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A Template for Preregistration of Quantitative Research in Psychology: Report of the Joint Psychological Societies Preregistration Task Force

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Abstract

Recent years have seen dramatic changes in research practices in psychological science. In particular, *preregistration* of study plans prior to conducting a study has been identified as an important tool to help increase the transparency of science and to improve the robustness of psychological research findings. This article presents the Psychological Research Preregistration-Quantitative (PRP-QUANT) Template produced by a Joint Psychological Societies Preregistration Task Force consisting of the American Psychological Association (APA), British Psychological Society (BPS) and German Psychological Society (DGPs), supported by the Center for Open Science (COS) and the Leibniz Institute for Psychology (ZPID). The goal of the Task Force was to provide the psychological community with a consensus template for the preregistration of quantitative research in psychology, one with wide coverage and the ability, if necessary, to adapt to specific journals, disciplines and researcher needs. This article covers the structure and use of the PRP-QUANT template, while outlining and discussing the benefits of its use for researchers, authors, funders and other relevant stakeholders. We hope that by introducing this template and by demonstrating the support of preregistration by major academic psychological societies, we will facilitate an increase in preregistration practices and thereby also the further advancement of transparency and knowledge-sharing in the psychological sciences.

Keywords: open science, preregistration, reproducibility, replicability, PRP-QUANT Template

Significance Statement:

Study preregistration has been identified as an important step towards increasing the transparency and credibility of scientific research. This report describes the work of a joint task force of the American Psychological Association, British Psychological Society and German Psychological Society, and introduces a new template for the preregistration of quantitative-empirical studies in psychology.

A Template for Preregistration of Quantitative Research in Psychology: Report of the Joint Psychological Societies Preregistration Task Force

Advancing a culture and practice of transparency, reproducibility and replicability in psychological research has become a central scientific mission of the American Psychological Association (APA), the British Psychological Society (BPS), the German Psychological Society (DGPs) and many other professional organizations in academic psychology. Following the *credibility revolution* (Angrist & Pischke, 2010), the psychological research community has taken a leading role in developing the values and practices of open science for its discipline (see Vazire, 2018, for a review), serving as a model to inform and inspire other scientific disciplines engaging in open science. It is particularly noteworthy that the current and fast-paced developments in making psychological science more transparent, accessible, robust and credible are often spearheaded by enthusiastic early career researchers.

One important aspect of research transparency is the *preregistration* of empirical studies. To underline the importance of study preregistration, and to help in establishing common preregistration standards in psychology, the three aforementioned professional psychological societies (APA, BPS, DGPs), along with the Center for Open Science (COS; https://www.cos.io/) and the Leibniz Institute for Psychology (ZPID; https://leibniz-psychology.org/en/), initiated a Joint Psychological Societies Preregistration Task Force. The aim of the Task Force was to provide the psychological research community with a consensus template for the preregistration of quantitative research in psychology that is broadly accepted within our scientific community, that is detailed and, if necessary, allows itself to be adapted (revised and extended) to fit the needs of authors, journal editors, various subdisciplines of Psychology and other stakeholders. By supporting this work, the APA, BPS and DGPs also want to provide guidance and highlight the importance of preregistration for psychological science.

Preregistration of studies means the specification and documentation of the key aspects of an empirical study prior to conducting the study, and submitting these details to a

registry prior to actually conducting the work. Most noteworthy, the preregistration should include the hypotheses, study design, data acquisition and data analysis plans. Submitting a preregistered plan has several benefits. First, it helps ensure more systematic planning and coordination, such that all 'bases' of a study are more likely to be covered before the work begins. Second, preregistration helps ensure that everyone on a research team has a mutual understanding of the work to be conducted, such that any misunderstandings or knowledge gaps can be resolved early on in the research process. Third, laying out all of the major components of a study beforehand can improve researchers' appreciation of the scope and timeline of the work.

Through preregistration, additional benefits are hoped to accrue as the work is conducted and written up for publication. For example, by preregistering their work, researchers specify the nature of their confirmatory hypotheses, such that the distinction from other exploratory hypothesis-generating work is made very clear. Presenting results from exploratory work is clearly important and vital to science. But presenting exploratory results as if they were confirmatory misrepresents the scientific process (Munafò et al., 2017), and preregistration can serve as a strong reminder to avoid this serious problem. Preregistration also helps to reduce the prevalence of other questionable research practices (QRPs, John et al., 2012), such as writing or revising 'confirmatory' hypotheses post hoc to fit the empirical results obtained (i.e., HARKing; Kerr, 1998); not reporting non-significant results; peeking at statistical tests while collecting data until results are statistically significant; selecting outcome variables post-hoc; or exploring a wide range of data analysis and reanalysis strategies to cherry-pick significant or compelling results found in the 'garden of forking paths' (see, e.g., Gelman & Loken, 2013; John et al., 2012, for in-depth discussions of QRPs). The combination of just a few of these and other poor research practices can drastically misrepresent the evidence obtained (Simmons et al., 2011). These and similar problematic research strategies - even if not used intentionally - can easily be avoided by specifying in advance what data are acquired, how they are analyzed, and how this contributes to testing the hypothesis or hypotheses of interest (see Nosek et al., 2018,

for an in-depth discussion). Study preregistration, thus, has the potential to reduce QRPs, increase the trust in research findings, and improve the robustness of our evidence base.

The Psychological Research Preregistration-Quantitative (PRP-QUANT) Template introduced here is by no means the first template available for preregistration. In fact, our template borrows insights across a wide range of templates, such as those that have for years been offered by the Center for Open Science's Open Science Framework (OSF; (https://osf.io/zab38) and AsPredicted.org (see Table 1 for a more comprehensive list of existing preregistration templates). The work of the Joint Psychological Societies Preregistration Task Force and the resulting PRP-QUANT Template does not aim to replace any of these initiatives or existing templates. Rather, the involved academic societies sought to create a preregistration resource specifically tailored to the needs of psychological researchers and broadly supported by the psychological science community. Furthermore, this joint effort expresses how strongly these societies (as well as several others who support this initiative; see Appendix A) value transparent and open psychological science, thus sending a signal that study preregistration is to become more best practice in psychological research, if not the default.

The PRP-QUANT Template is a comprehensive list of design choices to be considered by psychological scientists when planning a study and, in addition to being inspired by existing templates, is closely organized along the lines of APA's Journal Article Reporting Standards (JARS; Appelbaum et al., 2018). The template is made available under the CC BY 4.0 license, so that every user is free to use and change the template with attribution (the latest version and all archival versions are accessible at http://dx.doi.org/10.23668/psycharchives.4584). PRP-QUANT can be used by researchers for uploading a file-based preregistration on any repository, but also for preparing the Stage 1 submission of registered reports (see Hardwicke & Ioannidis, 2018, for more details) or the study plan for a clinical trial. However, it can also be used by journal editors or providers of study registries to tailor the registration or preregistration of planned studies according to the

needs of psychological scientists, in general, and specific journals or repositories, in particular.

In the present manuscript, we (i) describe the work of the Joint Psychological Societies Preregistration Task Force, (ii) discuss to which types of studies this template applies, (iii) provide guidance on how to work with the template, and (iv) describe and discuss the structure of the template. There are by now several resources available that introduce the process of preregistration and that discuss the potential for improving the quality of psychological research (see Table 1). For that reason, we decided to not try to 'reinvent the wheel' in the current article, but to briefly summarize these resources for the benefit of the reader.

Table 1. *Resources for Preregistration and Registered Reports in Psychology*

Literature on Preregistration
Claesen, A., Gomes, S. L. B. T., Tuerlinckx, F., & Vanpaemel, W. (2019, May 9). Preregistration: Comparing Dream to Reality. https://doi.org/10.31234/osf.io/d8wex
McPhetres, J. (2020, June 1). What should a preregistration contain? Pre-print on PsyArXiv. https://doi.org/10.31234/osf.io/cj5mh
Nosek, B. A., Ebersole, C. R., DeHAven, A. C., & Mellor, D. T. (2018). The preregistration revolution. *Proceedings of the National Academy of Sciences*, *115*, 2600-2606. https://doi.org/10.1073/pnas.1708274114
Van't Veer, A. E., & Ginger-Sorolla, R. (2016). Pre-registration in social psychology - A discussion and suggested template. *Journal of Experimental Social Psychology*, *67*, 2-12. http://dx.doi.org/10.1016/j.jesp.2016.03.004
Vazire, S. (2018). Implications of the credibility revolution for productivity, creativity, and progress. *Perspectives on Psychological Science*, *13*(4), 411-417. https://doi.org/10.1177/1745691617751884
Online Resources
Open Science Framework's About Registered Reports (https://osf.io/3wct2/wiki/home/)

Stewart, S., Rinke, E., McGarrigle, R., Lynott, D., Lunny, C., Lautarescu, A., … Crook, Z. (2020, October 30). Pre-registration and Registered Reports: A primer from UKRN. https://doi.org/10.31219/osf.io/8v2n7

Wagenmakers, E-J. & Dutilh, G. (2016, October 31). Seven selfish reasons for preregistration. *APS Observer* (https://www.psychologicalscience.org/observer/seven-selfish-reasons-for-preregistration)

Online Preregistration Forms

AsPredicted (https://aspredicted.org/)

OSF's Registration Forms and Templates (https://osf.io/zab38/wiki/home/)

- OSF Preregistration Template (https://osf.io/preprints/metaarxiv/epgjd/)
- OSF Analysis Plan Checklist (https://osf.io/ncqg7/)
- Preregistration in Social Psychology (https://osf.io/ce3hr/)
- Qualitative Research Preregistration (https://osf.io/w4ac2/)
- fMRI Preregistration Template (https://osf.io/dvb2e/)
- Secondary Data Preregistration (https://osf.io/jqxfz/)
- Open Stats Lab and Project Tier (https://osf.io/fjy79/)

Aims and Approach of the Joint Psychological Societies Preregistration Task Force

As noted,the Joint Psychological Societies Preregistration Task Force comprises an international collaboration of psychological professional societies whose representatives have worked over the course of one year with the aims of (a) establishing a broad and integrative consensus about study preregistration for quantitative research in psychology and (b) providing the research community with a practical means of implementing preregistration based on this consensus. Several principles have guided the work of the Task Force:

1. First, the nature of study preregistration and the specific form or use of the preregistration template resulting from the work of this Joint Psychological Societies Preregistration Task Force is *discretionary*, i.e., the involved academic societies use

their judgment for how the template is to be used by their affiliated journals and authors. Journals and authors should also use their own discretion, depending on the preregistration policies in place.

2. Second, related to the previous point, the preregistration template should be *flexible* in multiple ways, i.e., flexible to be used by researchers, editors, or other interested parties, flexible with respect to the level of detail that can be specified for the individual study (e.g., depending on the level of pre-existing knowledge in the respective research field), flexible to be used for different types of research (like experiments or questionnaire studies), and lastly also flexible to be adapted according to individual needs (e.g., by journals or online repositories).
3. Third, in order for choices concerning flexibility to be well informed and wise, the final preregistration template developed by the Joint Psychological Societies Preregistration Task Force should be *closely aligned with the Journal Article Reporting Standards* of the APA (JARS; Appelbaum et al., 2018), so that all relevant details on methods that are typically required in psychological publications are covered by the template. We believe that this close alignment with the JARS has the potential to make the workflow from preregistration to a later manuscript as efficient as possible.

To achieve these goals, the Joint Psychological Societies Preregistration Task Force has used the JARS as the starting point, and then collected and evaluated in depth items from other preregistration templates available at that time (e.g., Aczel et al., 2020; American Psychological Association, 2020; Bowman et al., 2016; Simonsohn et al., 2017; Van den Akker et al., 2019). Through consensus-based discussions, items were selected, given a label, and brief descriptive texts were developed for all items. Subsequently, external feedback was obtained from multiple stakeholders within the involved societies and institutions, including the APA's Board of Scientific Affairs, Council of Editors, Open Science and Methodology Committee, and Publications and Communications Board; the BPS

Research Board; the European Federation of Psychologists' Associations Board of Scientific Affairs, and the DGPs Committee for Open Science, as well as a slate of interested colleagues. In a last step, the PRP-QUANT Template was distributed to contact persons from several other academic psychological societies across six continents (those who responded are documented in Appendix A). At every stage, feedback was integrated after in-depth discussion.

The resulting PRP-QUANT Template is explicitly aimed to be used for quantitative empirical research in psychology. It can also be used to preregister studies involving the re-analysis of existing datasets and also for meta-analyses, even though there are no specific items included for this latter case. The initial plan was to begin with a quantitative template, and later engage open science experts versed in qualitative methods to build out a preregistration template based on the JARS-qualitative standards. However, since that time, we have been made aware of a Delphi study for preregistering qualitative research (Haven et al., 2019), which interested readers may review online (https://doi.org/10.31235/osf.io/pz9jr).

Which Studies Should be Preregistered?

Researchers and editors often fear that preregistration is a tool that one-sidedly focuses on confirmatory research while discouraging or hindering exploratory research (e.g., Goldin-Meadow, 2016). Certainly, studies designed to test well-specified a priori hypotheses are optimally suited for preregistration. However, it remains very useful to preregister studies that do not test specific hypotheses. Some research is highly exploratory by nature due to new settings, measures, or manipulations; and also a field may simply lack pre-existing knowledge for deriving and testing explicit and specific hypotheses. Furthermore, it is often true that not every detail of a study can be specified in advance -- and preregistration does not necessarily impose this requirement. Obviously, the levels of detail will vary between the preregistration of an exploratory study that forms the early stage of a developing research program and a confirmatory study that builds on a body of research and refined theoretical

models. However, even in a developing research program, researchers should benefit from pre-specifying core components of the study, such as research questions, study design, measured variables, and their rationale for sample size decisions. Finally, by helping to make the distinction between exploratory and confirmatory research more clear, preregistration can allow both modes of work to complement each other and to be valued, as they deserve to be.

We risk repeating ourselves by emphasizing that exploratory research has an important value for advancing knowledge, and preregistration can be a helpful tool also in this case. Preregistration can, for example, serve to document the theoretical considerations leading to a study, provide important documentation that a study is free of QRPs such as the arbitrary and capricious exclusion of data points or variables, and otherwise protect researchers from 'critiquing after the results are known' (CARKing; Nosek & Lakens, 2014; see also Wagenmakers & Dutilh, 2016, for more reasons to preregister your studies). As empirical findings accumulate, as research programs develop and as theories become more specific, the researchers' hypotheses within specific studies or research programs will become more detailed and explicit as well. By specifying the confirmatory and exploratory components of a study in advance, it becomes a promise to the researchers' future selves (if to anybody) to keep the inferences from their work at an appropriate level. What was a current exploratory finding can become a future confirmatory study.

Thus, preregistration of both types of research is encouraged and reflected in the PRP-QUANT Template by including distinct fields for exploratory and confirmatory research. By making the plan of a study explicit and by sharing this plan with the research community, a level of transparency is achieved that will provide a more honest view of and a greater appreciation for the scientific process. When we, as a psychological research community, preregister studies, we not only build a culture of transparency; we educate others, sharing the knowledge and skill behind our science and keeping the backbone of our research strong, diverse and innovative.

Who Should Use the Template and How Should They Work With It?

As psychologists we should be very aware that science is behavior and, as outlined above, conducting 'good' scientific research consists of a series of discrete behaviors such as planning study designs, formulating hypotheses, and choosing statistical tests (Norris & O'Connor, 2019). In the same way, conducting 'bad science' is also a series of discrete behaviors – or questionable research practices - such as *p*-hacking, HARKing, and selective reporting. In the latter case, many of these behaviors are unplanned by the researcher and are likely to be reduced by forming clear, specific, and well-articulated research plans in advance. To this end, preregistration is a sophisticated word for 'planning' - we all have made plans (dissertation proposals, New Year's resolutions, grocery lists), and preregistration is the approach to planning research studies. Research plans are explicit and often more of a confirmatory approach; but that should not stop a researcher from stating other exploratory work that arises in the research process (just like someone can pick up a grocery item not on their list). Distinguishing the deductive/confirmatory from the deductive/exploratory aspects of research valuably informs reviewers, editors, readers and the authors themselves, not only about the nature of the research at hand, but also about how future research builds on it. The value of preregistration as a guiding and informational resource for all these stakeholders is outlined below. Also, note that there are many forms of preregistration to fit the needs of the stakeholder, in addition to accommodating disciplinary specifics and the nature of the research at hand.

Using the Preregistration Template as a Researcher and Author

Creating a preregistration can improve the quality of all aspects of the research process, from start to finish. Developing a detailed analytical plan, connected to specific hypotheses in the preregistration, can inform the design of the research, the data collection needs of the study, as well as refine the subsequent analysis of the existing dataset. The specific details required to complete the preregistration can help the author refine key details

in the study's design prior to conducting it. Creating specific hypotheses that are directly tied to portions of the analysis can ensure that the main research questions are truly answerable with the proposed design. Having to account for each variable can help organize the data collection procedures and allow researchers to prioritize their research questions. For example, the statistical power of a study to investigate the most important outcome of interest may be higher than anticipated if the model incorporates moderators and mediators, and anticipating greater statistical power upfront via preregistration can inform the realistic needs of the study. Otherwise, such decisions are forced upon the researcher by default, where the problem is regretfully discovered after the fact, after time and money have been spent, which then can motivate questionable research practices.

Another reminder may arise during the drafting of a preregistration: how will one interpret findings that are not statistically significant. In the best-case scenario, it can prompt one to consider how to answer different, but important questions, such as the strength (or weakness) of the evidence in support of alternative explanations, as opposed to limited testing and conclusions derived from null hypothesis significance testing (NHST). Developing a preregistration is also a valuable opportunity to prompt the author to receive feedback on the research design and its possible interpretations (e.g., causal vs. correlational). The most rigorous form of preregistration would be through peer review, such as under a journal's "Registered Reports" publication model (see Figure 1, and also Chambers et al., 2015; Hardwicke & Ioannidis, 2018). In this model, the proposed research question and research plan are reviewed, revised, and if accepted, offered an In-Principle Acceptance (IPA) for final publication regardless of the study's outcome. It is this latter point that is key: Regardless of the *p*-values obtained (or any statistical test results), the outcomes of analyses are accepted and published, which helps reduce *p*-hacking and other questionable research practices that weigh against obtaining accurate results. In between preregistration and registered reports are less formal review processes that are also possible and helpful, through simple sharing with colleagues or through sharing plans through preprint servers (e.g., OSF registries or PsyArXiv).

Figure 1. Process for Registered Reports. Taken from Center for Open Science; https://www.cos.io/initiatives/registered-reports.

Substantial benefit will be realized after the study is completed when the investigator can review the rationale and, importantly, the interpretation of the results within the confines that were prespecified. This post-study reflection is one of the core features of preregistration for authors. It can remind the author about the distinction between planned, confirmatory hypotheses and unplanned, exploratory findings that might signal an important new development in the field but that deserve to be confirmed before the finding is treated as true. Preregistration helps clarify that process by providing a structure for that later confirmation through direct, preregistered replication. Crucially, it can remind the author about the primary aims of the study and signal when post-hoc explanations arise that deserve this follow-up work.

When writing up the results of preregistered work, there are a few simple rules to guide the author (Table 2). First, include access to the preregistration (e.g., in the form of a DOI or a URL). This ensures that the details behind the study design and hypotheses can be examined by interested readers, reviewers, and other third parties. Second, report the results of all analyses specified in the preregistration. Selective reporting of only the statistically significant findings diminishes the credibility of all findings. Third, clearly indicate any changes from the original plan (any aspects that were omitted, modified, or added). Such changes may be inconsequential, or they could limit the generalizability of the reported

findings, but reporting all changes transparently is important for understanding the process of the research and for interpreting its outcomes. Crucially, be very careful about making changes during the research process that have somehow been informed by incoming data and their analyses (e.g., collecting an independent set of data once one has examined or analyzed existing data), and such changes can be the most consequential in affecting the integrity and interpretability of results. Finally, any additional analyses beyond those that were preregistered can and should be included in the manuscript - but they must be clearly denoted as such. Authors can summarize such changes in a 'Transparent Changes' section of the Methods part, which makes it easy for editors, reviewers, and readers alike to evaluate the degree of change in the final report relative to the preregistration. Very possibly, the effect of interest was affected by some unanticipated variable or some surprising effect judged to be worth exploring further. Since there are nearly limitless such variables and effects that arise, and because post-hoc explanations are subject to hindsight bias, these new explanations must be presented and emphasized as preliminary and in need of confirmation through replication.

Table 2. *Reporting the Results and Making Transparent Changes*

Reporting the results of preregistered work and making transparent changes.

1. Include a link to the preregistration (e.g., a DOI or URL).
2. Report the results of all hypotheses and analyses.
3. Any design, hypotheses, analyses, and outcomes that were not included in the preregistration must be explicitly denoted in the paper as "unregistered" or "exploratory."
4. Include a "Transparent Changes" section in the paper, where deviations from the preregistered plan are documented.

Using the Preregistration Template as a Publisher or Journal Editor

How an editor engages with a preregistration template will in part depend on whether the journal encourages preregistration to be submitted with submissions, on how explicit the links have to be between sections of a manuscript and items of the preregistration, on whether or not the journal offers Registered Reports, and more generally on whether the journal has an explicit policy on the preregistration of research. Editors should adopt the approach that is most fitting for the journal, based on the specific needs of the journal and its peer review policy. Among the most important considerations for a journal editor or publisher when publishing research that was preregistered are connecting the manuscript to the original preregistration, providing guidance on documenting any deviations from the original plan, and setting a level of comparison between the preregistration and final manuscript (see also Claesen et al., 2019). Here we consider each in conjunction with utilizing the PRP-QUANT Template.

When a researcher submits a preregistration to a registry, it is typically allocated a digital object identifier (DOI) or other way of persistently accessing the preregistration. Editors should require authors to provide this unique identifier that points back to the preregistration together with the submission, e.g., in the author's note, below the keywords, or in any other standard location in the manuscript. One consideration will be at which point the author(s) include this identifier; does the journal require masked review, in which case the preregistration would unmask the authors during the review process? These policies should be outlined in author instructions, and enabled in the peer review system.

The second way editors can encourage preregistration is by providing clear guidance on how any changes to the study design or analysis introduced after the preregistration should be documented. From the time a study is first preregistered until a manuscript is ready for submission, there may be a few minor changes in design and analysis; or there may be many such changes - for various reasons. Authors document with their preregistration their original study plan prior to running the study, and journal editors should give clear guidance on how to indicate what and why changes occurred relative to this

original plan. These changes should not be considered ‘penalties’ for the researcher -- quite the opposite, because editors should be encouraging researcher transparency at all stages, whether during preregistration or during the conduct of their research. Moreover, editors and reviewers must be cognizant of their own biases toward statistically significant results that could cloud their guidance and recommendations. For example, recommendations for additional tests or changes in a study that are made during the process of reviewing a manuscript should not be guided primarily by the *p*-values obtained, and any additions should be declared explicitly as resulting from the review process and as being exploratory in nature.

If an editor encourages or requests study preregistration for any or all types of articles, the PRP-QUANT Template offers an easy way to prepare this preregistration. As noted, the structure of the template enables a direct match of the preregistered design and analysis plans against their final report in the submitted manuscript because the sections of the PRP-QUANT template are aligned with a standard manuscript formatted in APA Style. In the most explicit form, this could be achieved by referring to the labels of the template’s items in the manuscript. Ensuring that this match is appropriate might depend on the section or subsection of the preregistration and paper (e.g., hypotheses vs. analyses) and be reflected in some combination of (a) authors submitting a checklist with their manuscript, (b) the manuscript coordinator reviewing the checklist and perhaps key sections of the paper, (c) the reviewers and action editor conducting their own key comparisons, or similar procedures. Again, the goal is not policing or to place extra work on journal editors; instead, the goal is to engage in better open science practices in psychology that improve both the science and the scientists involved.

Publishers supporting preregistration can provide the appropriate journal infrastructure that makes submission of preregistrations easier for authors and their review easier for editors and reviewers (see Table 3 for suggestions of respective policies as based on the Transparency and Openness Promotion (TOP) guidelines (Nosek et al., 2015), which might guide the development of journal infrastructures and policies). For example, setting up

the back-end platform such that various preregistration repositories are connected with the publisher's peer review system facilitates the submission process for authors and may help reviewers more easily compare and assess the alignment between preregistration and the authors' submission. Publishers might go so far as to advocate for their peer review system providers to design and implement a tool for checking a preregistration against a manuscript, e.g., by explicitly referring to the labeled items of the PRP-QUANT Template. Publishers and editors should assure that some basic checks are implemented, among them whether or not data collection was in fact started after the preregistration was finalized (which might involve checking the preregistration date against experimental logfiles or similar). Here, editors and publishers can and should reduce the workload of reviewers by implementing standard solutions that can be easily fulfilled by the authors upon submission. Finally, publishers can ensure ways to keep preregistrations anonymized prior to manuscript publication, provide free space for uploading preregistrations, make sure preregistrations receive a DOI or other persistent identifier, and define best practices for editors to consider.

Table 3. *Examples for policies related to preregistration according to the Transparency and Openness Promotion (TOP) Guidelines**

Preregistration in the TOP Guidelines*		
	Journals and Publishers	Funders
Level 1: Disclosure	Authors state whether or not work was preregistered and, if so, include a link.	Grantees state in application and reports whether or not work is or will be preregistered.
Level 2: Verification	If preregistered, journal or reviewers verify that plan was followed and that changes	If work is preregistered, funder appoints reviewers to verify that the plan was followed and

	were reported.	that changes were reported.
Level 3: Mandate	Authors must have preregistered when reporting the results of confirmatory research.	All confirmatory research must be preregistered as a condition of funding.

*The Transparency and Openness Promotion Guidelines (TOP) (Nosek et al., 2015) provide specific recommendations for journals to implement policies for preregistration, among other practices, and an extension has been applied to funding agencies. For recommended language and examples of journals and funders using each of these standards, see https://cos.io/top and https://cos.io/top-funders . The text in this table represents abbreviated versions of more detailed descriptions that can be found under these two links.

Using the Preregistration Template as a Reviewer

Just like preregistration is used by authors to improve the planning of their research before it is executed, preregistration also helps reviewers ensure that manuscripts are communicating transparently about their underlying science,i.e., whether or not manuscripts are portrayed by the authors in a manner that is consistent with the content of the preregistration form. To be clear, this does not mean that authors need to follow everything that was originally preregistered against their better knowledge at later stages of a project, or that reviewers should penalize authors for not doing so. Instead, it means that as a reviewer and reader of the article, it has to become eminently clear what aspects of the research were planned beforehand via preregistration, and what aspects were not. Some exploratory work can still be preregistered (e.g., exploratory factor analysis, where the number and nature of factors extracted is unknown), but other exploratory or follow-up aspects might not have been preregistered and should therefore be described clearly as such.

Reviewers are important evaluators of preregistrations - and although they help to ensure the usefulness and integrity of preregistration, the largest responsibility in this respect falls upon the authors themselves. Thinking of the ‘big picture’ of open science, it is the authors who are submitting an expanded set of materials to journals: their article, preregistration form, data files, study measures and materials, and analysis code. Thus, preregistration helps the reviewer understand the scientific process behind the article as they review it, just like the paper itself and other supplementary materials. Authors should do everything they can to make this as effortless as possible for the reviewers.

Reviewers might take note of three fundamental types of potential discrepancies between the form and the study, of which authors should have made them aware. First, the study might not have been implemented exactly as described in the preregistration form. For instance, the realized sample size and sample composition might differ from what has been envisaged, and the experimental design might have changed. Second, some analyses may have been conducted but were not preregistered; and third, other analyses may have been preregistered but were not conducted or are not reported. Often, people readily think about the first two discrepancies but not the third, yet all of these differences should be clearly disclosed in one form or another. The most challenging task for the reviewer may be how to evaluate such deviances from the original study plan. If reviewers notice differences that are not disclosed, they should request that authors inform the readers about discrepancies and the conditions that caused them. If differences between study plan and final report are made transparent, reviewers should by default acknowledge this openness by the authors; only if the reviewer has well-substantiated reasons to believe that the deviation from the original study plan reflects questionable research practices (like in the case of post-hoc changing the main outcome variables), such discrepancies could be a reason for criticism or rejection of a manuscript.

Other Stakeholders

Several other stakeholders can have an impact on how fast and how widely open science practices are adopted (National Academies of Sciences, Engineering, and Medicine, 2020). Among those, funding agencies provide the financial support for conducting research and thus provide a great incentive and influence on the actual behavior of scientists. Research institutions and professional scientific associations are also critical for promoting an open science culture and specific practices among their members; and the organizations that host scientific registries provide researchers with the technical infrastructure for transparent research. We will discuss these four critical stakeholders in somewhat more depth in the following.

By enforcing the adoption of transparent research practices, *funding agencies* can have a very strong impact on whether or not strategies like preregistration are widely adopted in a research field. For example, under a directive from the European Parliament and the Council of the European Union in 2001, grant funded researchers were required to register clinical trial research design prior to data collection (https://bit.ly/3qEn2x0) and as a result, the European Clinical Trials Register (www.clinicaltrialsregister.eu) was created as a repository of preregistrations of clinical trials. Similarly, the United States Congress passed the FDA Amendments Act of 1997 and expanded in 2007, after which trial registration for many federally funded clinical trials became a requirement and ClinicalTrials.gov was created as a repository for registering clinical trial design prior to starting new research and making these preregistrations available to the public (https://clinicaltrials.gov).

Although not currently a requirement for grant funded research other than clinical trials, many funders of preclinical biomedical, education, and social science research encourage the use of preregistration among their researchers (see https://cos.io/top-funders for examples). This may constitute a third pillar of promoting research transparency besides the need to publicly share data acquired in the course of a project as well as requirements for open access publications of results from grant-funded projects. Researchers, in turn, would have to document that they have adhered to such criteria for good scientific practice

defined by their funding agency. Table 3 lists policies that research funders might adhere to based on the TOP guidelines.

Research institutions, including universities as well as extra-universitary research institutes, have a critical role in ensuring that their scientists adhere to the standards of good scientific practice. Tenure is a large incentive for early career researchers, and open science contingencies could be tied to tenure judgments of high-quality scientific work. In fact, over the course of the last several years, universities have demonstrated increasing interest, attention, and action when it comes to open standards for ensuring transparent and reproducible research (as documented, e.g., by the impressive list of institutional members to the UK Reproducibility Network: https://www.ukrn.org/institutional-leads/). Research institutions can foster the adoption of standards for open and reproducible science, not only by communicating a broad mission statement, but by providing clear and concrete guidelines tied to in-house training opportunities for researchers at all career stages. Research institutions can also support organizations that promote open and transparent research standards (such as the Center for Open Science or the currently developing reproducibility networks, e.g., https://www.ukrn.org/; https://reproducibilitynetwork.de/) and they can financially reward the adoption of open science practices by their members. Another incentive could be to include open science practices as a point of evaluation in the faculty or researcher hiring process (see an example at https://www.nicebread.de/open-science-hiring-practices/). The preregistration of studies is one central aspect to be considered in this context. There is a potential tradeoff between open practices and research output; however, benefits include a more robust and replicable scientific record. Research institutions would not have to commit to specific tools like the preregistration template introduced here, but they can encourage the different disciplines to establish their own set of options, guidelines, and norms.

Professional associations in psychology might want to adopt the PRP-QUANT Template in order to promote among their members open science practices in general and preregistration of hypothesis-driven research specifically. In that context, there are several

measures that professional associations could take, ranging from recommending preregistration and the PRP-QUANT Template to providing training opportunities for their members to actually requiring the preregistration of studies in their own scientific journals. For those associations with journals, they could encourage or require use of the template as well as editor-generated or adapted checklists for the review of manuscripts submitted with preregistrations, as discussed in more depth above.

Several advantages of adopting the PRP-QUANT Template for these matters appear obvious and have been discussed in more depth above, including the integration of key ingredients from a broad range of existing preregistration templates its similarity in structure to the APA Style Journal Article Reporting Standards (JARS; Appelbaum et al., 2018). From the perspective of professional associations in psychology, it may however be most important that this template arose out of the concerted effort by three international psychology associations and is supported by several further associations (see Appendix A). By adopting the PRP-QUANT Template, further scientific organizations can join this group and contribute to advancing common standards and similar cultures across academic psychology.

The same reasons for using this template apply to *providers of publicly accessible repositories and registries* alike. Moreover, using this off-the-shelf template helps users of repositories and registries specify their research plans in a unified way across studies, rendering the final protocols comparable across different content providers. Providing unified categories for describing content is essential for meeting the guiding principles for making data Findable, Accessible, Interoperable and Reusable, or FAIR (Wilkinson et al., 2016). The FAIR principles, in turn, provide guidance for scientific content management and stewardship by challenging data producers and data publishers to promote the maximum use of research data. A core component of implementing the FAIR principles is standardization of data formats and metadata, and the use of consensus-templates like the present one may contribute to this by encouraging the implementation of technical solutions for linking different platforms (e.g., between repositories and publishers; see also previous

section). Infrastructural providers also have to take into account the specific needs of different disciplines, which can be achieved by using a template established by disciplinary communities like the PRP-QUANT. On the other hand, aligning such standards to standards in other disciplines may constitute a further challenge for infrastructural providers.

Structure of the Preregistration Template

Beyond descriptive information like title, abstract and further study details, the PRP-QUANT Template is structured into an *Introduction* section specifying the theoretical background and research objectives, as well as two methodological sections, one covering details of the data acquisition and study design (*'Method'*) and one covering details of the planned statistical analyses (*'Analysis Plan'*). Each section has multiple items to be completed by the user, and the template contains brief instructions on what should be minimally included when filling out the respective item. Often, these instructions have the form of suggestions or examples as a guide, but not a dictate.

Not all items in the template are typically enumerated in psychological research publications. For example, the treatment of missing data is often only reported when missing data occur, and how to deal with missing data often depends on the nature and amount of missing data and may not have even been planned out beforehand (Newman, 2014). However, we strongly recommend pre-specifying as many aspects of the study methods as possible, because planning tends to improve study quality, and lack of specification tends to increase researcher degrees of freedom when conducting the study. So in the case of missing data, authors could pre-specify in the preregistration how they plan to decide whether further measures have to be taken. As research programs develop and more experience accumulates, researchers may be more and more able to specify also such initially open aspects of the data treatment. As we have noted, even with preregistration in place, deviations from the original research plan are not unusual, should not be penalized,

and in fact the researcher should be rewarded for stating them explicitly in the study description (see Table 2, above).

For items that involve a comprehensive list of possible responses, we propose using drop-down menus rather than free text (in technical implementations of the PRP-QUANT Template). Each section furthermore has an item for 'Other Information', so that details of the study plan not covered by any of the items can still be described. Some key elements of the template reinforce recommendations of JARS-Quant (Appelbaum et al., 2018); namely, having clear sampling procedures, providing an analytic strategy for primary, secondary, and exploratory hypotheses, and providing a clear description of statistics and data analysis, including how missing data are handled. However, whereas JARS-Quant provides a framework for how to report on what has already been done in a study, the PRP-QUANT Template provides a framework for what should be considered when first planning and preregistering a study. Using the PRP-QUANT template for preregistration thus facilitates following closely the recommendations of JARS-Quant for writing up psychological research at later stages of a project.

Importantly, each preregistration item has a unique label, and we strongly encourage that these labels are also used when writing up the preregistered research at a later point in time (see also below). This makes it easier for reviewers and readers to directly link the final report of a study to each individual aspect of the preregistered study plan. The template also encourages to internally link hypotheses to measured variables to statistical models used for testing the respective hypothesis, via these item labels. The important role that we place on the item labels also implies that we propose to retain the use of explicit labels in possible future adaptations of this template. In the following, the sections and items of the preregistration template will be described in more detail.

Section 1: Title and Title Page, Abstract

On the title page, the project title (Item T1) provided should be substantive, informing the reader with initial key points about what will be accomplished in the study. Note that the

'cuteness' or cleverness of a title may detract from this main purpose. In the title page, provide separate entries for each contributor (T2), including their professional affiliation and a persistent ID (one that is unique to the contributor, such as ORCID ID, https://orcid.org). In technically implemented variants of the PRP-QUANT Template, the preregistration system itself will assign the date (T3), version (T4), and identification number (T5; persistent ID or DOI) for the preregistration, while this information has to be provided by the authors if depositing the form as a document-based preregistration.

Several key points about the project are also indicated on the title page: the estimated duration of the project (its full duration, from preregistration submission to project completion (T6); the status of the IRB submission (human or animal subjects; an overview of ethical guidelines followed; any reasons for exemption; and the IRB number if obtained (T7); a conflict of interest statement stating anything that might be reasonably perceived as a conflict (financial interests; corporate funding; or authors state explicitly there is no conflict; T8). Then, add several keywords (T9) that capture the nature of your paper; they pertain to the topic, but they may also indicate the methodology, the population, or novel study features. Next, indicate whether and how the data will be made accessible: e.g., open for public use, restricted to scientific use, arranged on an individual basis, or available at a secure data center (T10). Optionally and as appropriate, investigators can indicate the availability of analysis and programming code (T11), as well as indicate the availability of standard lab practices (T12), such a timestamped document that specifies the typical procedures, analytical decisions, personnel roles, etc., that apply in the investigator's laboratory.

The project abstract will summarize the background, objectives and research questions, participants, and study method components that are found in the *Introduction* and *Methods* sections to the preregistration, as described below. Note that even though abstract and keywords have not been typically included in previous preregistration templates, they can contribute to making preregistrations findable by other researchers.

Section 2: Introduction

The *Introduction* section of the PRP-QUANT preregistration template contains four major subsections, theoretical background (I1), objectives and research questions (I2), hypotheses (I3), and exploratory research questions (I4). In section I1, the researcher(s) are asked to provide a brief overview of the theoretical background that justifies the research hypotheses. This may include referring to conceptual models, empirical findings or practical needs. In the next two sections, I2 and I3, the researcher(s) are prompted to state the objectives and hypotheses, respectively, that inform the methodology and analyses (that will be specified in later sections). If multiple hypotheses exist, they should be uniquely numbered (H1, H2, …) and referred to in a consistent manner throughout the preregistration document and in the manuscript. The last section of the introduction, I4, is optional and may be used to state planned exploratory analyses (where precise hypotheses are not made). These should also be uniquely numbered (e.g., E1, E2...) and referred to consistently. The important point to be made here is how preregistration draws a clear line - to the research community, and even to the investigators themselves and their research labs - about which aspects of the research were specified in advance as confirmatory and exploratory aspects, versus which follow-up aspects were unspecified in preregistration and thus are exploratory in nature.

Section 3: Method

The Method section consists of three broad groups of items. First the researcher declares where the data are in terms of the data acquisition process (M1; e.g., is the author registering prior to the creation of the data or prior to analyses of the data). It is also hoped that the template will be used by researchers who are planning to analyse pre-existing datasets or using secondary data. Therefore, there is the option to state whether this is the case and to specify the level of knowledge the researcher has of the dataset and if the dataset has been previously published (M2).

The second broad group of items in the *Method* section deal with the planned sampling procedure and data collection. This section requests a statement on the sample size and information on the rationale underlying this decision, most typically a power analysis (M3). A useful resource for calculating optimal sample sizes has been developed by Faul et al. (2007) and various related packages exist for the *R* statistics software. An overview of different approaches for justifying sample sizes has recently been provided by Lakens (2021; see https://psyarxiv.com/9d3yf/) and a useful primer on power analysis was published by Perugini et al. (2018). For sequential acquisition plans, description of any 'stopping rules' and relevant timings of when you plan to look at your data should be given in this item. In the next item (M4), information is required on the methods of recruitment (e.g., participant pool advertisements or snowball sampling), on how the researchers plan to select participants (if necessary), inclusion/exclusion criteria, and whether participants will receive compensation for taking part in the study. Item M5 allows the researchers to specify how participant drop out will be handled (e.g., if such cases are replaced). Given the importance of demand characteristics in psychological science, researchers are also requested, as appropriate, to indicate all forms of masking and/or allocation concealment used in the proposed study (M6). The next items ask researchers to outline clear data cleaning and screening strategies (M7) together with their plans for handling missing data (M8). More information on critical considerations and practical approaches for the treatment of missing data can be found in Gomila and Clark (2020), Graham (2009), and Newman (2014).

The final group of *Method* items is related to the design and conditions of the study. This includes outlining the type of study (M10; e.g., experimental, observational, cross-sectional, longitudinal), the nature of the design (e.g., between vs. within subjects, factorial), and if applicable, how participants and experimental materials are randomized to conditions (M11). Researchers are also requested to unambiguously state and clearly operationalize each of the measured and manipulated variables (M12). This should involve explicit statements about the functional role of each variable in the study (M13; i.e., independent variable, dependent variable, covariate, mediator, moderator), as well as how each variable

will be used to test the respective hypotheses (which should map onto the analysis plan). Finally, the preregistration should give detailed information on all study materials and precise information on the study procedures (M14; e.g., the number and timing of measurements, the number of blocks or runs per session of an experiment, laboratory setting, or the number of training sessions in interventional studies). Lastly, any other information that does not fit into the pre-specified items of the *Method* section can be provided in item M15.

Section 4: Analysis Plan

The analysis plan within the PRP-QUANT preregistration form takes the researcher through the typical steps of analysis for any given study. The first items are associated with data cleaning and preprocessing prior to statistical analyses, beyond the treatment of missing data (which is covered in the previous section). As a first step, researchers should specify those criteria that would lead to the exclusion of participants (AP1; e.g., depending on performance or when not responding to a treatment) or the exclusion of variables or trials (AP2; e.g., due to floor or ceiling effects). Next, all sorts of data preprocessing required before submitting the data to a statistical analysis should be described (AP3). This includes but is not limited to calculating scale scores as a composite of items (e.g., whether items were reverse-coded, or averaged so that missing data were accounted for); linear (e.g., adding and/or multiplying) or nonlinear transformations (e.g., square-root or natural log); or disclosing data preprocessing packages such as those applied to EEG or fMRI BOLD imaging data. For studies involving psychological measures, reliability analysis is often the next step in the preregistered analysis plan (AP4). Researchers should report for what variables they are reporting psychometric information like internal consistency (e.g., Cronbach's alpha, omega from factor analysis), test-retest reliability, or some other form of reliability (e.g., based on a confirmatory factor analysis incorporating multiple factors as sources of variance; Le, et al., 2009). If the study involves measure-development work where measures will be refined, then researchers should specify the criterion for removing items (e.g., largest factor loading magnitude, smallest drop in alpha-if-item-removed).

Next, researchers should declare the variables on which they will be reporting descriptive statistics (e.g., means, standard deviations), and indices that reflect practical effect sizes (e.g., correlations, *d*-values, odds ratios; AP5). These values are generally associated with the next two stages, where the researcher is to preregister the statistical model (AP6; e.g., *t*-tests, ANOVA) and inference criteria (AP7; e.g., *p*-values, Bayes Factors and their significance thresholds) that will be used in the study. Inferential models should specify any planned contrasts; any global fit indices for evaluating models (e.g., RMSEA, AIC, BIC); as well as any concerns and controls for multiple testing and/or the violation of statistical assumptions. Furthermore, using item AP7 to preregister the smallest effect size deemed practically significant commits and guides the researcher when interpreting results. Finally and to the extent possible in preregistration, researchers should explain whether exploratory analyses are planned (AP8). As already stated several times in this text, the goal for preregistration is not to discourage exploratory analyses but rather to ensure readers (and even researchers themselves) have a clear appreciation for which aspects of a study were confirmatory versus exploratory in nature. The inclusion of item AP7 also is not intended to prevent research exploration that might arise during data analysis but could not have been anticipated during preregistration (see above for more details). Rather, it shall indicate that also exploratory research questions and analyses can be preregistered.

Outlook: Future Developments, Higher Aspirations

Developing a concerted template comprises only a first step toward improved standards for study preregistration. We currently provide the template in several different formats (see http://dx.doi.org/10.23668/psycharchives.4584), and are planning concrete steps for an empirical evaluation of the template. In February 2021, an online study testing the usability of the PRP-QUANT template will begin fielding (preregistration: http://dx.doi.org/10.23668/psycharchives.4465). Invitations for participation will be sent out via the APA, BPS, and DGPs to their members and the study will be advertised on social

media in order to reach a broad and diverse audience of psychologists. The first aim of this evaluation study is to gather in-depth feedback from researchers of the different subdisciplines of psychology, to establish an empirical basis for further improving the template. To this end, the PRP-QUANT template will be presented together with an online questionnaire assessing the participants' satisfaction and comprehension as well as the perceived effectiveness and complexity of the template. Additionally, participants will be probed on different subsets of the template's items by asking them (i) to fill out the items having their own study in mind, (ii) to rate the perceived importance of the items, and (iii) how they think the items could be improved. Ample opportunities for commenting either on specific items or on the template as a whole are provided throughout the study. The results will be used to critically re-evaluate the items of the template and their usability, and to inform potential future developments of the template. The study, secondly, uses a theoretical framework, the unified theory of acceptance and use of technology (Venkatesh et al., 2003, 2016), to investigate in more depth the participants' process of forming the intention to preregister their studies. All data obtained will be published to encourage their secondary use.

While providing and improving the means that aid preregistration is certainly an important step on the way towards more transparent and reproducible psychological science, achieving a wide adoption of this practice requires more than that - as is demonstrated quite clearly by the fact that even though a variety of preregistration templates have been established over the last several years, preregistration is still far from being the norm (Hardwicke & Ioannidis, 2018). The goal of the Joint Societies Task Force on Preregistration, accordingly, reaches beyond delivering a comprehensive and user-friendly template. The underlying mission is to send a strong signal that major societies of psychology have teamed up to jointly encourage and recommend preregistration as an important part of good scientific practice. We hope that this signal will spread to other stakeholders (see Section 4.4) so that preregistration develops from being a courageous act by a minority of researchers, perceived by many as requiring unknown steps or too much

effort, to a natural component of conducting research in psychology, that ensures more solid scientific processes and thus progress. The potential benefit of preregistration is greatest when it becomes a universal practice within a research community, where revealing one's research planning up-front is expected, where others can easily understand the researchers' confirmatory versus exploratory research goals, and where reporting null results is accepted and even expected as long as research is conducted in an unbiased and best-practice manner.

Conclusion

In the current article, we have outlined the work of the Joint Psychological Societies Task Force on Preregistration, provided guidance on how to work with the PRP-QUANT template, described and discussed its structure, and outlined the potential benefits for researchers, authors, funders and other relevant stakeholders of using this template (and preregistration in general). The uptake of preregistration practices and registered reports is increasing, and there is clear evidence to suggest that these innovations are beginning to reduce publication bias and the use of questionable research practices, and that these changes in scientists' behaviors will ultimately and collectively improve the scientific research process and robustness of our cumulative scientific evidence base (Allen & Mehler, 2019; Chambers, 2019; Hardwicke & Ioannidis, 2018). We hope that the introduction of the PRP-QUANT preregistration template and its support by APA, BPS, DGPs as well as several further academic psychological societies (see Appendix A) contributes to further improving the culture of scientific openness in our discipline. We look forward to a future where it will seem strange not to preregister one's work, a future where journals, disciplines, and authors will compete on their science in terms of greater transparency and knowledge-sharing within their publications and research endeavors and appeal to you as our colleagues to support this important development.

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Appendix A. List of Psychological Societies and Groups Who Provided Feedback and Support on the PRP-QUANT Template

American Psychological Association

Association for Psychological Science

Austrian Psychological Society

Australian Psychological Society

Brazilian Society of Psychology

British Psychological Society

Canadian Psychological Association

Chinese Psychological Society

Colombian Society of Psychology

European Federation of Psychologists' Associations: Board of Scientific Affairs, Belgian, Italian and Serbian Representatives

German Psychological Society

Japanese Psychological Association

National Academy of Psychology - India