores ethics across the research process. Chapter 7 considers many aspects about careers generally while specifically explaining why people support open science initiatives, and in response to one critic's derisive label of replication scientists, it is titled "Becoming a Second Stringer." Chapter 8, "Open Science Alphabet," describes different examples of open science initiatives and suggests methods to keep up to date in the ever-changing landscape of trying to keep science transparent. Chapter 9 proclaims "Progress: Open Science Promotes Diverse, Just, and Sustainable Outcomes" after challenging the reader to engage in deep reflection on the topic. Chapter 10 envisions a future full of "Scientific Transparency" while similarly presenting realistic criticisms of the movement. My earnest hope is that the readers will follow this path with their own research and go forth to conduct transparent science.

ACKNOWLEDGMENTS

There are so many people who I should thank personally for helping me complete my own journey as I became a better scientist, reengaged music as a hobby, crystalized my worldview, and completed this book. There are really too many for me to list here, and any list will assuredly include some unintended omissions. The work of open science occurs in a very large community, with many people working on one project. And so I will keep my list very brief and limit it to people that helped me explicitly with the task of finishing this book and the Crisis Schmeisis album.

In terms of the music, I want to thank the members of Band of Waxx, Frank Murphy and Jeff Cason, who learned the songs for the debut of most of the songs. Along with Jeff, Andrew Franks and Amber Matteson joined me for the live debut of all the songs with The Purrfect Second Stringers in December 2019. That show was a highlight of this process because it was a test of the entertainment value of the music itself, and it was a complete delight. Amber also played the songs with me as my teaching apprentice for my statistics/methods students and I want to thank her for pressing me to teach her the songs, and subsequently some music. I am sure these songs are better because I knew that I had someone waiting for me to finish them.

When I sit down and think about the people who helped with the book, Amber is at the top of that list. As one of the few people who knew the songs as well as I did and who recently graduated with her BS in psychology after being my research assistant and teaching apprentice for methods courses, she offered a very good perspective as a reviewer. She also cowrote the "About the Song" boxes, since they were presented at WPA 2020. Finally, she wrote the R code that provided the images for Figure 4.2. In sum, her interest in the songs and open science were very helpful.

Another very helpful reviewer of the book was Leslie Cramblet Alvarez, whom I worked with on many open science initiatives and the Psi Chi board of directors. Because she was a coauthor on numerous prior projects and early adopter of undergraduate crowd projects, I could trust her to provide feedback that would advance my vision.

Another person who assisted with this project, Tiffany Williams, is a former student who earned an MA in library science and served as a personal research and editing assistant while I wrote the book. Having graduated in 2004, she was actually the student who asked the question that prompted me to write "You Can't Plagiarize Yourself," something I had forgotten until she texted me while reviewing the paper about how funny it was. I am very grateful to her for all the feedback and minor editing she offered during the process.

Though not directly related to writing the book, there are people who, for one reason or another were influential in helping me complete the book: Ronald Riggio, who said, "Wow! That's a great idea. You could do that for your career" in response to my ideas on how to fix psychology way back in 2009. Michelle Ceynar, whose friendship is eclipsed only by her commitment to her students and colleagues. Bobbie Spellman, for "un-rejecting" my commentary introducing the idea of crowdsourcing student projects. Jeffrey Spies for building the Open Science Framework as part of his dissertation and then co-founding the Center for Open Science with Brian Nosek, who has done so much himself worth acknowledging. Most notably, I am ever grateful for his recognition that I should work with Mark Brandt and Hans IJzerman to build the CREP.

And then for Martha Zlokovich, the staff at the Psi Chi Central Office, and those who served on the board who were willing to try out open science with me in many ways. Those early CREPers who helped when there wasn't enough help: Nicole Legate, Brady Wiggins, Lily Lazarevic, Cristina Baciu, and especially Jordan Wagge, who gave their time and energy to build an international project with zero operating budget. The people on the EAMMi2 planning committee who made that project work: Holly Chalk, Caitlyn Faas, and Joseph McFall. For both those projects, the dozens of faculty and hundreds of students who tried a new way to learn psychological methods. John Edlund, as Psi Chi research director, and Kelly Cuccolo, as first Network for International Collaborative Exchange director, who made that project work as envisioned by the Psi Chi board of directors.

There are too many PLU students who participated in one or more of these projects to list them all. But some students made extra efforts by working on projects after the term ended until they were complete or by serving as assistants to the larger projects. Nicole Bennet, Devin Bland, Katie Coddington, DeVere Dudley, Emily Fryberger, Halé Gervais, Katye Griswold, Samantha Henderson, Kaitlin Johnson, Hannah Juzeler, Andrew Nelson, Hailey Sandin, Meghan Schultz, Kelsey Serier, and Tiana Wamba all have my extra gratitude.

Last and maybe most importantly, I need to thank my wife, whose patience and understanding allowed me to keep my focus on these projects for

many more hours than we expected. She allowed me the extra time I needed, and the emotional security, to engage in these projects and then to write this book. She was there supporting me whenever I needed her throughout this process and before. Now, she asked me not to put her in the acknowledgments, so I must ask the reader to proceed directly to reading the book and promise not to tell her that I thanked her.

CRISIS SCHMEISIS: SONGS TO INSPIRE SCIENTIFIC TRANSPARENCY

Background and Explanation: After recording two self-produced albums with My Name Aint Skip in 2010, the band split, and I stopped playing music except with my children. By 2016, they had found their own interests, and I had stopped actively engaging in music. Multiple attempts to write music or restart playing ended with failure. No doubt this was in part due to my immersion in open science activities. However, in September 2016, "The Replication Crisis" wrote itself as I walked my dog. Over the course of a week or so, all the verses were identified in my head, and I started thinking about picking up my guitar and figuring out a melody.

As anyone who has ignored their musical instrument for five years can tell you, even though I wanted to play chords, my fingers and hands were not following my brain's instructions. I ended up writing a much simpler song than I imagined just so I could play it. The situation remained unchanged with my single song and no plan until I found myself in a conversation with a group of open science enthusiasts who found my song idea compelling.

In response to some good-natured ribbing about making science into music, I decided to write an entire album about the movement. Following my approach in writing an earlier concept album, "MMiX: the Year" with My Name Aint Skip, I followed a set of guidelines to add structure to the process. The guidelines were as follows: (a) write the songs to follow an order which could accompany a methods course, (b) add something to each song that challenged me to be a better musician, and (c) write songs that would be interesting to people who were not involved in the movement.

The plan to start writing the album coincided with my sabbatical, so I incorporated the project into my plans to create better teaching material for open science. Finally, I had begun a journey to more deeply consider the intersections of diversity, social justice, and sustainability (DJS) four years earlier and devoted a portion of my time to reading and reflection. When a friend invited me to give a talk 1,500 miles away, I decided to make a road trip instead of fly and offer free open science talks or workshops to anyone interested along the way. This began the Crisis Schmeisis Open Science Musical or Talking Tour. It became important to then integrate travel into the other components of my sabbatical: music, open science, and DJS. Over the next 12 months, I represented open science almost 50 different times in 21 states in talks, meetings, workshops, and a few musical performances.

I followed my guidelines and built the songs one at a time, with the exception of one song, "You Can't Plagiarize Yourself," which fit the theme, but I wrote it 12 years earlier. Though I planned to write the album in a year, later songs took more time. The challenge to make each song more complex and interesting slowed my completion of the final three songs for almost another year. In the time that I worked through the end of the album, I joined a new band, Band of Waxx, whose players agreed to learn the songs so that I could perform them live. This resulted in two performances, a "practice show" on my 49th birthday and the "debut" performance of the first eight songs in January 2019 at the University Scholar Association connected to Pacific Lutheran University. I was supposed to perform the songs again solo at APS 2019 but lost my voice during the trip and could not sing.

Along the way, a student (research assistant, teaching apprentice, PLU Psi Chi vice president, coauthor) found the project so compelling that she decided to learn the songs as a way to learn piano too. Across the fall 2019 term, she and I performed the songs for my P242: Advanced Statistics and Methods students as they were intended. When a new faculty member joined the department in fall 2019 who knew bass, we decided to form the Purrfect Second Stringers (www.youtube.com/channel/UCov44ebsQcgS58MBCNR69Wg). The PLU Psi Chi chapter hosted the band to perform the entire album after the psychology department's fall research conference, which can be watched on video (www.youtube.com/watch?v=dbF-aPWkTzw&t=184s). Plans to perform again at WPA 2020 were interrupted by the pandemic. The ongoing pandemic interrupted the ability of the band to work together and stifled our ability to record. However, the live performances of the full band, also with the acoustic classroom performance, offer a glimpse into the fun these songs encourage while offering lyrics that help clarify fundamental concepts in the open science movement

CRISIS SCHMEISIS: SONGS TO INSPIRE SCIENTIFIC TRANSPARENCY

1. The Replication Crisis
2. Go Forth and Replicate
3. Preregistered
4. Decision Heavyweights
5. Ode to p-Hacking
6. You Can't Plagiarize Yourself
7. Becoming a Second Stringer
8. Open Science Alphabet
9. Progress: Open Science Promotes Diverse, Just, and Sustainable Outcomes
10. Scientific Transparency

Please use the following link to access the songs: https://osf.io/y2hjc/

1 A REPLICATION CRISIS

Responses Benefit Personal Workflow

Chapter 1 Objectives

- Define Replication Crisis
- Introduce causes of the Replication Crisis
- Conceptualize diverse, just, sustainable lens for science
- Explain why national parks are useful contextual examples
- Describe the open science movement
- Introduce tools and topics described later
- Introduce the book research question

MUSIC IN A BOX: ABOUT THE SONG "REPLICATION CRISIS"

The first song contains background information about the Replication Crisis, a series of events leading to major questions about the reproducibility of scientific findings. The lyrics introduce the setting of the album and consider some of the issues and problems that led to the crisis, ending with a nod to some early responses to the situation. This is the only song that names specific people and cheers them on for their part in initiating some changes to increase scientific transparency. The song offers a good list of scientists who pioneered open science for anyone who wants to look up their work. This song sounds like classic rock, but the minor key reminds the listener of the conflict of the crisis.

WHAT WAS THE REPLICATION CRISIS?

The beginning of this research methods journey, which aims to achieve scientific transparency in our work, started for many at the beginning of the Replication Crisis or "crisis of confidence" that emerged in the 2010s. Because many have been traveling this path for more than a decade, there are multiple retellings of the causes and consequences of this crisis (see Shrout & Rodgers, 2018). This book is personal in nature; the story is shared from my own experience within the crisis. This limited scope will result in a briefer description but does not intend to prioritize my singular narrative. Rather, the hope is that readers will face these questions from their own perspective and that this narrative will entice that interest.

In short, the Replication Crisis reflected concerns that published findings in peer-reviewed journals could not be replicated. Think on that problem for a moment. Textbooks, mental health treatments, educational interventions, and even public policies are drawn from research that is published using peer review. If the published findings cannot be trusted, then all the conclusions are suspect. To learn about the many causes, some of which will be explored in more detail later in the book, refer to the series of Special Sections in *Perspective on Psychological Science* (v. 7, #6, November 2012; v. 8, #4, July 2013; v. 9, #1, January 2014; v. 9, #3, May 2014), in which they are deeply explored. The first, entitled "Replicability in Psychological Science: A Crisis of Confidence," introduces the problem (Pashler & Wagenmakers, 2012; Pashler & Harris, 2012), potential explanations for why the problem existed (Makel, Plucker, & Hegarty, 2012; Bakker, van Dijk, & Wicherts, 2012; Ferguson & Heene, 2012; Giner-Sorolla, 2012; Klein et al., 2012; Neuroskeptic, 2012; Ioannidis, 2012), and recommendations for solutions (Frank & Saxe, 2012; Grahe et al., 2012; Koole & Lakens, 2012; Nosek, Spies, & Motyl, 2012; Wagenmakers, Wetzels, Borsboom, van der Maas, & Kievit, 2012). Across these manuscripts, one might draw a short list of causes as follows: (a) publication bias favors novel and unusual findings over replication and confirmatory research, (b) the presence of reward structures that favor many previous publications, and (c) poor reporting standards. Each of these is itself complex, with multifaceted causes, but the outcome is that research reports with flashy findings receive the greatest attention from both readers and researchers. The problem is that striving for those findings led to particularly inadequate practices in science.

POTENTIAL CAUSES OF THE CRISIS

These bad practices are highlighted in major events that occurred in 2011. Researchers often refer to 2011 as "the year of the crisis." Before these events, there was little concern for these problems in psychology, though some were voicing alarms more generally (Ioannidis, 2005). I myself had been pushing for reform for two years before these events, but no one really cared. After the year of crisis, I finally had an audience who was willing to help with "Harnessing the Undiscovered Resource of Student Research Projects" (see Grahe et al., 2012). Here is a brief description of two events that illuminated the replication crisis.

The most egregious affront against psychological science that alarmed the field in 2011 was when Diedrick Stapel was found to have falsified data in more than 40 published papers (Stroebe, Postmes, & Spears, 2012). This researcher was extremely influential, and his work is cited in many papers and textbooks. Over time, the lure of publication overwhelmed his ethics, and he started writing results sections with imaginary numbers. The papers were well written and interesting, but the findings were fiction.

Certainly, this man is not the only one who made up data or committed other forms of academic dishonesty. More critically, this example highlights a few problems with scientific reporting that need fixing. First, science reporting

is built on trust. When manuscripts are submitted for peer review, reviewers are tasked with challenging the authors' rationale and methodology. They are expected to review and consider the results, but they are not expected to rerun analyses or review the quality of the data. While a reviewer might disagree with an author, authors' intentions are rarely questioned. This event highlights that in some circumstances, bad data and conclusions are due to willful disregard for scientific ethics.

However, another crisis event illuminates how bad science can emerge from good intentions. Daryl Bem published a paper in 2010 purporting to demonstrate precognition (parapsychological activity). Though there are many papers reporting the existence of parapsychological activity, this paper was published in the *Journal of Personality and Social Psychology*, one of the most prominent journals in social psychology. Further, Daryl Bem is a prominent social psychologist who suggested credible findings. Readers who believe in ghosts, goblins, astrology, tarot cards, and mind reading might be surprised to learn that this publication led to an uproar. Researchers demanded to see the data as they began to highlight many reporting issues evident in the manuscript. To his credit, Bem shared the data and did not argue strongly with the criticisms.

This second event introduces a number of related publication bias problems. Besides having a topic that is sensational and a prominent author that editors might favorably publish, the research was not maliciously reported. Bem did not intend to mislead or lie. Instead, his error was that he engaged in a series of questionable research practices more commonly described as hypothesizing after the results are known HARKing (Kerr, 1998) and p-hacking (Simmons, Nelson, & Simonsohn, 2011).

More critically, Bem was one of the researchers that taught the field how to effectively use these practices. In a book chapter about publishing an empirical article, Bem (2000) explains to future authors that, "There are two possible articles you can write: (a) the article you planned to write when you designed the study or (b) the article that makes the most sense now that you have seen the results" (p. 4). Bem argues that the correct answer is (b). Among otherwise good writing advice, Bem posits that the author should not bother a reader with the many pitfalls of the research practice. He suggests that rather than keeping a failed hypothesis in an introduction after conducting analyses, authors should rewrite a manuscript with new hypotheses and background literature to justify the findings that did emerge in the data. This is the definition of HARKing, but Bem argued that it was preferable to present a clear and straightforward story rather than distract the reader with errors made by the researcher. Later, in Chapters 3 and 5, this topic of massaging data to find effects, or p-hacking, and how to avoid it will be explored in more detail. For now, these events highlight that the challenges facing science were complex, while others would demonstrate that questionable research practices were both pervasive and systematic (Simmons et al., 2011; Bakker & Wicherts, 2011).

To understand these events, it is useful to remember that tools to make science easy to share are fairly recent. At the beginning of the new millennium,

scientific manuscripts were still being submitted as hard copies, and journals published all materials in print, as there were no online journals or supplemental materials. With the cost of mailing documents and publishing printing pages, asking authors to also share data and materials was prohibitively expensive. Further, the drive toward shorter reports and, consequently, less stringent reporting standards was made in part to offer more publication opportunities for more authors as well as help disseminate findings and effects more broadly.

Regardless of the causes, this is a good moment to remind the reader that though this was publicly noted in social psychology, and many of the solutions were tested in social psychological research, the problem of publication bias and poor replicability pervades all fields of science, as suggested by Ioannidis (2005), who estimated that 50% of all published findings are false. In the decade that followed, many others recognized the need to change our approach to science, both in other psychological disciplines and also across the social and natural sciences.

WHY THE REPLICATION CRISIS DOES NOT MATTER

During 2017–2018, I completed a Crisis Schmeisis Tour to Increase Scientific Transparency. In almost 50 speaking engagements and meetings, I began my persuasive arguments with the position that it does not matter if there is a replication crisis in the field. Finding errors in methodology and improving them is the purpose of the scientific method. A good scientist avoids believing any truth, because the basic assumption is that our knowledge is only the best representation of truth, not the actual truth. From that perspective, one would expect publication errors, and our job is not to debate why they exist but, rather, how to do better science. This debate yielded tools and calls for change that will improve science and benefit the researcher at the same time.

While others continue to debate what effects may or may not be generalizable or whether replication efforts are appropriate or sufficient, my position has been and continues to be that there is greater benefit to learning new ways to be more transparent than there is in debating. Future scientific efforts will demonstrate what effects are generalized, but only if we move forward. This book focuses on this goal by introducing the reader to new tools and methods to conduct more transparent science. These tools include (a) new, free computer programs and software that make it easy to share plans, materials, and data; (b) research opportunities that collate resources and researchers to conduct more powerful research; and (c) reward structures that offer different paths to success. These tools are introduced through lyrics intended for both amusement and deep learning. Where possible, the examples consider the context of diversity, social justice, and sustainability while considering national parks. The objective of the examples is to connect the research methods content to ongoing social struggles with meaningful impact to the reader.