Promoting Responsible Research Practices

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Executive Summary

This position paper emerged from a request from the Dutch funding body ZonMw to inform future research funding programmes based on three specific objectives: 1) give a sketch of the current (inter)national discussion on Responsible Research Practices (RRP); 2) give an overview of current initiatives and already obtained results regarding RRP; and 3) give an overview of potential future needs for research on RRP.

To establish an informed advice, the authors drew on their own academic background, expertise, academic networks, and literature reviews. Through various forms of wider consultation, we aimed to align our evidence-based perspectives with those in the field of research on RRP and to solicit input from multiple stakeholders.

We summarise the current state of research and provide a conceptual overview of initiatives to foster RRP, both nationally and internationally. We do this by conceptualising RRP as an overarching theme consisting of three different levels: Scientific Frameworks; the Scientific System; and the Empirical Cycle. By picturing this landscape of current initiatives, we identified potential gaps of knowledge. These gaps were classified in six main themes that need attention in future research:

1. Responsible evaluation of research and researchers
2. The influence of Open Science and transparency on RRP
3. Research on responsible mentoring, supervision, and role modeling
4. The effect of education and training on RRP
5. Checking for reproducibility
6. Responsible and fair peer review

Generally, we stress that RRP are relevant for the entire research enterprise and for all scientific domains, even though this may manifest itself differently across research disciplines. Currently, these differences are poorly understood. We contend that future studies should amplify the initiatives mentioned to a more diverse set of disciplinary domains in order to better understand RRP in different disciplinary fields.

The main themes that we consider underrepresented are broad areas of research that focus on the level of the scientific system, more than on the level of the individual researcher. Some current initiatives are already gathering empirical evidence to start filling these gaps. Both the current academic debate on these issues, as well as wider societal concerns are indicative of a sense of urgency to solve the problems concerning RRP. We believe that there have been important first steps made in the right direction already, and with sufficient support from various stakeholders, more progress can be made.

[1] The author order was determined alphabetically. All authors contributed equally to this document.

1. Introduction

While academic research is generally recognised as an institute of crucial importance to the well-being of our contemporary society, concerns over its functioning are growing. Stakeholders from within and outside the academic community are increasingly worried about issues regarding research funding, the scientific publication system, research evaluation practices, and career trajectories in academia. Fuelled by several highly visible cases of scientific misconduct, there is a growing awareness that the results of scientific research should be reliable, that research practices should be responsible, and that the workflows and results of research need to be transparent. While media coverage has mainly centered on large fraud cases, the research community has acknowledged that fundamental causes of current issues are embedded in more systemic aspects of evaluating, rewarding, and disseminating research (Biagioli, Kenney, Martin, & Walsh, 2019). Experts of research integrity are convinced that, on an aggregate level, factors such as detrimental research practices, lack of supervision and mentoring, the system of research with hypercompetition, unidimensional assessment criteria, an individualistic research culture, and publication pressure are more threatening to the reliability and validity of research than (arguably rare) cases of misconduct (Begley & Ioannidis, 2015; Fanelli, Costas, & Lariviere, 2015; Martinson, Crain, De Vries, & Anderson, 2010). This has led to a shift in focus towards research on Responsible Research Practices (RRP). The increased attention for this subject is reflected by the large number of (inter)national initiatives from various stakeholders to foster RRP. These initiatives have mainly emerged from the biomedical sciences and psychology, and there is now an increasing need for initiatives tailored to other research disciplines and cultures.

In the Netherlands, the debate on responsible research was predominantly fuelled by the high-profile fraud case of Diederik Stapel. The investigation team studying this case declared that this type of fraud is actually not that common, but the case itself nevertheless triggered a plethora of Dutch initiatives to foster RRP (Abma, 2013). This included not only research on research integrity, but also a newly revised national code of conduct in the Netherlands (see here). This also included initiatives from funding agencies including ZonMw, establishing two funding programmes called ‘Bevorderen Verantwoorde Onderzoekspraktijken’ (BVO) or ‘Fostering Responsible Research Practices’ (RRP), and the NWO Replication Studies Programme (see here). In these programmes, several researchers are currently working on and assessing initiatives that foster RRP.

Research on RRP has shown several trends. Initial interest in this field was mainly in defining research integrity and gaining more insight in the different forms of research misbehaviours, leading to classifications of major and minor forms of misbehaviours (Falsification, Fabrication, and Plagiarism [FFP] and Questionable Research Practices [QRP] respectively; Bouter, Tijdink, Axelsen, Martinson, & ter Riet, 2016; Steneck, 2006). In addition, ample attention has been paid to estimating the frequency of transgressions and analysing individual cases (e.g. Fanelli, 2009; John, Loewenstein, & Prelec, 2012, van der Heyden, van de Ven, & Opthof, 2009). Repeatedly, boundaries between research integrity and research ethics have been questioned in this debate with other concepts such as Responsible Research and Innovation (RRI) prominently co-shaping discussion on research integrity. This has led us to adhere to a broad interpretation of ‘research integrity’ including aspects that some may classify as research ethics. To keep our paper sufficiently focused, we nevertheless refrain from merging the research integrity and RRI concepts. The scope of our concepts and paper will be further clarified in section 3.

Over the past years, discussions and research interests have evolved to encompass a wider variety of topics. Currently, studies are increasingly redirecting their focus towards root causes and possible solutions. This has resulted in a shift from micro-level analyses, mainly concerned with the individual and his/her characteristics, towards current discussions acknowledging the important role of broader

cultural, organisational, and systemic factors, including the research climate, organisational settings, and incentive structures (e.g., Haven, Tijdink, Martinson, & Bouter, 2019; Martinson et al., 2010). This shift is, among others, represented in the new Dutch Code of Conduct for Research Integrity, dedicating a full section to institutional responsibilities (KNAW et al., 2018).

In addition, openness and transparency have been increasingly identified as drivers of RRP. Both nationally and internationally, a growing number of initiatives is calling for and facilitating increased transparency in research, voiced in terms like 'FAIR Data', 'Open Access', and 'Open Science'. Initiatives include proposals as diverse as calls for openly sharing data, facilitating reproducibility and replication studies (including the humanities), publishing in Open Access journal articles, and using Open Peer Review formats (Nosek et al., 2015). Lastly, suspicion about published findings that are not replicable, mainly within psychology and the biomedical sciences, has directed research focus towards ways of enhancing replicability. This includes studying publication bias, methodological flexibility, and transparency (Munafò et al., 2017; Wicherts, 2017).

While the number of initiatives aiming to foster RRP is growing and diversifying, the evidence base for what initiatives are actually successful is often lacking. In addition, initiatives are commonly restricted to specific niches or academic disciplines. In particular, most initiatives and studies originate from the biomedical and social sciences, leaving blind spots in other research disciplines, cultures and methods, and risking the tendency to overgeneralise both challenges of research integrity as well as their potential solutions. Therefore, more research is still needed to guide the implementation of RRP across the full range of academic disciplines, cultures, and settings.

This position paper aims to shed light on the (inter)national debate on RRP and emerged from a request from the Dutch funding body ZonMw to establish a document addressing three key issues:

1. A sketch of the current (inter)national discussion on RRP
2. An overview of current initiatives and already obtained results regarding RRP
3. An overview of potential future needs for research on RRP

Our position paper will hence address these three points. We first discuss the methodology used to write this position paper. After the methodology section, we summarise the current state of research on RRP and provide a conceptual overview of initiatives to foster RRP, both nationally and internationally. Third, we identify major gaps of knowledge in the field of research on RRP that need to be addressed. We do so by providing an overview in which we classify the most pressing themes that need further study. Our position paper aims to inform policymakers and funders on current issues for RRP and may serve as a starting point for future research programmes under ZonMw.

2. Methodology

This position paper emerged from the close collaboration of its authors in several steps. The authors were chosen for their expertise in the field of RRP and by the fact that they are early-career researchers, an important group which will not only have to adjust to future RRP but form the future generation of senior researchers. During the process, the authors drew on their own academic background, expertise, academic networks, and literature reviews to establish an informed advice. Unavoidably, the voice of the individual authors, based on their academic background, may have influenced and shaped our discussions. Through various forms of wider consultation, we aimed to align our personal perspectives with those in the field of research on RRP and to solicit input from multiple stakeholders with their varying stances. At the end of this position paper, we present short biographies of the authors that will put their expertise into context and show the authors' diversity in

disciplinary backgrounds. All authors of this paper are based in a university research setting, and are hence less familiar with the research context of universities of applied sciences (HBO). While this paper's focus rests with the university context, we aimed to be inclusive and believe that many of the aspects we discuss are equally relevant for HBO.

Step 1: Exploratory phase
After an initial round of discussion among the authors, each author individually provided an overview of current initiatives and underrepresented topics in the field of RRP. These overviews were inspired, but not restricted to, the personal background and knowledge of the authors, supplemented by discussion within their peer networks. While this paper does not provide a systematic review of the academic literature on RRP, it is inspired by literature reviews by the individual authors.

Step 2: Creating an overview of current initiatives across different academic disciplines
In a second stage, the independent overviews were combined and supplemented to form one set of current initiatives and studies focusing on RRP. The initiatives were then collaboratively clustered into a thematic map of current initiatives, showing networks, connections, and dependencies between the various themes. The results of this endeavour are presented in section 3 of this paper.

Step 3: Identifying underrepresented themes
In a third phase, the underrepresented topics identified by the individual authors in step 1 were combined to form a list of themes that are in need of further research. This list encompasses important gaps in knowledge on RRP that need more attention in future funding programmes. This list was established through discussions on the scope of our project and the characteristics of the identified gaps, combining similar themes and deleting themes out of scope.

Step 4: Creating a ranking of underrepresented topics
Last, we created a ranked list of the underrepresented topics from step 3. This was done in a two-tier manner. Each author independently ranked the complete set of underrepresented themes through a short web-based survey. Each author was then asked to provide a brief justification for their prioritisation of the top five themes in need of further research. The authors discussed which of the themes currently lack a robust evidence base and can be effectively addressed in future funding programmes. The resulting rankings were subsequently merged into a single ranking by calculating the overall ranking scores of the authors. The resulting ranked list of underrepresented research topics is presented in section 4 of this position paper.

Step 5: Drafting a position paper on the results of steps 1-4

Step 6: Consultation of first draft by 16 experts in the field of RRP.
A list of experts in RRP was assembled and all experts were then asked to provide feedback on the draft position paper. All expert suggestions were taken into account and, as far as possible, incorporated into the position paper. The contributing experts are listed in the Acknowledgements.

Step 7: Recommendations for future funding programmes on RRP

3. Current Initiatives Promoting Responsible Research Practices

The scientific community has already started many initiatives to promote and address RRP. These initiatives cover all aspects of the scientific 'empirical process' and are in differing stages of development and acceptance by researchers. In this section, we categorise the main types of initiatives and sketch the current state-of-the-art of RRP. A list of concrete examples of initiatives can be found in Appendix I, whereby we acknowledge that the list is not exhaustive and may overlook other initiatives.

RRP effectively encompass the entire scientific ecosystem from overarching frameworks to the implementation system to the research process. In Figure 1, we have framed RRP as an overarching theme consisting of these three different levels: Scientific Frameworks; the Scientific System; the Empirical Cycle. We are aware that we focus on research adhering to a research paradigm following the empirical cycle and thus put less emphasis on other methodologies. This reflects the fact that most current initiatives are tailored to this paradigm. We acknowledge that some disciplines may not be fully covered by this paradigm, but we believe that the empirical cycle is a useful framework to create and present an inventory of current initiatives that aim to foster RRP.

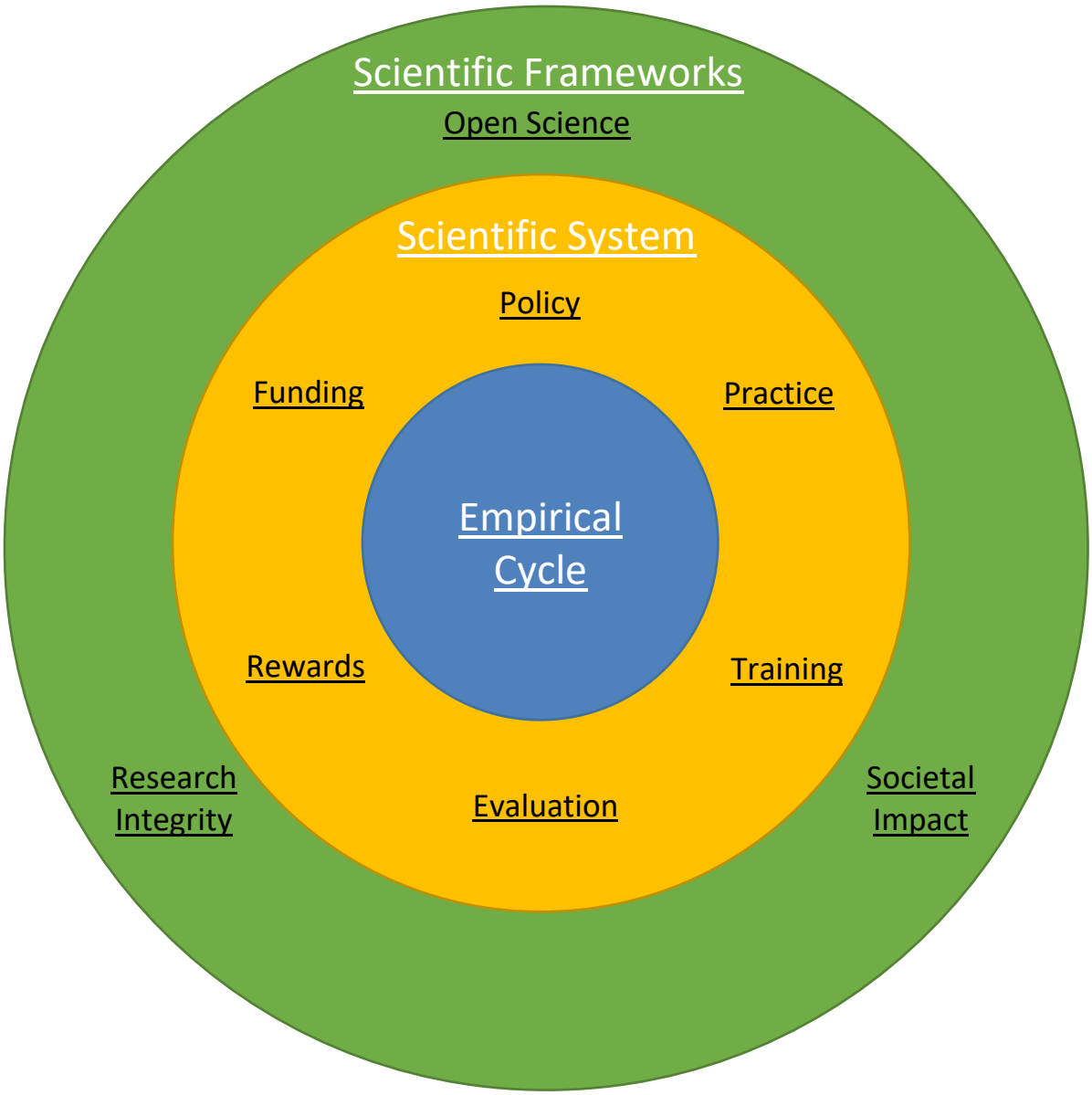

Figure 1. A schematic representation of the elements that interact in responsible research practices. The three elements all consist of initiatives that we have collected in Appendix I. The three rings in this figure represent the different levels at which we can look at responsible research practices: Scientific Frameworks, the Scientific System, and the Empirical Cycle. Each underlined term inside the rings are linked to a list of concrete initiatives in Appendix I. Figure 2 elaborates on the initiatives to promote responsible research practices in the empirical cycle.

Scientific Frameworks

The overarching first level of Scientific Frameworks refers to three broad value frameworks under which all RRP are expected to be carried out and judged in the current socio-political climate: Open Science; Research Integrity; Societal Impact. These three frameworks are not to be seen as distinct but rather overlap and feed into each other. In fact, by making research more open and transparent, Open Science is expected to be an enabler for research integrity and societal impact. Each framework consists of a multitude of practices, whereby researchers are expected to engage in some, but not necessarily all, of the potentially varied, practices in a given framework. We recognise hereby that more specific moral values such as honesty, scrupulousness, transparency, independence, responsibility, collegiality, and productivity (KNAW et al., 2018) play some role in each of our broader value frameworks, which we will briefly describe separately.

The practice of an open science has existed for centuries in Europe in the form of open letters and select publications in scholarly outlets. A modern interpretation of **Open Science** has been proposed by the European Commission (2016) as the opening up of research workflows and outcomes via digital technology. This approach applies to the entire research process: designs and methodologies (Open Methodologies); data that is Findable, Accessible, Interoperable, and Reusable (FAIR) and open (Open Data); software code (Open Source); initial versions of publications and peer review (Open Peer Review); and access to final versions of publications (Open Access). This approach also includes opening up study materials (Open Education) and involving citizens in research (Citizen Science). The Netherlands has taken a leading role in Open Science with the *Amsterdam Call for Action on Open Science* (2016) and the *National Plan Open Science* (2017).

The concept of **research integrity** is crucial to the scientific endeavour and refers to research practices that follow five key principles of honesty, scrupulousness, transparency, independence, and responsibility (see the Netherlands Code of Conduct for Research Integrity). Research misconduct arises from researchers intentionally or unintentionally not following these principles. High-profile cases of intentional misconduct often lead to public outcry and calls for changes in the way we do science. Examples of research integrity initiatives in the Netherlands are the Netherlands Research Integrity Network (NRIN) and Embassy of Good Science.

Similarly, there has been considerable public indignation about the (lack of) **Societal Impact** of publicly funded research. There is a growing call for research activities and outcomes to not only involve citizens but also be relevant for and benefit society. This can take many forms: opening up and communicating about the outcomes of research; direct application and commercialisation of research technologies; directly involving the public in the design, collection, and analysis of research; or directly letting the public decide future research funding topics. The Netherlands aims to facilitate this, among other initiatives, through Knowledge Transfer Offices (KTOs) and Technology Transfer Offices (TTOs) and also through the participatory National Research Agenda (NWA).

The Scientific System

The secondary level of the Scientific System focuses on the steering and facilitation of RRP by governments, funding agencies, and academic institutions under six key areas: Research Policies; Research Practices; Training Researchers; Evaluating Research(ers); Rewarding Researchers; Funding Research(ers). Each of these areas may focus on specific aspects of the scientific frameworks as well as individual steps in the empirical cycle. The goal of the scientific system for RRP is to ensure that researchers learn about RRP and conduct their research in a 'responsible' manner.

The **policies** for RRP relate to the legislation affecting research, funding programmes, guidelines and codes of conduct, and general principles for how researchers are to be trained, evaluated, and rewarded. These policies crucially determine the initiatives that are intended to foster RRP. Any identified gaps in initiatives should lead to new policies for stimulating initiatives to fill such gaps. The Netherlands has focused on RRP via the BVO programme by ZonMw and this position paper itself

aims to identify any gaps for developing new policies. These policies also include a tendency towards codification of research misconduct and the increased role of research ethics committees in assessing integrity and ethical aspects of research projects.

Aside from formal policies, actual research **practices** form the most effective initiatives to foster responsible research. While stakeholders agree that mere changes in policies, guidelines, and codes of conduct will not suffice to establish more responsible research, much attention has been given to these formal academic structures. Nonetheless, actual research practices, as well as informal rules, academic cultures, and interpersonal relations have been the target of recent initiatives and studies on RRP. These initiatives include implementation efforts of ZonMw's BVO projects as well as studies of research cultures and organisational climate.

The raising of awareness and **training** of researchers in RRP is crucial for RRP to be carried out successfully and be widely adopted by the scientific community. A recent survey by the European Commission (2017), however, has shown that the majority of researchers in Europe do not fully understand and are not being supported to implement the principles of Open Science. Initiatives for supporting and training researches in RRP in the Netherlands are currently grassroots and locally organised, such as the Open Science Community Utrecht and the Superb Supervision course.

The **evaluation** of research and researchers are perhaps the most important factors in promoting RRP. The current evaluation system is focused on judging research, and by extension researchers, according to the number of publications that appear in high impact factor and branded journals, instead of judging the quality of the research itself. Furthermore, researchers are to a much lesser extent (if at all) evaluated on the basis of other research-related activities such as teaching, supervision, unsuccessful grant applications, research designs, peer reviews, the publishing of datasets, and public engagement. Examples of assessment initiatives are the Declaration on Research Assessment (DORA) and the Leiden Manifesto for Research Metrics.

The **rewarding** of researchers for RRP is crucial for stimulating researchers to change their behaviour and commit to RRP. The rewards system is intrinsically linked to the evaluation system and thus any initiatives or changes in the one system will naturally influence the other. The Netherlands has recently proposed an overhaul of the recognition and reward system towards a differentiated and collaborative model to assess and reward other aspects of RRP.

Finally, the **funding** system drives academic research and is also closely related to the careers of researchers. The funding system has the potential to directly influence the behaviour of researchers via funding mandates and funding award criteria. One example is the mandating by funders of researchers to publish in Open Access journals: publication costs are simply not covered by the funder if the publication is not Open Access. Another example is the refusal by funders to use journal impact factors to evaluate researchers: this reduces the pressure on researchers to publish only in high-impact and branded journals. Funding also directly determines the research agenda of researchers.

The Empirical Cycle

Most of the initiatives to promote RRP are aimed at the empirical cycle itself. Figure 2 shows the many types of initiatives at this level, including how they link to the different steps in the empirical cycle and how they relate to each other. In many fields and types of research, the empirical cycle often roughly follows the same steps. From a theory (step 1), a hypothesis is formulated (step 2). To test this hypothesis, a study is designed (step 3) and data are collected (step 4). Based on the analysis of the data, a conclusion is drawn (step 5) and the research is disseminated (step 6). Finally, during and after dissemination, the published literature can be corrected (step 7). These steps are loosely based on the empirical cycle as discussed by De Groot (1961). We realise that not every single scientific study will fit this representation (e.g. exploratory research where the data generates the hypothesis or conceptual research fields that do not employ data). However, most of the initiatives to promote RRP at the empirical level seem to fit within this framework. The fact that

most initiatives fit this framework is also indicative of a potential lack of diversity in those initiatives, arguably not covering research methods and traditions working from different frameworks. In the paragraphs below, we briefly outline the initiatives to promote RRP at each of these steps in the empirical cycle. Furthermore, for each step and each practice we have collected a list of initiatives that fall under these practices. The full list is available in Appendix I.

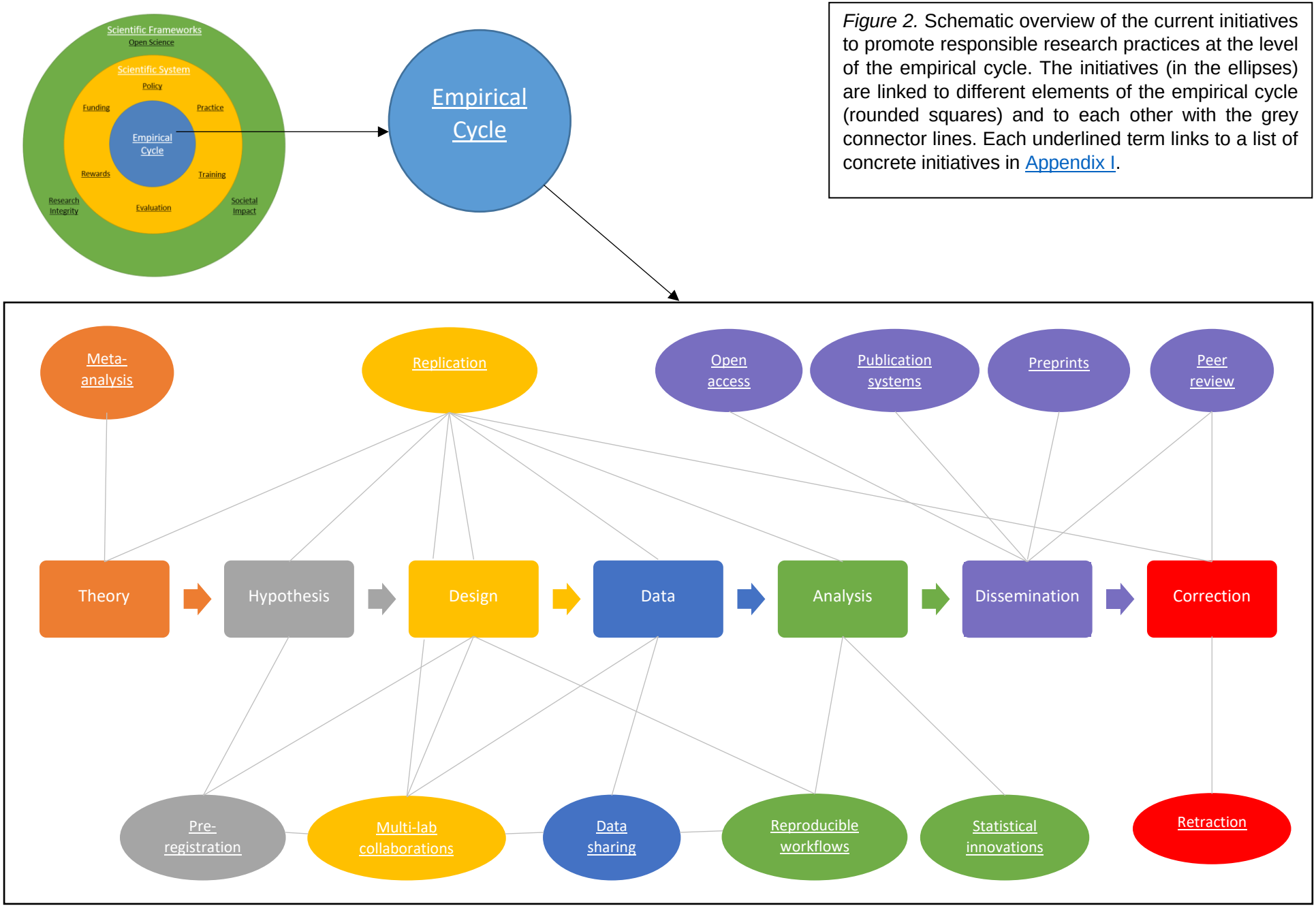

Figure 2. Schematic overview of the current initiatives to promote responsible research practices at the level of the empirical cycle. The initiatives (in the ellipses) are linked to different elements of the empirical cycle (rounded squares) and to each other with the grey connector lines. Each underlined term links to a list of concrete initiatives in Appendix I.

To build theory or to assess which effects are stable enough to build upon, research synthesis is an important step. One method to synthesise results is via **meta-analysis**: a statistical summary of different studies with (more or less) the same research question.[2] A problem with meta-analyses, is that they are not immune to problems such as publication bias, which means that they can lead to biased results. To improve meta-analytic estimates and to promote RRP at this theoretical step, researchers have been developing advanced meta-analytical methods, such as statistical methods to detect and/or correct for (publication) bias in order to increase the accuracy of the estimates of the effect under investigation (see e.g., p-uniform and p-curve).

In the next step of the empirical cycle, a hypothesis is formulated. At this step, one of the most notable types of initiatives to increase RRP is **preregistration**. There are different ways to preregister a study, but generally, researchers publish their hypotheses and research plan online, before conducting the study. Preregistration can have several goals. First, it allows for a clear distinction between confirmatory and exploratory analyses (Wagenmakers, Wetzels, Borsboom, Maas, & Kievit, 2012). Second, it could prevent exploiting flexibility in methods and data analyses to obtain the desired result, because the plans were registered beforehand (initiatives such as Compare and EU Trials Tracker compare registrations with the accompanying published papers). Third, preregistration could decrease the effects of publication bias: even if a study was not published because the results were not significant, others can still find the preregistration and know that this study was performed. The practice of preregistration has been standard in biomedicine for years, but has only recently gained popularity in the social sciences. One relatively new form of preregistration is a 'Registered Report'. Here, the preregistration is submitted to a journal and peer reviewed. Once the preregistration is approved, the authors can get an 'in principle acceptance', meaning that if they follow their preregistration, their paper will be published regardless of the outcome. Over 200 journals now accept this format. Funders can also partner with journals on a Registered Report model and review a protocol at the same time, increasing efficiency and impact.

The next phase in the empirical cycle is the study design phase. Two notable types of initiatives that promote RRP at this step are **multi-lab collaborations** and **replication studies**. Multi-lab collaborations are coordinated efforts to run the same study in different labs, sometimes across the world (see the Psychological Science Accelerator and the Many Babies project). This strategy increases statistical power and allows investigating generalisability of the findings. It also requires detailed study protocols, which likely increase reliability. A second initiative to improve RRP at the design step is a stronger focus on replication studies; running the same (or similar) study on existing data or a new sample to assess the reliability of previous findings. Replications affect the design phase, but they also link to many other steps in the empirical cycle; from theory to analysis, all the steps are more or less the same as the study that is replicated. An example of a Dutch initiative to promote replication studies is the replication grant of NWO. A special case of a replication study is a 'registered replication report': a multi-lab collaboration that performs a preregistered replication study. This combines the advantages of several initiatives to promote RRP throughout the research workflow.

Another clear point in the empirical cycle where RRP can be stimulated is when data has been collected. One of the most advocated strategies is to **share data**. Openly sharing data allows for reanalysis to detect and correct mistakes, to check robustness, and to answer new research questions. Several stakeholders (journals, funders, institutions) now require Open Data, and there is an increasing number of infrastructural solutions to facilitate data sharing. One crucial prerequisite for opening data, as noted earlier, is that the data is made FAIR (Wilkinson et al 2016). Data that has been made FAIR can, but may not necessarily, be opened afterwards. We note hereby that the concept of openness is not polar but a spectrum whereby the phrase 'as open as possible, as closed as necessary' generally applies, especially concerning private, medical, commercial, and security

[2] Researchers with a qualitative focus typically produce a systematic review involving the collection, critical appraisal, and synthesis of all relevant studies.

data. A good example is the Open Library of Humanities that is dedicated to publishing in Open Access with no author-facing Article Processing Charges (APCs).

In the analysis step of the empirical cycle, RRP are promoted via initiatives related to **statistical innovations** and **reproducible workflows**. Statistical innovations include rethinking thresholds for statistical significance, advanced analyses, and promoting statistical frameworks (frequentist vs. Bayesian statistics, effect size estimation, etc.). An example is the development of the free statistical software such JASP and R. Most of these innovations focus on increasing the reliability and robustness of statistical conclusions. Other initiatives focus on increasing reproducibility of workflows. A study is reproducible[3] if a reanalysis of the data, following the reported procedures, leads to the same results. Reproducibility requires that data should be available and that procedures should be clear. Reproducibility can be greatly improved if researchers manage their data according to the FAIR data principles. Researchers can share their data via data repositories, such as the Dataverse Project, Figshare, or Dryad. Furthermore, platforms such as the Open Science Framework can serve as a data repository, but also help researchers to make their entire workflow reproducible by providing a template to share all steps and outcomes of the research process.

To guarantee reproducibility of systematic reviews and meta-analyses, more and more journals require authors to follow specific reporting guidelines (see also **policy**), such as the CONSORT statement for randomised controlled trials, and PRISMA or MARS for meta-analyses and/or systematic reviews. These guidelines serve as checklists for authors to make sure that all important information is included in their article. They result in more standardised reporting, which makes it easier for researchers to find the information they need, and to verify results and conclusions.

The next step of the empirical cycle is dissemination. In most cases, this entails publishing a study in a peer-reviewed journal. Many initiatives promoting RRP appear to focus on this step. Consider for instance initiatives that shift the focus to pre-publication peer reviews, by promoting **preprints**, published online in preprint archives. Yet other initiatives aim to revise the publication system completely via innovative online platforms (e.g., the megajournal F1000). Finally, the Netherlands is working on promoting Open Access publishing through the funding mandates of Plan S that aim to provide full and immediate Open Access to scientific publications by 2021.

The final step in the empirical cycle is the correction of research reporting. Correction can take place before/during dissemination through peer review. Several initiatives focus on improving the quality of peer review, for instance, by publishing the reviews alongside the article (e.g., in the journal *Royal Society Open Science*). Correction can also take place after dissemination through replication (for initiatives linked to replication, see above), and errata or retractions (see, e.g., the popular blog Retraction Watch that tracks scientific retractions and covers cases of misconduct).

4. Themes that warrant future research

Before we start our discussion on themes that warrant future research, we would like to stress that responsible research is the product of applying the overarching scientific frameworks of Open Science, research integrity, and societal impact across the scientific system and in the empirical cycle. This is a concern for the entire research enterprise, and for all scientific domains, even though it may manifest itself differently in diverse research disciplines. Currently, these differences are poorly understood. The traditional focus on several disciplines is reflected in the list of abovementioned initiatives, stemming mainly from the biomedical and social sciences, leaving the natural sciences, engineering, and humanities understudied. Some studies have already indicated how integrity challenges emerge differently across research disciplines (Haven, Bouter, Smulders, &

[3] Please note that we use the term *reproducibility* to refer to analytical reproducibility, which is not the same as replicability. Replication and replicability refer to a situation in which new data is collected to assess whether the original results can be *replicated* in a new sample.

Tijdink, 2019; Haven, Tijdink, Martinson, & Bouter, 2019; Horbach & Halffman, 2019), but future studies should amplify the current initiatives towards other disciplinary domains (such as the natural sciences and humanities) and put more efforts into studying and resolving these differences.

While the above list of current initiatives regarding RRP consists of laudable efforts, and sketches a hopeful picture, much remains to be elucidated. Many of the initiatives described are relatively understudied and there remains a paucity of evidence on their effectiveness and potential impact. Few controlled studies have compared the differences between new initiatives with existing frameworks, as well as the potential hurdles and consequences of implementing the initiatives in different research settings.[4] This could be a theme that warrants future research in itself.
In this section, we will outline some of the most prominent knowledge gaps that might be effectively addressed in future funding programmes addressing RRP.

Following steps 3 and 4 described in the methodology section, we created a set of underrepresented themes in the current research on RRP. Through a short ranking exercise, we then condensed this set into a list of six major themes that we believe lack a robust evidence base. Below, you will find a summary of the most important themes. The full list of ranked themes can be found in Appendix II.

First, we believe the **responsible evaluation of research and researchers** is a crucially understudied issue. The current evaluation criteria are thought to create a perverse incentive structure, are unidimensionally focused on the 'bean counting' of publications in high-impact and branded journals, and may nudge researchers unconsciously into QRP with a focus on publishing as many articles as possible, instead of getting it right. How these incentive structures actually influence research practices is still unknown and how the research evaluation criteria should be reformed needs further research. The urgency for this research was also voiced during the 6th World Conference on Research Integrity (WCRI2019) in Hong Kong in June 2019 and in recent events by ZonMw and NWO. Research on this theme may also shed light on the obstacles to address. Many strategies to promote RRP are not new, but have also not been widely implemented yet. Finding out the reason for this lack of uptake could help form better policies and incentives. Furthermore, we recommend formal consideration by the funder of ways to offset risks to early-career researchers in engaging on open research practices and ensuring proper reward and incentive structures are in place (e.g. grants and fellowship schemes that take into account commitment to open practices).

Second, we believe that the **influence of Open Science and transparency on RRP** requires further study. The Open Science movement is quickly adopting various initiatives that help to create a more open and transparent science (sharing data, pre-registering studies, and openness in peer review and in publishing). While researchers may agree that Open Science can benefit RRP, there is much misunderstanding on what 'Open Science' actually means. More research is thus needed to address possible benefits and disadvantages of this trend in the research community. We are also still unable to determine if preregistration and the sharing of data are reliable determinants that reduce publication and outcome reporting bias. A shift to Open Science will furthermore require a coherent operationalisation of the many open practices across the empirical cycle so that researchers can work effectively and efficiently in an open manner. The relationship between Open Science and innovation, especially in collaborations between academic institutions and industry where openness can hamper innovation, is lastly understudied and needs further scrutiny. A shift to

[4] However, we do note the rise of "meta-scientific" studies and even entire meta-research groups (e.g., the Meta-Research Center at Tilburg University and METRICS at Stanford University) that study exactly these questions.

Open Science and increased transparency should also involve reducing the bias of solely publishing positive research: negative and null results are just as important for advancing science.

Third, we identified a lack of knowledge on **research on responsible mentoring, supervision, and role modeling**. Mentors and supervisors play a key role in establishing a responsible research climate for early-career researchers. As such, they have an enormous influence on the next generation and thus on the (future) practice of responsible research. Furthermore, most of the education in crucial phases of an academic career happens through socialisation processes, largely influenced by mentors, supervisors, and role models. However, this pivotal role is not always fully acknowledged and it is seldom thoroughly reviewed in academic research settings. The role of bad supervision or even harassment can furthermore have detrimental effects on research and researchers and should be openly acknowledged and addressed. We believe that additional research may shed light on this, which might eventually assist in mentors and role models establishing a research culture that fosters RRP.

Fourth, the **effect of education and training on RRP** needs further study. The role of education and training is commonly proposed as one of the main interventions to foster RRP. However, the research on its effectiveness is inconclusive and restricted (Marusic, Wager, Utrobicic, Rothstein, & Sambunjak, 2016). Besides, hardly any educational programmes are organised with a focus on responsible research in senior researchers. Empirical research should assess what type of education and training is successful and describe what potentially or definitively can make a difference.

Fifth, future research programmes should focus on increasing the **reproducibility of their workflow and analyses**. We need to investigate how we can facilitate and incentivise sharing data, analysis scripts, protocols, and other relevant materials that are necessary to retrace the steps that the original researchers took to reach their conclusion. More research could expose possible factors that limit researchers to reflect on the reproducibility of their results and make people aware that reproducibility, at least in many research disciplines and cultures, is one of the pillars of RRP.

Finally, **responsible and fair peer review** is currently understudied and does not receive sufficient attention in research funding programmes. Peer review is often considered to be one of the cornerstones of academic research. Currently, it is still largely a black box at risk of conflicts of interest, unfair procedures, serendipity, and inconsistency. This leaves questions such as: How can we improve peer review? What role can transparency play? Do we know enough about peer review to propose novel strategies and interventions that can make peer review more reliable? Can responsible peer review reduce publication bias? What can automated software do to alleviate the enormous pressure on the peer review system? More research can detect potential flaws and can search for novel techniques that help us to improve the peer review process, ultimately making it more efficient and trustworthy.

For all these themes we believe that it is crucial to acknowledge the epistemic, methodological, gender, and cultural **diversity** in research in order to comprehensively tackle issues of QRP. To move away from one-size-fits all approaches to solving these issues, we need to better understand which QRP are prevalent in the different academic disciplines and which RRP are most effective in these disciplines. For the themes mentioned above, this means for example that training, mentoring, and supervision should be tailored to the specific needs of a certain community, allowing different approaches in different disciplines and different ranks.

Strengths and Limitations

As in all research, there are some strengths and limitations in our analysis. First of all, we believe that this position paper has the potential to inform ZonMw about potential gaps of knowledge in the field of RRP. One of the strengths is that our team consists of four early-career researchers who bring in a multidimensional perspective from their own disciplinary fields and expertise in RRP.

There is also a downside to the fact that the authors are all early career researchers; we might lack the experienced perspective of a researcher with more seniority. We have tried to limit this potential bias by inviting 16 more senior experts to comment on our paper.

Furthermore, the field of research on RRP is steadily expanding. Therefore, it could well be that we may have missed some relevant initiatives and themes that merit further study.

5. Conclusion

In conclusion, we have used different methods to gain insight into the initiatives that are currently being implemented in the Netherlands and in Europe to foster and study Responsible Research Practices (RRP). We have mapped these initiatives and subsequently identified gaps of knowledge and underrepresented themes in RRP that we believe require further exploration in a potential next round of the project Bevorderen Verantwoorde Onderzoekspraktijken (the so-called BVO 2.0).

We have identified six main themes for further attention: responsible evaluation of research and researchers; the influence of Open Science and transparency on RRP; research on responsible mentoring, supervision, and role modeling; the effect of education and training on RRP; checking for reproducibility; and finally responsible and fair peer review.

These themes are in line with the gaps that we have identified by mapping current initiatives to foster and study RRP. Interestingly, we have found that the themes that we find underrepresented are broad areas of research that focus on the level of the scientific system. Some current initiatives are already gathering empirical evidence to start filling these gaps. However, we do feel that a future funding programme should take these gaps into account in order to bring the field of research on research integrity a step further.

Generally, we feel that there is an urgent need for more research on research and research practices. Specifically, studies of RRP and how to foster them require additional support. Both the current academic debate on these issues, as well as wider societal concerns, are indicative of this urgency. We moreover believe that current initiatives have made important steps in the right direction already, and with sufficient support from various stakeholders, more progress can be made. We hence call upon all relevant stakeholders to actively engage in efforts to further support studies on RRP and initiatives to foster them.

6. Biographies

Serge Horbach

Serge Horbach works as a PhD student at the Institute for Science in Society, Radboud University, and the Centre for Science and Technology Studies, Leiden University. His research focuses on research integrity and the scientific publication system, working in a sociology of science and science and technology studies tradition. Currently he studies how erroneous or fraudulent research may enter the scientific literature and how editorial and peer review practices may be organised to prevent this. Wider research interests include scientific (e)valuation practices and the impact of misidentified biospecimen on replicability.

Michèle Nuijten

Michèle Nuijten is an Assistant Professor in Methodology and Statistics at Tilburg University, where she is part of the Meta-Research Center. Michèle obtained her Bachelor's (2011) and Master's (2012) in Psychological Methods at the University of Amsterdam. In her PhD thesis (2018, Tilburg University), she focused on meta-scientific studies of problems and solutions in psychological science. Among other things, she co-developed the tool "statcheck": a spellchecker for statistics. Currently, her work focuses on reproducibility and replicability in psychology.

Gareth O'Neill

Gareth O'Neill is a doctoral candidate in linguistics at Leiden University and has represented early-career researchers extensively in the Netherlands and in Europe. He is former president of the European Council of Doctoral Candidates and Junior Researchers (Eurodoc) and has been active as contributor to the Dutch National Plan for Open Science (NPOS), expert on Open Science for the European Commission, and advisory board member for the FOSTER Plus project. He is currently an ambassador for Plan S for cOALition S and adviser for the European Open Science Cloud (EOSC).

Joeri Tijdink

Joeri Tijdink is an Assistant Professor at the metamedica department at Amsterdam UMC, location VUmc and philosophy department at VU University. He obtained his PhD in 2016 with the thesis entitled Publish & Perish; research on research and researchers. Currently he is involved in several research projects that investigate research integrity, publication pressure, research culture and responsible research practices and is the author of the self help guide: Scientist on the Sofa; how to survive at the university. He also works as a clinical psychiatrist.

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Appendix I: Examples of Current Initiatives to Promote Responsible Research Conduct

This list contains examples of current initiatives to promote responsible research practices. Please note that this list is not exhaustive, and mainly serves as an illustration. For a schematic overview how all these initiatives relate to each other, see Figures 1 and 2 in the main text.

Scientific Frameworks

Open Science

- Open Science Amsterdam Call for Action on Open Science
  Conference in Amsterdam in 2016 that set goals for an Open Science agenda in Europe
- National Plan Open Science
  National strategy proposing concrete steps to achieve Open Science in The Netherlands

Research Integrity

- Embassy of Good Science
  A place where the community can share experiences and insights, deepening understanding and continuously contribute to the development of good science.
- Netherlands Research Integrity Network
  A Dutch network that aims to facilitate collaboration, exchange and mutual learning between the actors in the field of research integrity
- Retraction Watch
  Popular blog tracking scientific retractions and covering cases of misconduct.

Societal Impact

- Knowledge Transfer Offices (KTOs) and Technology Transfer Offices (TTOs)
  Offices at universities that contact research and innovation stakeholders to valorise research
- National Science Agenda
  Dutch Initiative aiming, among others, to enhance societal relevance of research by inviting the wider public to contribute to research at various stages.
- Standard Evaluation Protocol (SEP)
  Dutch protocol for assessing research and education that includes societal impact criteria

The Scientific System

Policy

- Fostering Responsible Research Practices (BVO)
  Research funding programme in The Netherlands that aims to foster responsible research
- Science in Transition
  Movement to improve the rewarding and societal relevance of research in The Netherlands
- Journal reporting guidelines
  - CONSORT
    Reporting guidelines for randomized controlled trials
  - PRISMA, MARS
    Reporting guidelines for meta-analyses and systematic reviews

Practice

- Society for the Improvement of Psychological Science (SIPS)
  SIPS is a service organization aimed at bringing together scholars working to improve methods and practices in psychological science.

- BITSS
  The Berkeley Initiative for Transparency in the Social Sciences aims to enhance the practices of economists, psychologists, political scientists, and other social scientists in ways that promote research transparency, reproducibility, and openness.
- Implementation ZonMW's BVO
  ZonMw is currently funding several implementation projects that aim to translate findings from the BVO programme into actual interventions that foster responsible research practices.

Training

- Dilemma Game
  Card game on research integrity developed by Erasmus University, inviting players to deliberate on dilemmas and potential ways of dealing with them.
- FOSTER Open Science Portal
  Online portal for training researchers in Open Science practices via courses and webinars
- On Being a Scientist
  Short, professional movie describing several research integrity challenges in context
- Open Science Communities
  Grassroots network of researchers at Dutch universities to teach and support Open Science
- PRINTEGER
  Horizon 2020 project that studied research integrity from an organisational and institutional perspective, among others leading to an online training course UPRIGHT.
- *VIRT2UE*
  Horizon 2020 project that is developing a new blended learning train the trainer programme on Ethics and Research Integrity (ERI) to form new trainers and give them tools to internalize, apply and uphold the principles of the European Code of conduct for Research Integrity

Evaluation

- Declaration on Research Assessment (DORA)
  Global guidelines for improving the assessment of research and evaluation of researchers
- Leiden Manifesto for Research Metrics
  10 principles to improve the measurement of research performance from Leiden University

Rewards

- Open science badges
  Effectively, these are small icons printed at the first page of an article to indicate if an article contains open data, materials, and/or is preregistered.
- The Reward Alliance
  Specifically, Cochrane has created the Cochrane-REWARD prize that highlights both underused "remedies" against research waste and the need to invest in research to identify problems and solutions to them.
- New reward structures
  University of Ghent has recently implemented new reward structures for its employees, now rewarding a more diverse set of academic practices, partly decided on by the researchers themselves.

Funding

- NWO Replication Grant
  The Dutch funding agency NWO started a grant specifically meant to fund replication research
- Inclusive funding
  NWO*, VSNU, NFU and ZonMw are currently investigating how novel funding structures can*

be more inclusive. They aim to set up funding scheme's that enables more diverse career tracks, innovates the evaluation mechanisms and fosters team science.

The Empirical Cycle

Meta-analysis

- Publication bias detection/correction methods
  - P-curve
  - P-uniform

Replication

- NWO Replication Grant
  The Dutch funding agency NWO started a grant specifically meant to fund replication research.
- Collaborative Replications and Education Project (CREP)
  This is a replication project where students are encouraged to conduct replications as part of their courses.
- Replications through multi-lab collaborations
  - Reproducibility Project: Psychology
    Collaborative effort to document the replicability of studies in psychology.
  - Reproducibility Project: Cancer Biology
    Collaborative effort to document the replicability of studies in cancer biology.
  - Many Labs
    A series of collaborative efforts to replicate sets of psychological experiments. See e.g., Many Labs 2.
  - Registered Replication Reports
    Pregistered, multi-lab replication studies. This is a subset of the Registered Reports format.
  - Psychological Science Accelerator
    A globally distributed network of psychological science laboratories that coordinates data collection for democratically selected studies.
- The "Pottery Barn Rule" in the journal *Royal Society Open Science*
  This is the guarantee to publish any close replication of any study previously published in the same journal.
- KNAW report "Improving Reproducibility in the Empirical Sciences"
  Report analyzing causes for non-replication and offering recommendations for improving reproducibility and conducting replication studies.

Peer review

- RetractionWatch
  Popular blog tracking scientific retractions and covering cases of misconduct.
- PubPeer
  Online platform for post-publication peer review.
- Registered Reports
  Publication format where peer review takes place before data are collected and articles are accepted regardless of the results.
- Exploratory Reports
  Publication format specifically meant for exploratory research (as opposed to confirmatory, hypothesis-testing research)

- Open peer review
  Peer reviews are published alongside the article. See e.g., the journal Royal Society Open Science.
- Peer Reviewers' Openness (PRO) Initiative
  Signatories of this initiative only accept review invitations if the manuscript adheres to open practices or states why it does not.
- Peer Community
  A platform for peer reviewing and publishing preprints.

Publication systems

- F1000 research
  F1000Research is an Open Research publishing platform for life scientists
- Publons
  Platform that allows researchers to track publications, citation metrics, peer reviews and journal editing work.
- Journal of Open Psychology Data
  The Journal of Open Psychology Data (JOPD) features peer reviewed data papers describing psychology datasets with high reuse potential.

Preprints

- Preprint servers
  Online archives to publish manuscript versions that have not undergone peer review yet. Preprint servers are also often used to publish post-prints: the non-edited version of a published paper. Examples are:
  - *ArXiv*
  - *PsyArXiv*
  - *BioArXiv*
  - *For a more complete list, see https://osf.io/preprints/*
- Peer Community
  A platform for peer reviewing and publishing preprints.

Open Access

- Plan S
  Initiative by a coalition of research funders and charities to open up research publications
- Dutch Open Access Deals
  Agreements between Dutch university libraries and scholarly publishers for Open Access

Preregistration

- AsPredicted
  A website to generate and publish standardized preregistrations
- Open Science Framework
  A platform that allows sharing all steps and products of the research process and publicly preregistering research plans.
- Registered Reports
  Publication format where peer review takes place before data are collected and articles are accepted regardless of the results.
- Registered Replication Reports
  Pregistered, multi-lab replication studies. This is a subset of the Registered Reports format.

Multi-lab collaborations

- Reproducibility Project: Psychology
  Collaborative effort to document the replicability of studies in psychology.

- Reproducibility Project: Cancer Biology
  Collaborative effort to document the replicability of studies in cancer biology.
- Many Labs
- *A series of collaborative efforts to replicate sets of psychological experiments. See e.g., Many Labs 2.*
- Study Swap
  Platform to exchange resources (such as lab-time) between labs across the world.
- Registered Replication Reports
  Pregistered, multi-lab replication studies. This is a subset of the Registered Reports format.
- Psychological Science Accelerator
  A globally distributed network of psychological science laboratories that coordinates data collection for democratically selected studies.

Data sharing

- Journal of Open Psychology Data
  The Journal of Open Psychology Data (JOPD) features peer reviewed data papers describing psychology datasets with high reuse potential.
- Data management; DMPonline
- Open Science Framework
  A platform that allows sharing all steps and products of the research process and publicly preregistering research plans.
- GO Fair
  Initiative that aims to implement the FAIR principles: making data Findable, Accessible, Interoperable, and Reusable
- figshare
  figshare helps academic institutions store, share and manage all of their research outputs
- The Dataverse Project
  Open source research data repository software
- Transparency and Openness Promotion (TOP) guidelines
  Eight transparency standards of which journals can indicate a level of implementation
- Open Sciences badges
  In remains uncertain if this approach works and is effective (link & link). Research is inconclusive, but interesting to follow *up.*

Reproducible workflows

- Open Science Framework
  A platform that allows sharing all steps and products of the research process and publicly preregistering research plans.
- Jupyter Notebook
  "The Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations and narrative text."
- R Markdown
  R Markdown is a file format that allows the user to create dynamic documents in which narrative text and code are interweaved. This format greatly increases (analytical) reproducibility.
- Code Ocean
  Code Ocean is an online platform where users can develop and share code through a web browser in a fully reproducible environment.
- Journals who check computational reproducibility of submitted papers
  For a list, see https://osf.io/kgnva/wiki/home/
- Journal reporting guidelines

    - CONSORT
      Reporting guidelines for randomized controlled trials
    - PRISMA, MARS
      Reporting guidelines for meta-analyses and systematic reviews
    - *EQUATOR Network*
      Library of reporting guidance

Statistical innovations

- JASP; jamovi
  Free, statistical software that allows for both frequentist and Bayesian analysis
- Statcheck, GRIM, GRIMMER, GRIMMEST, SPRITE
  Free software to check for statistical inconsistencies in papers, without needing access to raw data
- Journal guidelines on improved statistical inference
  E.g., the new statistical guidelines for journals of the Psychonomic Society - METRICS Institute (link)
- Free online statistics courses (MOOCs)
  E.g., the Coursera course "Improving your statistical inference"
- Myth of NHST
  Dutch research project investigating researchers' views on the use of NHST or alternative methods and what they see as the advantages and disadvantages of these methods.
- Publication bias detection/correction methods
    - P-curve
    - P-uniform

Retractions

- RetractionWatch
  Popular blog tracking scientific retractions and covering cases of misconduct.

Appendix II: Full list of ranked themes that we have indicated as gaps of knowledge by the authors of the position paper (n=4)

List of themes that are currently underrepresented in our topic list (in ranked order n=4):
1. Responsible assessment of researchers 2. Research on responsible mentoring, supervision and role modeling 3. The influence of Open Science/Transparency 4. Effect of education/training of Responsible Research Practices 5. Responsible and fair peer Review 6. The influence and implementation of preregistrations 7. Checking of reproducibility 8. Responsible funding 9. Monitoring of the research process 10. Consequences of power and hierarchy structures 11. Publication bias 12. Responsible reporting of research 13. Consequences of research misconduct 14. Statistical inference and analysis 15. Credit and authorship issues 16. Performing replication studies 17. The influence of diversity-issues on responsible research 18. The use of theories for methodology