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Opening Doors to Open Science and Scholarship for School Psychology Research, Training, and
Practice

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Abstract

Trustworthy scientific evidence is essential if school psychologists are to use evidence-based practices to solve the big problems students, teachers, and schools face. Open science practices promote transparency, accessibility, and robustness of research findings, which increases the trustworthiness of scientific claims. Simply, when researchers, trainers, and practitioners can ‘look under the hood’ of a study, (a) the researchers who conducted the study are likely to be more cautious, (b) reviewers are better able to engage the self-correcting mechanisms of science, and (c) readers have more reason to trust the research findings. We discuss questionable research practices that reduce the trustworthiness of evidence; specific open science practices; applications specific to researchers, trainers, and practitioners in school psychology; and next steps in moving the field toward openness and transparency.

Keywords: open science; preregistration; replicability; methodology; school psychology

Impact Statement

This paper highlights some of the key factors threatening the reliability of the research basis in psychology, introduces core practices of the open science movement, and overviews how greater embrace of openness and transparency among school psychologists can improve our research, training, and applied work with students and schools.

Opening Doors to Open Science and Scholarship for School Psychology Research, Training, and Practice

School psychologists have a vastly important role in the lives of the students they serve. To satisfy that role, school psychologists are charged to use only those services that have been vetted and found effective in solving problems (Shapiro, 2000; 2006) and minimizing harm (Lilienfeld et al., 2019). To accomplish this, school psychologists adopt and implement evidence-based practices (EBP; Every Student Succeeds Act, 2015; National Association of School Psychologists [NASP], 2020). This burden is heavy and a significant obstacle is the identification of *trustworthy* evidence for a given practice (Cook et al., 2018). Given that replicability of results is one of the central tenets of scientific progress (Sidman, 1960/1988) and frequently a prerequisite for determining the evidentiary status of practices (Travers et al., 2016), the so-called ‘replication crisis’ (e.g., Open Science Collaboration, 2015) has made professionals across disciplines face difficult truths about what is and is not actually known in their fields (Vazire, 2017; Vazire & Holcombe, 2020). The causes of this issue are many ranging widely from biased reporting of methods and findings (Gelman & Loken, 2014a) to misapplication and misinterpretation of statistics (Gelman & Loken, 2014b)—i.e., types of ‘questionable research practices’ (QRPs)—to broader systemic problems such as journal editorial boards valuing studies with significant and novel findings over those reporting null effects or replications (Franco et al., 2014). Though no formal studies have yet been conducted to quantify replication specifically for school psychology, replication prevalence in related fields is low (e.g., Makel et al., 2016) and our rate is likely similar (Shaw et al., 2019). These issues pose a serious threat to scientific progress and the credibility of our practices. School psychology requires significant and intentional shifts in research training, practice, and culture to combat these insidious problems and cultivate lasting positive change in the field (Adelson et al., 2019).

Trustworthy Evidence

In describing research, *trustworthiness* is the extent to which research methods, data, and analytic procedures support the author’s claims (Carnine, 1997). In addition to research needing to meet a high standard of methodological rigor and theoretical consistency, Cook et al. (2018) suggest that evidence

should be “open, transparent, and reproducible” (p. 2). These qualities are consistent with core scientific values, such as communalism and skepticism (Merton, 1973). With regard to skepticism, open and transparent materials, data, and analytic procedures reduce barriers for reviewers charged with evaluating underlying components of research, which may enhance the self-correcting mechanisms of our science (Vazire & Holcombe, 2020). Moreover, open availability of this information and materials reduce barriers to practitioners, policy-makers, and other readers who are evaluating whether a particular claim is adequately supported for their intended use. Behaviors that make research more open, transparent, and reproducible—generally referred to as *open science*—have been described as “a collection of actions designed to make scientific processes more transparent and results more accessible” in order to “build a more replicable and robust science” through use of “new technologies, altering incentives, and changing attitudes” (Spellman et al., p. 2).

Given this context, our efforts here first aim to familiarize, or refresh, our audience on common questionable research practices (QRPs) and summarize several practices related to open science as a primer and partial solution to QRPs. Next, we connect these open practices back to school psychology, outlining ways in which embrace of open science and scholarship can significantly enhance not only our research efforts, but also training and applied practice as well. Finally, we conclude with a look forward and provide recommended next steps on how we might monitor and advance open science in our field.

Questionable Research Practices (QRPs)

Investigations into the behavior of psychological researchers following the increased attention of the replication crises in medicine, life sciences, and psychology revealed that QRPs were more common than previously believed (Fiedler & Schwarz, 2015) and made more likely when a study was resource intensive but resulted in non-significant findings (Banks et al., 2016). This is especially concerning given that to properly evaluate whether practices are truly evidence-based, both supporting and disconfirming evidence must be considered (e.g., Ferguson & Heene, 2012; Meehl, 1990a). Further, field-based research, a necessary step in evaluating school psychology practices, is inherently resource intensive and

more likely to yield smaller effects than laboratory research (Kratochwill & Stoiber, 2000). If we view the scientific process as a set of “safeguards against confirmation bias” (Lilienfeld, 2010, p. 282), then any behavior that increases the likelihood of a specific result, beyond the variables under study, jeopardizes those safeguards. Several QRPs are noteworthy and present in psychology, including p-hacking; hypothesizing after the results are known (HARKing); selective reporting of outcomes, relevant conditions, measured variables, and studies; and even data fraud (Fiedler & Schwarz, 2015). We explore each of these briefly as understanding is the first step in combating.

P-Hacking

Researchers have substantial degrees of freedom in how they conduct their data analyses (Gelman & Loken, 2017b); however, when researchers test a variety of statistical models (e.g., repeated measures ANOVA then repeated measures ANCOVA) and data exclusion criteria, and ultimately report only those producing statistically significant results, this leads to an inflation bias often called ‘p-hacking’ (Head et al., 2015). P-hacking is a broad term that includes a number of specific practices that are dependent upon analytic outcomes, including (a) conducting analyses prior to the official conclusion of a study to determine whether more data are needed, (b) selectively deciding whether to include or exclude outliers in a data set, (c) ad hoc splitting and grouping of variables, and (d) selectively including or excluding covariates. P-hacking is pervasive (Head et al., 2015) and may diminish on our ability to make sound judgments about the results of a single study—Simmons et al (2011) found that p-hacking could lead to ~60% false positive rate—or the results of meta-analyses in which p-hacked studies are included (Friesen & Frankenbach, 2020).

HARKing

In the hypothetico-deductive research model, a researcher derives a hypothesis from a theory or theories, generates test predictions from the hypothesis, and gathers data to confirm or disconfirm the predictions. These are then taken to corroborate or falsify the hypothesis (Haig, 2018) and perhaps even the original theory (Meehl, 1990b). However, after reviewing the results of exploratory statistical

analyses, researchers may pass off post hoc hypotheses as if they were developed before the analysis (i.e., a priori) and part of the plan from the beginning (Kerr, 1998). In this way, exploratory analyses come to pass as confirmatory analyses. This is known as hypothesizing after the results are known, or HARKing. While abductive reasoning permits the generation of hypotheses from observed data patterns (e.g., exploratory factor analysis), HARKing can be significantly problematic as it may exclude the possibility of falsification (i.e., pure HARKing), lead to overly complex hypotheses (i.e., overfitting), and lead to suppression of a priori hypotheses that were unsupported by results (Rubin, 2017).

Selective Reporting

Meehl (1990a) and others (e.g., Ferguson & Heene, 2012) have argued that failure to report null results risks a disproportionate rate of false positives in the literature and delays or prevents theoretical development. Others contend this is an ethical dilemma in clinical areas of research where findings will be used to directly affect the lives of clients (Cleophas & Cleophas, 1999). While surely related to publication bias—i.e., the tendency for editors to publish statistically significant findings and to reject nonsignificant findings; yet another obstacle in the social sciences (Franco et al., 2014)—selective reporting is more general and focuses on how researchers choose to report analytic decisions and results. For instance, selective reporting includes reporting post hoc analyses as a priori analyses, not reporting various data manipulation decisions, excluding measures, or not reporting changes in sample size (Cairo et al., 2020). Some of these strategies may be justified; however, the concern is that selectively reporting leads to a biased record with findings that are unlikely to replicate and no easy way to evaluate what exactly happened to produce the original results in the first place. Furthermore, favoring an aesthetically pleasing report over ‘warts-and-all’ transparency disadvantages researchers who diligently engage in open reporting practices. More plainly, “the cost of lack of transparency is not only that we end up investing in low quality findings, and building a science on shaky foundations..., but also that we are driving rigorous science out of the market.” (Vazire, 2017, p. 1).

Data Fraud

Data fraud—the falsification, fabrication, or unscrupulous modification of data—is the least reported QRP (Fiedler & Schwarz, 2015). While the negative impacts of fraud are vast and undisputed, there are few clear consequences for researchers who commit it (O’Leary, 2015). When a researcher engages in data fraud, the report takes on the auspices of science, but in no way protects against confirmation bias. Rather it intentionally biases the scientific record and misleads other researchers, practitioners, and the public who may be swayed by the report. More so, the effects of fraudulent data on clinical practice and public health may be challenging to reverse (e.g., misinformation about vaccines; Flaherty, 2011).

While the prevalence estimates for QRPs are unstable, it is important to note they are not zero. The effect of QRPs on research findings cannot be overestimated, and invariably inflate the false-positive rate of studies (Simmons et al., 2011). Given that science is often conceptualized as a set of safeguards against confirmation bias (Lilienfeld, 2010; Nickerson, 1998), QRPs undercut the very qualities that make scientific studies necessary. However, a number of meta-contingencies in academia select QRPs including grant culture and standard promotion and tenure expectations, which often require a track record of statistically significant results for novel research (Lilienfeld, 2017).

One mechanism for reinforcing science’s ability to defend against self-fulfilling prophecies is to implement open science strategies (Tackett et al., 2020; van der Zee & Reich, 2018; Vazire, 2017). Open science initiatives utilize technology and promote novel practices to (a) increase transparency and quality of research; (b) disseminate research stimuli, materials, and publications more freely; and (c) foster wider collaboration among professionals; which may (d) ultimately help narrow the research-practice gap. As school psychology moves further into the 21st century, integrating technologies and methods that promote transparency and rigor in research may make science more accessible to non-traditional researchers, practitioners, and the general public. It may expedite the self-correcting mechanisms of science, lead to greater trust in science, and expedite uptake and application of evidence-based practices. In the following

section, we describe common practices and tenets of open science we believe are most relevant for school psychology.

Open Science Strategies and Practices

Transparent Reporting

Fully transparent reporting of all aspects of research is foundational for open science. Recently, the American Psychological Association assembled two working groups to update journal article reporting standards (JARS) for quantitative (Applebaum et al., 2018) and qualitative/mixed methods (Levitt et al., 2018) research papers in psychology to help standardize the way authors formally communicate or ‘advertise’ their studies. While reviewing all of the specific standards is well outside the scope of this paper, we strongly encourage researchers to familiarize themselves with these and periodically revisit the relevant standards documents for their particular research designs when planning new studies. Considering the general principles undergirding JARS, four broad themes emerge and are described in Table 1.

Table 1.
Themes of Transparent Reporting

Theme	Description
Basic Disclosures	Disclose information pertinent to the authors and circumstances of the study, including (a) affiliations, (b) funding, (c) conflicts of interest, (d) whether data are reported elsewhere, (e) and reference to external documentation or materials.
Scientific Rationale & Context	Clarify the rationale and reasoning supporting the study as well as how it fits into the related literature. In addition, authors should specify (a) research questions and (b) hypotheses. Further, they should specify which questions/hypotheses were exploratory and confirmatory, and whether any were developed after review of results.
Methodological Rationale	Details of the study design, including each methodological step and decision criteria, should be clearly reported with reference to supporting literature. In addition, the rationale for those decisions should be plainly stated. While these components may vary by study design, type, and purpose, they generally include (a) sampling

	procedures; (b) sample size estimation; (c) exclusion criteria; (d) data collection procedures; (e) measures used, including evidence of reliability and validity; (f) data screening procedures; (g) details of planned analyses; (h) decision rules used in the interpretation of data; and (i) citations for software used.
Comprehensive Reporting	Report the results of analyses clearly and completely. For quantitative studies, authors should report results from each planned analysis, including (a) descriptive summaries from each group and outcome, (b) inferential test statistics including relevant effect size measures, (c) whether analyses are a priori or post hoc, (d) data quality problems (e.g., missing data), (e) analysis problems (e.g., model non-convergence), and (f) how data and analysis problems were handled. Finally, all outcome results should be reported (both significant and non-significant results). See the 21 Word Solution (Simmons et al., 2012).

Unlike the other practices we review here, transparent reporting is not a novel procedure unique to the developing open science movement, but an already well-established standard in scholarly communication. Transparency has a number of benefits apart from it being a professional expectation including helping address the problems associated with selective reporting described earlier. At the most basic level, transparent reporting is the primary mechanism through which the scientific community evaluates the rigor of the methods and associated assumptions made in a study as well as the substance and importance of the findings. Additionally, adhering to transparent reporting standards makes it easier for researchers to design their own direct or systematic replications or meta-analytic reviews of others' work (Brown et al., 2014) and provides a well-defined framework to follow when thinking through new studies thus reducing the likelihood of engaging in other QRPs. A perceived barrier to engaging in transparent reporting may be space limitations for journal articles; however, most journals now allow for including supplemental content and materials in online repositories with practically unlimited space available making this a trivial concern. One option may be to use a platform, such as *Open Science Framework* (OSF; <https://osf.io>), to upload stimuli, materials, and other project-related items, including expanded methods documents (e.g., research protocols) and to link to the project from within the manuscript.

Computational Reproducibility

Along the path toward replicating results of one study with a novel study is the issue of research *reproducibility*—the degree to which a single study’s results can be recreated independently. The most basic requirement to reproduce results is access to the data used in a study so others can analyze them as described in the manuscript. Even with the data, reproduction may or may not be possible depending on how clearly the analysis procedures were described in the first place. What makes the task significantly easier is if the code used to run the analyses is provided along with the dataset and contains descriptive comments throughout so that a third-party can understand exactly what each section of code does and to which analysis it maps in the written report (Peng, 2011). Having access to the code allows for more specific evaluation of the analysis choices used in a study, may help identify issues not reported or caught by the authors, and can facilitate easier troubleshooting or suggestions for improvements to the analytic approach by reviewers.

Several proprietary statistical programs exist for general (e.g., SPSS, Stata, SAS) or specialized analyses (e.g., Mplus, HLM) but licenses are financially costly. For many researchers and students working in traditional university settings, these costs may not be a concern if the software can be obtained from departmental or grant funds, yet not everyone who might be interested in reproducing the work will have access to the same software. Computational reproducibility is therefore significantly enhanced when researchers conduct their analyses with free, open-source programs (e.g., R/RStudio, JASP, Jamovi) allowing equal access to everyone regardless of their institutional affiliation or financial means (Ince et al., 2012). Further, some free software can be used to create reports that integrate the analysis syntax throughout the text and link with the data to reveal what is ‘behind the scenes’ of the results directly in the document as they read (e.g., R Markdown; <https://rmarkdown.rstudio.com/index.html>). Integrating code into the report also has the significant benefit of eliminating user typing errors as tables and figures can be produced directly in the report.

Open Repositories for Data and Materials

A key component to facilitate open science practices is making one's data, analyses, stimuli, and/or other materials available to others. Publicly archiving materials on open repositories allows for easier replicability and for the opportunity to enhance future research. Many researchers may choose to post their materials on their own, personal websites; however, there exist several public repositories of which researchers may wish to make use. The OSF is one such user-friendly repository. Soderberg (2018) outlines a tutorial for using OSF to post a variety of materials related to scientific research. Another repository and resource of that may be relevant to school psychology and special education researchers is Github. Although originally intended for use by software developers, Github's functionality nonetheless allows for easy integration of study materials and documentation as part of one continuous workflow for research endeavors as well. For example, Gilroy and Kaplan (2019) provide a tutorial for utilizing Github as an open repository for single case design research. An associated feature of Github is the use of *version controlling* where all changes to uploaded files are tracked and stored allowing for monitoring of a project's development over time further enhancing transparency of the research process (Gandrud, 2018). Other open repositories include Harvard Dataverse, Zenodo, Code Ocean, Figshare among many others.

Once a researcher has decided where to publish their research, they must then make sure their data and materials are in a usable condition. Importantly, researchers should first confirm that they may ethically share their materials and are not in violation of stipulations provided by copyright agreements or their Institutional Review Board (Soderberg, 2018; Wilkinson et al., 2016). Wilkinson and colleagues (2016) additionally outline several principles for data management and sharing: the FAIR Guiding Principles. They argue that for efficient open science and data sharing, data must be Findable, Accessible, Interoperable, and Reusable (Wilkinson et al., 2016). These standards allow for ease of use and transparent integration across psychology, education, and related disciplines.

Preregistration

Preregistration is the specification of research questions and hypotheses, research plans (i.e., sampling plan, protocol, instrumentation, procedures, and inference criteria), and analysis plans prior to

conducting the observations, running the experiment, or collecting data (Lakens, 2019). The preregistration proposal is then submitted to a publicly accessible registry (e.g., via OSF at www.cos.io/our-services/prereg) for storage. The registry serves as a time stamp and public statement of the details of the proposed research, though the preregistration could be embargoed if researchers are concerned about privacy or having their ideas used by others too quickly. This approach can be used for quantitative or qualitative¹ studies, research questions that are confirmatory or exploratory, and with various analytic approaches (Johnson & Cook, 2019; Krypotos et al., 2019; Lakens, 2019). The primary goals of preregistration are to avoid QRPs related to sampling, selective reporting, analysis decisions, and the development of hypotheses and thus improve the severity of the test conducted (Lakens, 2019; Lindsay & Nosek, 2018). In these ways, preregistration serves as an important bulwark against confirmation bias.

Preregistration is not a new concept. This process is widely used in medicine and is increasingly used in experimental psychology but remains little used in clinical and professional psychology (Nosek & Lindsay, 2018). Yet, often doctoral dissertations are forms of preregistration because most universities require that a research proposal is developed and defended before data are collected. However, with researchers under increasing pressure to publish their research in scholarly journals, and most scholarly journals preferring to publish statistically significant results, there is often little incentive for most researchers to use preregistration (Lindsay, 2020). Although the incentives to produce quality research that is transparent and reproducible may be valuable to an improved science, the individual incentives for tenure, promotion, and grant funding that rely on producing many publishable research papers of any quality are often more salient (Lilienfeld, 2017). In addition to the issue of incentive, preregistration does not address the final major cause of lack of reproducibility, publication bias (Nosek et al., 2018).

¹ The Center for Open Sciences has developed approaches for qualitative research as well. As of this draft, the webinar has not occurred and material is not readily available. The webinar will be archived at <https://www.youtube.com/centerforopenscience>.

Registered Reports

Registered reports integrate preregistration into the journal publication process (Hardwicke & Ioannidis, 2018). The result is that all the advantages of preregistration are included, plus the issues of lack of incentive for researchers under publication pressure and publication bias are addressed (Chambers & Tzavella, 2020). Registered reports divide the manuscript review process into two stages. In stage one, the introduction, methods, and data analysis plan are submitted for peer review. The criteria for acceptance are scholarship, importance of the project, quality of research design, and logic of the data analysis plan. Like all manuscripts, the stage one submission can be accepted, rejected, or revisions requested. Should the stage one submission be accepted, the author will receive an “in principle” acceptance. The successful stage one proposal (i.e., the preregistration) is then archived either via a dedicated journal repository or in a preregistration registry. Then the author collects and analyzes data and writes the results and conclusion sections. If the data collection process and analysis are consistent with the stage one proposal and the conclusions are reasonably based on the results, the manuscript is accepted whether the results are statistically significant and consistent with the hypotheses or not.

Registered reports not only address many of the same issues as preregistration, but the issue of publication bias is minimized (Scheel et al., 2020). This means that studies with statistically significant results are not necessarily more likely to receive a positive publication decision because the editorial decision has been made at stage one, which decreases the disincentive for preregistration. Registered reports value studies that are important and use sound scientific processes rather than simply demonstrate statistical significance (Grand et al., 2018; Soderberg et al., 2020). This can be a motivation for a new researcher as there is no longer the risk of allocating scarce resources to conduct a research study that may or may not yield the desired results and thus minimizing publication chances (Chambers & Mellor, 2018). Important and high-quality studies accepted as registered reports are certain to be published no matter the results.

The number of journals accepting registered reports has increased dramatically since the initiative began in the journal *Cortex* (Chambers & Tzavella, 2020). There are minor variations in how each journal executes the editorial process (see katiedrax.shinyapps.io/cos_registered_reports/ for searchable details). Preregistration and registered reports are not currently major aspects of the research culture in school psychology (Huber, 2007) though the *Canadian Journal of School Psychology* is the first school psychology-focused journal to accept registered reports (Shaw et al., 2019). Given the utility for EBPs, the likelihood of registered reports becoming a common research model in school psychology is increasing. This growing approach to publication is a valuable contribution to a culture of open, reproducible, and transparent science.

Open Access Publishing & Repositories

The definition of open access (OA) varies by source. The Scholarly Publishing and Academic Resources Coalition defines it as “the free, immediate, online availability of research articles coupled with the rights to use these articles fully in the digital environment.” (n.d.). As such, OA is simultaneously concerned with accessibility, usability, and author rights². In recent years, both color-based (e.g., Gold OA) and description-based systems (e.g., Hybrid OA) have been jointly used to describe the increasingly complex spectrum of OA types. It is beyond the scope of this manuscript to describe these types in detail, though interested readers are directed to Piwowar et al. (2018) for additional details. Regardless of type, awareness of OA has had something of a groundswell in recent years, with major grant-funding agencies mandating OA distribution of research products (e.g., US National Science Foundation), the development of academic social networks (e.g., ResearchGate.net), and the increasing popularity of general OA repositories such as PsyArXiv (<https://psyarxiv.com/>). PsyArXiv is notable because the American Psychological Association (APA) named PsyArXiv their preferred server in 2017 and now permits authors to submit preprints to select APA journals directly from the repository (Binion et al., 2017). In

² SPARC offers additional resources on author rights available at <https://sparcopen.org/our-work/author-rights/brochure-html/>.

addition to these organizational trends, the prevalence of OA has increased substantially. Piwowar et al. (2018) analyzed over 19 million scholarly products and found that approximately 28% are OA and that the ratio of OA to non-OA products is increasing over time (e.g., 45% of products were available OA in 2015). Finally, articles published as OA tend to be cited more frequently. While the estimate varies substantially, Ottaviani (2016) and Piwowar et al (2018) both used robust methods and found a moderate (16 to 18%) increase in citations for OA publications.

While OA extends to a variety of mediums, our focus here will be on research-related documents (i.e., e-Prints³). Generally, e-Prints can be shared either via OA repositories (*Green OA*) or OA journals (*Gold OA*); however, the boundaries are not always clear between them. OA repositories are used by authors to archive versions of their own work. While many may choose to do this on personal webpages or via a university archive, public repositories are becoming more common (e.g., PsyArXiv). One limitation of repositories is that they are not typically refereed (cf. Wang & Zhan, 2019), which means content is not vetted for methodological or theoretical adequacy. In contrast, OA journals include peer review as part of the publication process. OA journals typically function similarly to traditional journals, they are more likely to permit authors to retain copyright of published work (Suber, 2012). The adoption of varying OA policies in recent years has increased the heterogeneity of this category. As a result, authors should consult OA policies prior to making e-Prints available in OA repositories or otherwise to ensure they are consistent with copyright. *Sherpa Romeo* (<https://v2.sherpa.ac.uk/romeo/>) is an excellent resource for determining the policies of individual journals. Finally, the most notable feature of OA journals is that access to published content is free and the cost of publication is covered by authors (via article processing charges), foundations, organizations, or universities (Suber, 2012).

Bringing Openness to School Psychology

³ Scientific manuscripts take many forms during their development and publication. e-Prints are digital versions of scientific manuscripts and, depending upon their stage of development, are called (a) pre-prints, (b) post-prints, or (c) versions of record.

Implications for Research

Given that the primary purpose of open science and scholarship is to improve the transparency and trustworthiness of research (Cook et al., 2018), the application of the strategies we have described (e.g., preregistration) can be applied to research in school psychology with little modification. This has been modeled for school psychology researchers by those in education, special education, and clinical psychology (Cook et al., 2018; van der Zee & Reich, 2018; Walsh et al., 2018). Indeed, some school psychology researchers have already adopted open science practices. For instance, some have made research materials available online (e.g., Benson et al., 2018; Renshaw, 2018), preregistered and documented the research process (e.g., von Hagen et al., 2020), and shared code to promote reproducibility (e.g., Beaujean & Farmer, 2019).

Meta-contingencies in academia reinforce frequent publication (Lilienfeld, 2017) with significant results favored over null results (Franco et al., 2014). While it may be true that finding an intervention that works well is more useful than identifying an intervention that does not work, the latter finding may help to direct future research in a number of ways (e.g., clarifying salient treatment components) and may progress theory development (Ferguson & Heene, 2012; Meehl, 1990a). By adopting more rigorous and transparent methodology (e.g., ensuring adequate power, sharing materials), the absence of an effect may take on clearer meaning, and thus be more likely to be published. Adoption of registered reports or results-blind reviewing (see Grand et al., 2018) can reduce publication bias and increase the frequency of publishing null results (Scheel et al., 2020). In addition, research that was submitted as a registered report tends to be more rigorous as well (Soderberg et al., 2020), which may contribute to the trustworthiness of research and ultimately to the reputation of the researcher (Allen & Mehler, 2019). Journals that publish consistently transparent and rigorous studies may also observe an increase in their reputation (Aalbersberg et al., 2018; Vazire, 2017).

In addition, articles published or stored as OA lead to greater accessibility for more people regardless of whether their university can afford sizable subscription fees, or if they are affiliated with a

university at all (Tennant et al., 2016). For the individual researcher, publishing and promoting OA articles may increase research impact, as suggested by the finding that OA articles tend to be cited more frequently (e.g., Piwowar et al., 2018). Early career professionals may particularly benefit from adopting open science practices as they (a) promote discoverable and reusable research practices, (b) place researchers ahead of the curve with regard to granting agency regulations on transparency, and may (c) promote collaboration with other researchers working on similar problems (Allen & Mehler, 2019; National Academies of Sciences, Engineering, and Medicine, 2018). Regarding collaboration, the technology supporting open science has facilitated significant collaborations in psychology and abroad. Perhaps the most notable examples of open science facilitated collaboration are the investigations into replicability (e.g., Open Science Collaboration, 2015) and the Psychological Science Accelerator (Moshontz et al., 2018). More recently, the Special Education Research Accelerator (<https://curry.virginia.edu/faculty-research/centers-labs-projects/research-labs/casper/casper-sped-accelerator>) has been announced. Projects such as these rely on transparent and collaborative procedures to distribute the workload for sizable, meaningful projects across many researchers. In addition, we believe open science can lead to more grassroots collaboration as well, such as making it clearer the types of projects researchers are engaged with and providing resources for others to learn about ongoing work.

Implications for Training

To affect fundamental change in school psychology's culture, a condition that seems necessary to move toward more transparent, accessible, and reproducible research (see Lilienfeld, 2017), we must prepare graduate students to understand open science principles and procedures, especially those who intend to conduct research or pursue federal funding beyond graduate school. It seems reasonable that this training could be integrated into coursework on research methods or data analysis. This content could explicitly be part of program standards and include student knowledge of common QRPs, open science and scholarship fundamentals, and their relevance to both research and practice applications. Trends in the acceptance and requirement of open science and accessibility suggest that the research sphere will

become more open in future years and preparing students now to engage in open science helps them get ahead of the curve (Allen & Mehler, 2019; National Academies of Sciences, Engineering, and Medicine, 2018). For example, trainers could use course materials from free, open-access sources such as community developed textbooks, lecture slides, or reference documents (e.g., Effect Size, Confidence Intervals, and Power Analyses Collaborative Guide; Xiao & Feldman, 2020) to support their instruction. Such resources are becoming increasingly available through online open scholarship hubs such as the *Open Scholarship Knowledge Base* (Open Educational Resources Commons, 2020). Further, instructors can draw directly from openly available data, analysis code, and study materials to provide direct illustrations of real-world study methodology and findings to enhance the learning experience of their students beyond what is possible with only discussion or demonstration with fabricated data created solely for teaching purposes.

For research endeavors outside the classroom, trainers could show student collaborators how an open workflow might look in practice. Mentors could demonstrate by involving students in discussions of improving their own reporting transparency when planning a study, working through preregistering hypotheses, collaborating on the logistics for making anonymized data available publicly along with analysis code and study materials, and/or in posting a preprint concurrently when submitting the manuscript for peer-review. Receiving scaffolded learning opportunities in this way brings the principles to life and helps demystify the process and specific practices.

Importantly, we contend that learning about open science and scholarship practices and the associated problems they help solve, is not a niche topic only of concern to those in and entering research-focused careers. Training in this area benefits all students regardless if they later enter a career in academia, practice, or elsewhere by fostering a general orientation toward transparency and openness as a core value no matter the specific application. At a minimum, knowledge of the motivation for and awareness of some of the specific open practices creates more critical consumers of the literature. It also

raises the bar for what is expected from our research output and ultimately the evidential foundation of our applied practice.

Implications for Practice

Research in psychology emphasizes original contributions to the knowledge base. Most valued is research that is novel, innovative, and has high impact that changes ideas in psychology (Lindsay, 2020). However, for clinical practice there is a higher, but frequently ignored, purpose for research: *usefulness*. How can open science aid in determining what works to improve academic development, social and emotional skills, promote mental health, social justice, and other critical goals in education and psychology? Moreover, knowing what works is not enough. Knowing how the ideas are most efficiently implemented and evaluated in classrooms, therapy settings, and other environments are equally important (Collier-Meek et al., 2019). Discovering the what and the how of innovation in school psychology are goals for which open science is required.

U.S. National Aeronautics and Space Administration (NASA) has long used a framework to guide research agendas and applications of research to determine when the quality and usefulness of evidence is ready for application to space flight. IJzerman and colleagues (2020) adapted the NASA framework to determine the readiness of psychological research for application to societal problems. This framework was then further expanded and adopted for clinical readiness (Shaw & Pecs, 2020). See Table 2 for the stages of the Clinical Readiness Level. Practice frameworks, such as that of Clinical Readiness Level require several elements of open science such as reproduction and replication, transparency and trust in research, accessibility to evidence and detailed protocols, focus on usefulness as a goal, open sharing of information, and partnerships that narrow the gap between producers and evaluators of interventions and consumers and implementers of interventions.

Table 2

Stages of Clinical Readiness Level

Stage	Description
1	Descriptions of the problem or phenomenon in clinical case studies, clinical accounts, and reports of the environments in which these problems are observed.
2	Theoretical descriptions and explanations of the problem of interest. This may include understanding of the cause, development, expression, context, culture, and environment that create or maintain the problem.
3	Case studies and examples of interventions that have been used to address the problem or phenomenon. This may include testimonials, program descriptions, or speculation on why some forms of interventions may be most effective.
4	Correlational or quasi-experimental support for the effectiveness of an intervention to address the problem. This level also includes qualitative research to improve understanding of personal and contextual factors influencing an intervention's effectiveness.
5	An experimental study (including randomized control trials) demonstrating the effectiveness of an intervention.
6	Detailed methodology described so that the protocol can be replicated and applied. This requires open science elements, such as sharing materials. In addition, variables required for implementation such as time required, training, materials, and costs are described.
7	Reproduction of the effectiveness of the interventions with a new sample is conducted. Replication of the effectiveness of the interventions with multiple implementers (e.g., teachers), settings, populations, and environments are conducted.
8	The robustness of the interventions is evaluated; that is, what factors and by how much can there be implementation variation from the protocol and remain effective.

- 9 The interventions have been implemented and evaluated in multiple clinical and classroom (i.e., not controlled or laboratory) settings.

Note. Table adapted from Shaw & Pecs, 2020

The Clinical Readiness Level (Shaw & Pecs, 2020) proposes that research requires far more information than a single high-quality experimental study (e.g., a randomized controlled trial) to be useful. Experimental studies are the highest level of evidence as codified in *Every Student Succeeds Act* (2015) and the What Works Clearinghouse (Institute of Education Sciences, 2020), but this stage is best thought of as proof of concept (i.e., Stage 5). This means that there is some quality evidence that the interventions can be effective under specific conditions, yet true readiness for applied use in clinical interventions involves several additional steps beyond proof of concept that are often ignored. Addressing additional levels of readiness helps narrow the research-to-practice gap and open science provides an excellent set of tools to bridge the divide.

Considering Clinical Readiness Level is an approach to bringing research closer to the relevance of the practicing school psychologist, teacher, counselor, or other educators or mental health providers. Open repositories and full access to detailed protocols and methods allows for advancement of evidence to Stage 6. Finally, practitioners require detailed information about resources required such as preparation time, time to implement, training, materials, personnel, step-by-step procedures and protocols, and costs. Typically, this information is not found in methodology sections of evaluative studies published in scholarly journals.

For an innovative intervention to advance through the Clinical Readiness Level, research is required to integrate evaluation, implementation, and consultation. Crowd-sourcing and partnerships value clinician and specific clinical needs. Research and practice partnerships allow clinicians, who know their students and clients best, to adapt interventions to meet cultural, linguistic, behavioral, systemic, and other specific needs, and evaluate outcomes together. Clinicians have ownership and increased agency in making the interventions both evidence-based and relevant to the specific needs of children and

adolescents. Moreover, transparency and direct partnership increases confidence that the research supporting the interventions is valid, can be feasibly implemented, and is robust.

Researchers also have incentives such as the ability to have multiple publications from a single intervention. There is also potential for replications of a central intervention concept across classrooms, diverse populations, and multiple systems; larger sample size and increased power; understanding that researchers' ideas have value; and bridging the research-to-practice gap using the tools of open science to create a useful science within school psychology.

The Road Ahead

While we believe the promise of open science and scholarship for school psychology is compelling, much work is still needed to lay a substantive foundation for its widespread adoption in our field. Like any intervention to promote positive behavior change for students, our efforts to shape the behavior of professionals in school psychology toward greater openness and transparency must start with a grounding in data to establish baselines and evaluate growth. Because there remain many unknowns about the adoption of open science and scholarship practices within school psychology specifically, we present a recommended research agenda for stakeholders to monitor progress to this end.

Although adoption of open science policies is becoming more commonplace for journals in psychology broadly (Nosek, 2019), school psychology-focused journals have only begun exploring the potential (Shaw et al., 2019). Formally assessing the extent to which core journals in the field allow for open science practices (e.g., preregistration, preprints) is needed to help support wider adoption and sustainability of the movement. Such an evaluation should take care to include information from direct contact with editorial staff to determine how likely they are to accept various open science practices even if these have not yet been formally integrated into written journal policy. On a related but more specific level, we recommend monitoring the actual rates of open science practices associated with individual articles published in school psychology journals for more targeted assessment of trends. This would help

evaluate rates of adoption for discrete practices for relative comparison and highlight how these rates change across time (e.g., Federer et al., 2018).

Additionally, consideration for changes in professional awareness of and attitude toward open science and scholarship is another important domain to monitor. Disaggregated surveys of school psychology students, faculty, and perhaps even practitioners could provide rich insight into some of the personal factors associated with embrace of relevant open practices (e.g., Harper & Kim, 2017), whether they are producing (e.g., publishing research with openly available data and code) or drawing from open materials (e.g., using open-source texts for a graduate course; drawing protocols from an intervention study's open supplemental materials for applied practice). Monitoring the inclusion of open science-related topics within graduate course curricula and program training standards may also be valuable as an indicator of change in institutional values of openness and transparency for developing school psychology's future professionals and leaders.

Though integrating open science and scholarship tools and practices into our work would mark a considerable step forward, it is not the end goal by itself. Instead, evaluating changes in terminal valued behaviors as a function of open practices is the ultimate yardstick in demonstrating the impact of this movement. For research, this might mean comparing rates of QRPs, in studies using different types open science practices and degrees of transparency. This logic could also extend to eventually monitoring practitioner use of evidence-based practices in schools and involvement in partnered research studies through the framing of Clinical Readiness Level (Shaw & Pecs, 2020).

Conclusion

School psychologists are charged with supporting the children, families, and schools they serve by using practices with a strong empirical basis to the greatest extent possible. But the influence of QRPs in our research weakens trust that the literature is pointing practice in the right direction. The methods and principles of the open science and scholarship movement offer a shining light in the dark to combat such harmful research practices, broaden access to quality evidence and useful materials, and ultimately

enhance the practitioner's toolbox and grounding of our applied work. Progress in our profession will be slow and lasting positive changes will not come easy. But through sustained collective action to raise awareness, develop useful infrastructure and resources to lower effort for engagement, reducing perceived risk, and enhancing perceived benefits of openness and transparency (e.g., Harper & Kim, 2017), progress is possible and greatly needed. The gains made in related disciplines is encouraging and the time for school psychology to take up the mantle in earnest has come. Our profession and those we serve only stand to benefit.

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