The Grassroots Path of Open Science Practice: Taking Psychology and Brain Science as Examples

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Abstract

开放科学能实现科学资源的有效共享和充分利用，重塑科研实践与文化，但其发展仍处于初生阶段。文章以心理与脑科学为例，阐述该领域从增强本研究的可信度和科学性出发，自发地开启了开放科学的草根运动，推动本领域科研全过程的开放科学实践，并引领跨学科的开放科学行动和文化塑造。文章还分析了心理与脑科学开放科学实践蓬勃发展的原因，为我国进一步推动开放科学发展提供建议。

Full Text

The Grassroots Path of Open Science Practice: Taking Psychology and Brain Science as Examples

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Abstract: Open science can enable the effective sharing and full use of scientific resources and reshape research practice and culture, but its development remains at an early stage. Taking psychology and brain science as examples, this article describes how, starting from the goal of enhancing the credibility and scientific rigor of research, this field has spontaneously launched a grassroots movement for open science, promoted open-science practices throughout the entire research process in the field, and led open-science actions and cultural construction across disciplines. The article also analyzes the reasons for

the vigorous development of open-science practices in psychology and brain science, and offers recommendations for further advancing the development of open science in China.

Keywords: open science; grassroots path; psychological science; brain science

Open science is a series of principles, concepts, and practices aimed at increasing the transparency of science, including preregistration, sharing of data and research materials, and open access[1]. Open science is not only producing a fundamental transformation in the norms of scientific research, but is also reshaping the concepts and tools of global science-and-technology governance, and has been actively advocated by the United Nations Educational, Scientific and Cultural Organization (UNESCO)[2]. Although countries around the world are currently paying increasing attention to the governance of open science, overall, open science is still in its infancy; its models, order, and other aspects still need to be explored and improved. In particular, how researchers in basic research fields can adopt open-science practices throughout the entire research process remains an urgent question to be explored.

Over the past decade, transparency and openness across the entire research process in psychology and brain science have progressed rapidly, with many innovations in research methods, research systems, and culture (see Figure 1). For example, the publication format of Registered Reports has been proposed[3]; papers have been published in *Science* and *Nature* and have generated broad influence[4-5]. These innovations have not only promoted self-reform within this disciplinary field, but have also gradually been adopted and improved by other fields, facilitating the formation of an open cultural ecosystem across multiple disciplines.

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Legend: Green—methodological reform; purple—institutional innovation; blue—cultural shaping.

Year	Event
1979	Rosenthal proposed the "file-drawer problem."
1999	fMRIDC was established.
2008	FCP was launched.
Around 2010	Psychology experienced a "replication crisis."
2012	OSF was released; Chambers promoted RR.
2013	OHBM adopted Brainhack.
2013	COS was launched.

Year	Event
2013	CREP was created.
2015	The TOP Guidelines were released.
2015	The Open Science Collaboration published in *Science*.
2016	The Montreal Neurological Institute adopted open science institution-wide.
2016	The University of Munich became the first to include open science in hiring requirements.
2016	PsyArXiv was launched.
2020	*eLife* introduced reviewed preprints.
2020	TOP Factor was released.
2021	PCI-RR appeared; the United Nations released the *Recommendation on Open Science*.
2023	*Nature* accepted RR.
2024	An international open-science cooperation initiative was launched.

Figure 1. The grassroots pathway of open science in psychology and brain science

The figure presents representative events in different stages of development; the meanings of the abbreviations in the figure are given in note .

Admittedly, the development of open science in psychology and brain science has depended on strong support from governments and other institutions, as well as on the continuous improvement of the scientific research environment. Yet its most distinctive feature is the grassroots pathway through which front-line researchers have actively driven change. Therefore, this article systematically reviews and summarizes the grassroots pathway of open science in psychology and brain science, traces the reasons for its development, and aims to provide a reference for the development of open science in China.

1 The Grassroots Pathway in Psychology and Brain Science

With the goal of enhancing the credibility and scientific rigor of research findings, psychology and brain science have formed an open-science pathway that proceeds from "methodological reform" to "institutional innovation" and then to "cultural shaping" (Figure 2). Along this pathway, researchers have consistently treated the pursuit of research credibility and scientific rigor as their foremost priority, continually promoting openness and transparency throughout the entire research process. As open-science practices have continued to innovate and expand, this movement has extended into research systems and policies

within the discipline and has gradually joined forces with other disciplines and open-science stakeholders, together shaping a broader open-science culture.

fMRIDC: Functional Magnetic Resonance Imaging Data Center; **FCP:** 1000 Functional Connectomes Project; **OSF:** Open Science Framework; **RR:** Registered Reports; **OHBM:** Organization for Human Brain Mapping; **COS:** Center of Open Science; **CREP:** Collaborative Replication and Education Project; **SORTEE:** the Society for Open, Reliable, and Transparent Ecology and Evolutionary Biology; **CoRR:** Consortium for Reliability and Reproducibility.

Figure text: Pursuit of the scientific spirit; method reform; institutional innovation; cultural shaping; openness and transparency at the publication end; open data, materials, and code; embrace new statistical methods; promote registered reports; early reflection; new forms of open-science conferences; open-science education and training; team science; open-science evaluation system; multidisciplinary construction of open-science communities; all parties actively embrace open-science standards; diversified collaborative innovation in open-science practice.

Figure 2. Grassroots pathways for open science in psychology and brain science

1.1 Reform of Methods

Psychology and brain science have long reflected on the credibility and scientificity of research findings in their fields. Around 2010, after the reproducibility crisis broke out, these reflections and new research evidence gradually led researchers to form a consensus: research methods and practices such as questionable research practices, publication bias, and overreliance on null-hypothesis testing are important causes of the reproducibility crisis[^6]. Researchers began to approach the issue from the perspective of the entire research process, proposing various methodological and practical innovations to enhance openness and transparency throughout the research process, thereby improving the credibility and scientificity of research findings.

1.1.1 Early Reflections in Psychology and Brain Science

Open-science practices in psychology and brain science originated from concern over the credibility and scientificity of research. As early as the 1960s and 1970s, researchers had already paid attention to the reproducibility and scientificity of the field, including reflections on the limitations of the file-drawer problem[^7], statistical power[^8], and null-hypothesis significance testing[^9]. At the beginning of this century, researchers in the field also discussed the significance of reproducibility[^{10}] and open data[^{11}].

However, these early reflections and discussions did not change mainstream scientific practice. It was not until around 2010 that a series of replication failures and fraud incidents in psychology, widely disseminated and debated after being

reported on social media, prompted researchers to seek collaboration through social media in order to evaluate and reflect on the state of reproducibility in psychological science[^{12}]. The "Reproducibility Project: Psychology"(RPP), published in *Science* in 2015, marked the peak of researchers' attention to the issue of replication[^{13}].

1.1.2 Promoting Registered Reports and Embracing New Statistical Methods

Registered reports refer to preregistrations that undergo peer review before data collection[3]. This publication format was proposed in 2012 by cognitive neuroscientist Chambers and was first piloted in *Cortex*. At present, more than 300 journals, including *Nature*, have adopted registered reports as a format for journal submissions[14]. Methodological reform also includes embracing new statistical methods, using Bayesian statistical methods, using effect sizes and their confidence intervals, and other practices to reduce overreliance on p values, as well as emphasizing statistical power to enhance the robustness of results[6,15].

1.1.3 Open data, materials, and code to enhance computational reproducibility

Open data have been particularly prominent in brain science. Initiatives have appeared successively, including the 1000 Functional Connectomes Project (FCP), the International Neuroimaging Data-sharing Initiative (INDI), the Consortium for Reliability and Reproducibility (CoRR), the Chinese Color Nest Project (CCNP), and the Chinese Color Nest Data Community (CCNDC, https://ccndc.scidb.cn), which developed on this basis. In psychological science, researchers represented by Nosek have vigorously promoted the development and improvement of infrastructure—the Open Science Framework (OSF, https://osf.io/)—as well as PsyArXiv, a preprint platform jointly created by the Center of Open Science (COS) and the Society for the Improvement of Psychological Science (SIPS), thereby ensuring the sustainable growth of open data and digital materials. At the same time, with respect to the use of open code and open-source software, researchers have devoted considerable effort to sustaining the continual development of open-source research software and tools in the field, greatly improving the efficiency and reproducibility of data analysis in psychology and brain science[16].

1.1.4 Strengthening openness and transparency on the publication side

Senior researchers have issued policies and initiatives through academic institutions such as journals and scholarly societies, thereby deepening methodological reform from the publication side. For example, the *Transparency and Openness Promotion Guidelines*[4] and the *Suzhou Initiative for Open Science in Psychology* have promoted the development of an open research culture; the field' s top journal *Psychological Science* introduced open science badges[17]; and in China,

Acta Psychologica Sinica, *Advances in Psychological Science*, and *Psychological Science* have successively implemented open peer-review comments. At the same time, a number of new journals dedicated to advancing open science practices have been founded one after another, including *The Journal of Open Psychology Data*, *Advances in Methods and Practices in Psychological Science*, *Collabra: Psychology*, and *Imaging Neuroscience*. The emphasis on openness and transparency on the publication side, by using journal policies to compel researchers to maintain openness and transparency throughout the entire research process, has put methodological and practical reforms into effect and has also encouraged researchers to reflect on innovations at the institutional level.

1.2 Institutional Innovation

Openness and transparency throughout the entire research process require institutional arrangements that can provide guarantees for sustainable development. Within the scope of what is feasible, researchers in psychology and brain science have pursued institutional innovation, including new forms of conferences, education and training, modes of collaboration, and evaluation systems. These new institutions have further disseminated and strengthened open-science practices.

1.2.1 New Conference Formats and Education and Training

Researchers have continually attempted to develop new types of conferences and educational training to compensate for the insufficient coverage of open-science practices in traditional school-based education systems, and, through these efforts, to promote open science and cultivate new talent. In terms of conference formats, Brainhack—an adaptation by brain-science researchers of the traditional computer hackathon format—has become an important form for advancing open practices in brain science[^{18}]. Similarly, the Chinese Open Science Network (COSN) also uses an adapted hackathon format as a platform for training in and exchanging ideas about open practices[^{19}].

Researchers have also actively promoted open-science concepts and practices through education and training. In 2013, Grahe, Brandt, and IJzerman founded the Collaborative Replication and Education Project (CREP), with the aim of teaching students good scientific practice by guiding them to use open-science methods to directly replicate highly cited studies in the field . Similar projects include the Framework for Open and Reproducible Research Training (FORRT) and the Collaborative Open-science and meta Research (CORE) team .

1.2.2 New Modes of Collaboration

Big-team science has become an excellent venue for assessing reproducibility and promoting open science. In psychology and brain science, a number of big-team science projects have emerged, such as the Many Labs Project, ManyBabies, the Psychological Science Accelerator (PSA), the Reproducibility Project: Psychology, and the International Consortium for Brain Mapping of Functional

Connectivity, among others[^{20}-21].

Big-team science projects have also brought new experiments in authorship attribution. Participants in the Reproducibility Project: Psychology published their research findings under the collective name Open Science Collaboration[^{13}]. The PSA Self-Determination Theory Collaboration, by contrast, lists all authors in an appendix, in order to avoid the possibility that collective authorship would disadvantage researchers from underrepresented regions in their local research-evaluation syste-

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Official website of the Collaborative Replication and Education Project: http://www.crep-psych.org/

Official website of the Framework for Open and Reproducible Research Training: https://forrt.org/

For more information on CORE, see https://mgto.org/core-team/

is at a disadvantage [22]. ManyBabies, on the basis of CRediT, ranks authors other than the project leads and major contributors alphabetically or in reverse alphabetical order, thereby reducing disputes caused by author-order sequencing [23].

1.2.3 Reforming Evaluation Systems

An evaluation system that traditionally overemphasizes quantitative indicators such as the number of papers and impact factors is a fundamental reason why, in open science practice, conflicts arise between individual interests and the public interests of the scientific community: if researchers devote substantial time to improving the rigor and openness of their research process, they may be at a disadvantage in terms of the number of papers they publish. Therefore, how to incorporate contributions related to open science into evaluation systems so as to motivate researchers to explore and adopt open science practices has become a focal issue.

On the basis of the TOP Guidelines, the Center for Open Science in the United States introduced the TOP Factor (Transparency and Openness Promotion factor, TOP factor) to assess journal quality and to serve as a quantitative indicator of journals' level of open science practice. At the same time, the establishment of numerous open science awards has provided researchers with material and reputational incentives, enhanced researchers' confidence in engaging in open science practices, and promoted the wider occurrence of open science practices.

Academic institutions are also gradually incorporating open science into position recruitment, promotion, and workflows. The Department of Psychology at the University of Munich in Germany requires job applicants to describe their personal open science practices and contributions. The Montreal Neurological Institute goes further, requiring the entire institution to adopt an open science

model and becoming the first academic institution in the world to adopt open science institution-wide [24].

1.3 Cultural Shaping

The efforts of grassroots researchers in psychology and brain science have gradually influenced the development of open science communities in other fields; these developments involve the building of open science communities as well as the active embrace and innovation of open science practices.

1.3.1 Building Multidisciplinary Open Science Communities

Grassroots organizations in psychological science—the Society for the Improvement of Psychological Science and ReproducibiliTea—have attracted researchers from around the world [19]. Other comprehensive and discipline-specific open science communities have also gradually increased, such as the UK Reproducibility Network (UKRN), the Society for Open, Reliable, and Transparent Ecology and Evolutionary Biology (the Society for Open, Reliable, and Transparent Ecology and

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To better promote the TOP Guidelines, COS has stopped adding or updating the TOP Factor since March 16, 2026, and its interactive website TOPFactor.org has also been closed. For details, see: https://www.cos.io/blog/sunsetting-topfactor.org-whats-changing-and-why

These awards include: multiple open science awards established by the Montreal Neurological Institute; the Open Science Award and Replication Award offered by the Organization for Human Brain Mapping; the Leamer-Rosenthal Prizes established by the John Templeton Foundation; the annual Open Science Innovation Award created by the Max Planck Institute for Human Development; and others.

Information source: https://legacy.nicebread.de/open-science-hiring-practices/

Evolutionary Biology, SORTEE), and the Association for Interdisciplinary Metaresearch and Open Science (AIMOS), among others.

1.3.2 Multiple stakeholders embracing and innovating open-science practices

Many disciplines have actively embraced open-science practices in psychology and brain science. The TOP Guidelines already have more than 5,000 signatories , and the TOP Factor website shows that more than 2,400 journals or organizations meet at least one of its open standards . Researchers in psychology and brain science, together with researchers in other fields, have innovated open-science practices. In 2021, PCI (Peer Community In), created by researchers in

fields such as genetics and ecology, innovated the Registered Reports model by proposing a "Peer Community In Registered Reports" (PCI-RR). This means that Registered Reports are no longer confined to any particular journal: instead, PCI conducts the review, and once a manuscript receives a recommendation, it can be submitted directly to a PCI-friendly journal for acceptance, greatly increasing authors' freedom [3]. *eLife* abolished the decision to reject or accept a paper after peer review, and has continuously innovated and improved the scientific publishing model, increasing attention to research quality [25]. Around the same period, platforms such as Review Commons and EMBO Press continued to promote the transition from preprints to reviewed preprints. The collective efforts of publishing groups and open platforms have improved or refined publishing efficiency, preprint quality, and evaluation systems [26].

2 Reasons for the flourishing development of open science in psychology and brain science

2.1 The pursuit of scientific rigor

Researchers' rigorous pursuit of scientificity in their fields is the core driving force behind the integration of open-science culture into the entire research process in psychology and brain science. In psychological science, researchers have taken the effort to address the field' s reproducibility crisis as their starting point, engaging in sustained and in-depth reflection on multiple aspects such as measurement [27], theory [28], and generalizability [29], thereby clarifying the important value of transparency and openness throughout the whole research process. In brain science, researchers have taken data sharing as their starting point, promoted the standardization of data formats such as BIDS (Brain Imaging Data Structure) [30] and data-preprocessing workflows such as fMRIPrep [31], and continuously explored issues such as the "dead salmon"[32] and the real variability present in data analysis [33], thereby continually advancing openness and transparency across the entire research process.

2.2 The impetus of grassroots peer communities

Grassroots peer communities in open science play a key role. In the field of psychology, the creation and sustained development of the U.S. Center for Open Science directly promoted the development of open-science communities around the world and the establishment of formal research centers and societies. First, the Center for Open Science relies on the COS ambassadors program to promote the Open Science Framework and related policies of the Center for Open Science. Second, re[[unclear: text continues on next page]]

Data from the official website of the Center for Open Science: https://www.cos.io/initiatives/top-guidelines

Data from the TOP Factor dataset: https://osf.io/kgnva/files/qatkz

Researchers' spontaneous establishment of local open-science communities has

promoted the localization and dissemination of open-science practices. For example, the Chinese Open Science Community was recognized by UNESCO as a typical case of Chinese young scholars promoting open science, and it has been invited by international journals and conferences to give introductions, thereby enhancing the influence of Chinese researchers in international open science[^{19}]. The ReproducibiTea journal club initiated by doctoral students at the University of Cambridge was introduced by *Nature* and has developed global influence[^5]. In the field of brain science, researchers involved in the International Thousand Functional Connectomes Project developed multiple grassroots organizations to advance the sharing and standardization of human brain neuroimaging data[^{21}]. The Organization for Human Brain Mapping also established an open-science special interest group and incorporated Brainhack as one of its official activities, greatly promoting open-science practices in brain imaging[^{18}]. Finally, researchers from developing countries and regions have begun to participate actively in the construction of open science. Examples include an open-science guide written through South–South collaboration[^{16}], and a global declaration on diverse, equitable, and inclusive open science jointly issued by researchers from the Global South and North[^{34}].

2.3 Development of Networked Information Technology

The development of networked information technology has provided strong technical support for open science. Earlier attention to and reflection on issues such as the file-drawer problem, statistical power, null-hypothesis significance testing, reproducibility, and open data indicate that researchers in psychology and brain science had become aware of problems in the research process. However, these early reflections and efforts gained collective attention and action only after social media became widespread[^{12}]. Equally important is that open infrastructures built on modern networked information technology, such as OSF, have made large-scale replication studies and various open-science practices possible.

2.4 Top-Down Support

Top-down support has also provided a favorable environment and resource guarantees for the development of open-science practices. Open science is an important lever for promoting the achievement of the United Nations Sustainable Development Goals, and countries have embraced open science in pursuit of these goals. Related policies, laws and regulations, and funding systems have also been continuously improved. In terms of timing, the open-science movement in psychology and brain science coincided with UNESCO' s and national governments' growing emphasis on open science, and thus received relatively broad support.

2.5 Relatively Limited Involvement of Commercial Interests

Relatively limited involvement of commercial interests is also an important reason for the development of open-science practices in psychology and brain science. As fields of basic research, most research findings in psychology and brain science aim to explore knowledge about human beings themselves, and are not especially prominent in terms of commercial applications or interests. By contrast, in the biomedical field, reliable pathways are still being explored in the process of promoting research toward openness, transparency, and reproducibility. For example, the Center for Open Science and *eLife* once organized a similar replication project, but it did not meet the initiators' expectations[^{35}].

3 Implications for the Development of Open Science in China

China' s scientific community is actively promoting the development of open science, and is striving, together with other developing countries, to lead the international development of open science so that the benefits of open scientific development reach more countries and populations. The vigorous development of grassroots pathways to open science in psychology and brain science can offer several implications for the development of open science in China. Specifically, the following aspects may serve as points of reference.

3.1 Emphasizing the Intrinsic Consistency Between Open Science and the Scientific Spirit

A steadfast pursuit of the scientific spirit has prompted continual innovation in research practices across many disciplines, including psychology and brain science. Registered reports, human brain imaging data-sharing initiatives, the pioneering digital open-access platform arXiv, and the "Polymath Project"are all attempts made by various disciplines to strengthen scientific development within their respective fields. After receiving positive responses in their own fields, these practices gradually spread to other areas and generated broad influence. At present, scientific research is highly specialized, and frontline researchers in each field are best positioned to understand the opportunities and challenges that open science brings to their own disciplines. Therefore, promoting open-science practices throughout the entire research process in basic research requires emphasizing the intrinsic consistency between open science and the scientific spirit, recognizing the role of open science in advancing scientific development (for example, the reuse of open data reduces repetitive labor, and transparency throughout the research process strengthens the rigor of scientific evaluation), re-examining the value and significance of open science from the perspective of promoting the sound development of basic science in China, fully mobilizing scientists' subjective initiative, and releasing researchers' vitality for open science to the greatest extent possible.

3.2 Supporting the Construction of Diverse Forms of Academic Communities

The construction of academic communities plays a key role in the development of open science in psychology and brain science. At present, China already has multiple forms of open-science communities, such as the Open Science Research Center , the Open Science Promotion Consortium , the Professional Committee on Open Science and Global Partnership, the Suzhou Open Science Research Center, and the Chinese Open Science Community . To further enhance openness and transparency throughout the research process across China' s basic disciplines, it is necessary to continue supporting the construction of diverse forms of open-science communities. Science and technology associations, research-management agencies, research institutions, and academic journals can build platforms for exchange, encourage researchers to establish or join various forms of open-science communities, facilitate dialogue and collaboration among stakeholders and across disciplinary fields, promote consensus on practicing open science throughout the entire research process, and gradually form mechanisms for exchange and mutual learning.

Open Science Research Center: http://os.las.ac.cn/zh-CN
Open Science Promotion Consortium: http://www.ospc.org.cn/
Chinese Open Science Community: https://open-sci.cn/; WeChat public account: OpenScience

3.3 Make Full Use of Existing Open Science Infrastructure

The development of open science infrastructure provides strong technical support for the sustainable development of open science in psychology and brain science. As with psychology and brain science, over the past two decades of open science development in China, relevant infrastructure has developed in a relatively dispersed manner within many basic disciplines. In the future, promoting open science practices throughout the entire research process will require connecting, to the greatest extent possible, China' s existing open science infrastructure and improving its utilization. At the design stage before research implementation, existing registration models—such as those of the Chinese Clinical Trial Registry and the ZhiJian Psychology preregistration platform—can be used as references to encourage fields across the natural sciences to explore research preregistration appropriate to their own disciplines. With respect to the sharing of research materials and data, on the basis of data centers such as Science Data Bank and the National Basic Science Data Center, continued investment should be made to form federated open data platforms spanning the central and local levels, disciplines, and industries; platform integration should be promoted to ensure the smooth sharing and cross-application of data and materials. On the publication side, various disciplines should be encouraged to co-develop discipline-specific preprint platforms with existing preprint platforms —such as the Chinese Academy of Sciences preprint platform for scientific and technical papers, the preprint platform for philosophy and social sciences, and

the national preprint platform—so as to gradually realize an operating model in which domestically published Chinese-language journals and foreign-language journals founded in China achieve global open access.

3.4 Strive to Play a Leading Role in the International Development of Open Science

Under the current international situation, the United States, a traditional powerhouse in scientific research, has begun to build "small yards with high fences," and the global progress of open science has consequently been hindered. In response, China has successively issued the *Initiative for Sharing and Collaboration in Open Science Infrastructure*, the *Xiangshan Initiative on Implementing Open Science*, the *Initiative on International Cooperation in Open Science*, and the *Outline of the Plan for Building China into a Leading Country in Education (2024-2035)*, demonstrating China' s potential in open science. China should improve the top-level design of open science as soon as possible, promote the formation of open science consensus across basic disciplines, and create an open science culture with Chinese characteristics. At the same time, using the "Belt and Road"Science, Technology and Innovation Cooperation Action Plan and the "Science and Technology Partnership Program" as vehicles, China should launch the "Digital Zheng He Program"[36], establish a National Open Science Fund [37], focus on frontier fields such as artificial intelligence and biotechnology as well as major global challenges such as climate change and energy, strengthen ties with countries around the world, and, drawing on the resulting advantages of open science organizations and resources that are transnational, cross-organizational, and interdisciplinary, propose supporting standards and plans for integrating open science into the entire research process in China, striving to play a leading role in the development of international open science.

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Grassroots Pathways in Open Science Practice: Lessons from Psychology science and Brain Science

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Abstract Open science enables the effective sharing and full utilization of scientific resources, reshapes research practice and academic culture, while its overall development remains in an initial stage. Taking psychology science and brain science as examples, this paper examines the grassroots open science movement initiated to enhance research credibility and scientific rigor. Such efforts promote open science practices throughout the entire research workflow, and led interdisciplinary open science actions and cultural construction. The paper further analyzes the driving factors behind the thriving open science in this field and provides suggestions for the development of Chinese open science.

Keywords open science, grassroots pathway, psychology science, brain science

Note: Figure translations are in progress. See original paper for figures.