Facilitating Open Science Practices for Research Syntheses: PreregRS Guides Preregistration

Abstract

Researchers increasingly engage in adopting open science practices in the field of research syntheses, such as preregistration. Preregistration is a central open science practice in empirical research to enhance transparency in the research process and it gains steady adoption in the context of conducting research synthesis. From an interdisciplinary perspective, frameworks and particularly templates are lacking which support researchers preparing a preregistration. To this end, we introduce preregRS, a template to guide researchers across disciplines through the process of preregistering research syntheses. We utilized an R Markdown template file to provide a framework that structures the process of preparing a preregistration. Researchers can write up the preregistration using the template file similar to filling out a form, with the template providing additional hints and further information for the decisions along the framework. We integrated the R Markdown template in an R package for easy installation and use, but also provide a browser-based option for users granting low-barrier access. PreregRS constitutes a first step to facilitate and support preregistration with research syntheses for all disciplines. It further adds to establishing open science practices in conducting research syntheses.

Keywords

Open Science; Preregistration; R package; R Markdown

1. Introduction

Research syntheses are an established approach to integrate and evaluate findings across disciplines. Within the last years, there has been an exponential growth in published research syntheses, such as meta-analyses and systematic reviews.[1] Research syntheses are sought to be a valuable approach to inform the scientific community and provide evidence-based directions to practice and policy makers. This holds particularly true in research fields in which rather small-scale experiments and studies are conducted, such as the behavioral and social sciences, as meta-analyses allow to aggregate the obtained findings.[2] However, the inferences we can draw from research syntheses depend on the decisions researchers make throughout the research process (e.g., concerning literature search, eligibility criteria and strategy for data synthesis).[3,4,5] At the same time, transparency concerning changes in the decisions during the research process allow for critical evaluation of these research syntheses and enhance reproducibility.[6] In this report we therefore reflect on transparency in research syntheses and present a tool to support preregistration.

1.1. Transparent decision processes facilitate evaluation and reproducibility

In published research reports, readers will usually find final decisions of the researchers producing the reported findings. Changes in the decision processes or updates to initial decision approaches are not necessarily mirrored in these publications. We will use three examples (on literature search, eligibility criteria and strategy for data synthesis) to illustrate the importance of transparency reflecting the decision-making process for the evaluation and reproducibility of research syntheses.

First, the literature search (i.e., sources of search and search strategy) constitutes an essential step for conducting research syntheses.[7,8] Changes within the scope of literature search, such as altering used databases or updating the search string may result in a difference of several hundred hits. Readers that are unaware of changes and reasons of change in the literature search lack important information to critically evaluate the continuation or termination of literature search. Second, eligibility criteria are a list of clearly defined rules for whether papers from the result of the literature search enter the research synthesis or not. Updates to eligibility criteria is a standard procedure when conducting research synthesis. However, changes need to be made transparent, justified, and potential consequences reasoned as they directly determine the pool of literature that form the basis of the synthesis.[6] Information regarding changes and their rationale allow readers to critically assess whether the development of eligibility criteria improved the pool of literature.[9] Third, the strategy for data synthesis based on the included

papers can have a high impact on the results of the meta-analysis (e.g., selection of moderators in meta-analyses).[10] Readers' inferences to be drawn from the paper heavily depend on their ability to distinguish between exploratory parts of data analysis that may develop in the process of a research synthesis and confirmatory parts assumed a priori.[11]

The increasingly mainstreamed open science movement addresses these challenges with practices that enable researchers to conduct transparent and reproducible research.[12] In the field of research syntheses, these practices are rarely utilized, however, they increasingly receive attention.[13] Preregistration is a crucial component of these open science practices to make research syntheses *as a process* transparent. As illustrated by the examples above, we argue for the importance of transparency with decision processes in research syntheses and thus for preregistration.

Similar to other open science practices, preregistration of research syntheses is not yet an established procedure.[14,15] This may be particularly, because preregistering research synthesis put high demands on researchers, and, therefore, require additional assistance in the registration process.[16] Making preregistration for research synthesis possible (e.g., by providing infrastructure) is a necessary first step and needs to be followed by making it easy as a next one.[17]

To date, the field lacks an interdisciplinary applicable framework for preregistering meta-analyses and systematic reviews that can be adopted to individual needs via a template. Several important approaches currently exist for this purpose. PROSPERO is a platform for pre-registration of systematic reviews in the field of health.[18] However, adapting the framework to other disciplines outside health poses additional challenges for each individual researcher. In contrast, frameworks like PRISMA-P[8] and the Inclusive Systematic Review Registration Form[19] aim to cover a wide range of disciplines and are valuable frameworks within their methodological boundaries (e.g., systematic reviews). With *preregRS* ("preregistering research syntheses") we want to add to these frameworks and offer a one-stop-shop approach for meta-analyses as well as systematic reviews from all disciplines. *PreregRS* guides and supports researchers in preparing a preregistration and enables them to include all essential information in one single file: Researchers will be able to provide not only text, but also statistical analyses and their results (e.g., simulations for power analyses), as well as figures, and embed external files (e.g. data, codebooks) in one composed document.

In the following section, we will outline the structure of the framework for preregistration utilized in *preregRS* and its alignment with heuristically used, established standards. Then we

introduce the *preregRS* template that includes the framework and demonstrate its functionalities.

2. Framework and implementation

2.1. The framework for preregistration utilized in preregRS

In the *preregRS* template we provide a framework to guide preregistrations of research syntheses. Its structure is aligned with (1) standards in preregistering systematic reviews such as the 'international prospective register of systematic reviews' (PROSPERO) from medical and health science, (2) standards in reporting such as the 'Meta-Analysis Reporting Standards' (MARS) provided by the American Psychological Association,[7] and (3) standards in protocols such as the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Protocol' (PRISMA-P)[8]. We explicitly adopt an interdisciplinary approach by synthesizing these perspectives in one framework to be broadly applicable (see Table 1). This way, researchers are provided with an adaptive framework without having to investigate, evaluate and heuristically apply standards from other disciplines.

[add Table 1 here]

2.2. Basic functionality and recommended workflow of the preregRS template

To support researchers in the process of using the framework for preregistration we implemented it in an R Markdown template. R Markdown is a file format that enables users to include formatted text, R syntax including its output. It employs the easy-to-use markup language 'markdown' which is highly compatible (e.g. for integrating HTML, LaTeX, YAML). What is more, R Markdown is convertible to standardized formats like HTML or PDF.

Sections in the *preregRS* template guide users through decisions to be made when preregistering a research synthesis, similar to filling out a form. Additionally, to facilitate usability of the template also without prior experience with R Markdown, the template provides placeholders ("*Put your text here.*") throughout the file for users to replace with their information. For every section, more detailed descriptions from the authors and the three standards (PROSPERO, MARS, PRISMA-P) are accessible to further support researchers making informed decisions. These detailed descriptions are most easily visible after compiling the R Markdown file to HTML: Next to each section users will find a "more info" button in the compiled HTML file that provides these detailed descriptions for the corresponding section on click (see Fig 1 for R Markdown syntax and the complied HTML template). Therefore, our recommended workflow

(see Tab. 2) includes compiling the R Markdown into HTML in a first step, to have a structured look at the descriptions before filling out the template. Readers can get a glimpse of the empty template compiled to HTML via http://bit.ly/preregRS-HTML.

[add Figure 1 here]

FIGURE 1. Excerpt of the R Markdown template regarding the 'Search Strategy' section (above) and the associated compiled HTML (below).

To provide easy access to the template we created an R package that includes the R Markdown file. Users can install the *preregRS* package from the software repository GitHub ([blinded for peer review]). Basic guidance on installation and usage is provided on the GitHub page of the package. After installation, the template is available when opening a new R Markdown file under the option "From Template" in RStudio.

[add Table 2 here]

We also provide the possibility to use the R Markdown template within a browser-based online version (see http://bit.ly/preregRS-jupyter). The browser-based environment sets up a temporary version of the template, that can be filled out, compiled to HTML and downloaded in the same session. However, the settings are reset and the progress is lost as soon as the browser window is closed. Therefore, installation is preferable in most cases (e.g., to be able to update one's preregistration). The browser-based version is particularly suitable in case the users want to experience the template first before installation.

In case users need good practice examples of several sections from the template, as an illustration, see http://bit.ly/preregRS-example.

3. Discussion

In this article, we introduced the R package *preregRS*. The package contains an R Markdown template that offers both a framework that supports scientists to preregister research syntheses across disciplines and to adapt this framework to the individual needs of one's research synthesis. That way, we aim to support researchers in the implementation of open science practices in research syntheses, an area where we perceive room for advancement on standards, tools, and frameworks.

The template was successfully utilized for preregistration in several research projects, within and outside our research group (see [links blinded for review]). Further developments, particularly regarding usability of the R Markdown template and accessibility outside of R are forthcoming.

As DeHaven put it: preregistration is "a plan, not a prison".[20, no page] The present template provides a tool to support and guide the establishment of this plan for research syntheses. In this respect, the present template is the first initiative explicitly targeted at researchers of all disciplines to plan their systematic reviews and meta-analyses. It marks a further step towards transparent and open science with research syntheses.

Highlights

What is already known

Open Science practices are an important approach to make research syntheses transparent and reproducible. Preregistration of research syntheses is still little established, as easy-to-use templates and frameworks lack from an interdisciplinary perspective.

What is new

We established a template including a framework to guide researchers preparing a preregistration with research syntheses in an R Markdown template file. Along with additional hints and further information for the decisions in the preregistration process researchers can complete the file like filling out a form and compile it to standardized formats like HTML or PDF.

Potential impact for Research Synthesis Methods readers outside the authors' field

The template is explicitly aimed at supporting and guiding researchers from all disciplines, while still being adaptable to the specific needs of individual research interests.

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TABLE 1. Sections of the template with short descriptions (extended descriptions in the template).

Level 1 Heading	Level 2 Heading	Description
1 General	1.1 Working Title	Provide title (e.g. from grant proposal), ideally aligned with frameworks referred to in the template.
	1.2 Type of Review	Meta-analysis, systematic review, scoping review, narrative synthesis, ...
	1.3 Anticipated start and completion date	Expected time frame of synthesis.
	1.4 Stage of Synthesis	Current state within the process of search, screening, extraction and analysis.
	1.5 Names, Affiliations, Contact	Contact details best linked with an ORCID.
	1.6 Collaborators	Names in case of collaboration or cooperation.
	1.7 Amendments to previous versions	If this is an update to a previous preregistration provide its DOI here.
	1.8 Funding sources, sponsors and their roles	Funding sources, best with identification number (e.g. grant number.
	1.9 Conflict of Interest	Conditions that could influence the author's judgements.
2 Introduction	2.1 Rationale	Describe the rationale of the synthesis, its relevance and theoretical deduction of research question(s).
	2.2 Research Questions	State the deducted research question(s).
3 Methods	3.1 Eligibility: Inclusion and Exclusion Criteria	Describe how studies will be selected, best with frameworks referred to in the template.
	3.2 Sources of Search: List and Rationale	List the sources that will be consulted: Databases, journals, ...
	3.3 Search Strategy	Provide the search string for the listed sources.
	3.4 Data Management Tools Used	How will publications and extracted data be managed?
	3.5 Selection of Studies	Describe the screening process, how studies will be selected and coded by the authors.
	3.6 Method of Extracting Data & Information (from Reports)	How will the relevant information be extracted from the selected studies?
	3.7 List and Description of Data and Information Extracted	Which information will be extracted from the selected studies?
	3.8 Effect size transformation from individual studies	If meta-analysis: Describe effect size metric used and transformation into that metric.
	3.9 Risk of Bias in Individual Studies	Provide how study quality and potential bias in individual studies will be evaluated.
4 Results	4.1 Strategy for Data Synthesis	Depending on the type of synthesis, describe how extracted data from studies will be synthesized.
	4.2 Moderators/ Subgroups	State the subgroups to be investigated.
	4.3 Assessment of Publication Bias	Describe how publication bias will be assessed and your countermeasures.
5 Discussion	5.1 Strength of Evidence	On what will the concluding evaluation of the strength and limitations of the evidence be based on.

TABLE 2. Recommended workflow and hints for novices with R Markdown

Steps	How to
1. Installation of preregRS via GitHub	*Run R Code:* install.packages("remotes") remotes::install_github("[blinded for peer review]")
2. Open Rmarkdown (Rmd) template	*In RStudio:* Click: file > new file > R Markdown > From Template > preregRS to HTML or PDF > ok
3. Compile Rmd to HTML in order to check descriptions (‘more info’ buttons)	*In RStudio:* Click: Knit (next to ‘save disk’) > to HTML
4. Replace “Put your text here” with your information in the Rmd	*In the template file:* Include plain or marked-up text, as well as plots, R code, LaTeX or HTML.
5. Compile final version to standalone HTML	*In RStudio:* Click: Knit (next to ‘save disk’) > to HTML
6. Upload to (public) repository to get a timestamp and DOI	Follow guidelines of the repository (e.g. osf.io, prereg-psych.org)