Open Science Monitor 2020 Utrecht University

Commissioned by the Utrecht University Open Science Programme

Utrecht University

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Contents

Acknowledgement

This is the first version of the OS monitor on awareness, attitudes and behaviours in relation to 10 open science practices. The monitor was conducted among academics at Utrecht University and UMC Utrecht in the summer of 2020 with the aim to gain insight in academics' attitude and behaviours towards various open science practices, the opportunities these practices may provide for the scientific community and the barriers in implementing open science practices the researchers may experience. With this monitor the university hopes to gain insight into what can be done to facilitate and support open science among academics at Utrecht University.

We would like to thank all the UU and UMCU academics who participated in this research during the summer of 2020. Without you, this report would not have been possible. Thanks to you, we can provide first insights in OS attitudes and behaviours at UU and UMCU, the barriers and opportunities academics experience in the transition to open science. These results allow for setting a baseline for OS monitors to follow. We hope that many more UU and UMCU academics will participate in the upcoming OS monitors. Special thanks to the open science platform, the track leaders, Utrecht University Library and Student & Academic Affairs Office and the Ethics committee of the Faculty of Social Sciences for help with preparing and distributing this OS monitor.

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Management summary

This research was commissioned by Utrecht University's Open Science Programme. The goal is to monitor the awareness, attitudes and behaviors regarding 10 open science (OS) practices within the university, and to get insight into obstacles and opportunities for OS implementation. In the table below an overview of the 10 OS practices is provided. The OS monitor was sent out in June 2020 and responses from N = 394 academics at Utrecht University and University Medical Centre Utrecht were obtained, from all faculties, and at all function levels (PhD, post doc, assistant professor and associate/full professor). Note that the response rate is low; due to a challenging Covid-19 year, amongst others, a mere ≈ 7% of the approached population participated in OS monitor 2020. Therefore, the insights reported in this OS monitor cannot be generalized directly to the approached population of academic staff at UU and UMCU. Results should be interpreted as providing a "snap-shot" insight - a first base-rate of OS awareness, attitudes and behaviors amongst UU/UMCU academics who were able and motivated to fill out a survey during busy times at the end of the academic "Covid" year in 2020. A follow up monitor, aiming at a higher response rate, will follow in 2022 to provide more representative data and identify priorities for OS implementation.

Table 1: Overview of OS practices.

10 OS practices		
Reproducibility	**Transparency**	**Collaboration**
• Pre-registration	• Pre-print	• Public engagement
• Open Data	• Open Access publishing	• Research with societal stakeholders
• Open Materials	• Open Code	• Team Science
	• Open Source Software	

The insights from this OS Monitor 2020 provide a valuable springboard to spark discussions about how to move forward with implementation of OS practices at the UU and UMCU. In this management summary the most important findings are highlighted with regards to awareness, attitudes and behaviors towards the 10 OS practices. We also discuss obstacles and opportunities that academics in the sample see as most (or conversely, least) important in order to engage in OS practices. In summarizing results, we offer discussion questions alongside the interpretation of data outcomes to further the dialogue on why, how and for whom different OS practices can be implemented in research.

Most respondents were aware of all 10 OS practices. Surprisingly, team science ranked low

Academics were introduced to all 10 OS practices with a brief description and asked whether they had ever heard from/were aware of the practice (yes/no answer). A vast majority of the sample was aware of all 10 OS practices. Almost all academics were aware of **open access publishing (99%)**, followed by open source software (92%) and open data (90%). Respondents were mostly aware of pre-prints (86%), **public engagement (83%)**, research with societal stakeholders (77%) and open code (73%). Academics were **least aware of pre-registration (61%)**, followed by open materials (64%) and – to our surprise – team science (64%). Over one-third of academics in the sample indicated to never have heard of team science.

As teamwork is now considered the default to the work of academics, and central to recognition and reward standards at UU since 2021 (TRIPLE [2] model, with T for Team Spirit), a discussion of policy actions to raise awareness about team science seems important. Are many academics indeed not taking part in any team science practices? Or are many academics unaware of how they are already (unconsciously) part of team science, yet haven't verbalized it yet as such? (see Chapter 2)

Positive attitudes, yet barriers to OS implementation: There is a structural attitude-behavior gap on all 10 OS practices

Across all OS practices, there is a large discrepancy between academics' generally positive attitudes (that is, how important the OS practice is considered) relative to their behaviors (that is, the concrete application of the OS practice in their work routine). The attitude-behavior gap was largest for OS practices regarding **transparency and reproducibility of data** (e.g., open source software, open code, open materials). What is needed from UU and UMCU to help academics to bring their positive OS attitudes into practice, in terms of time, resources, training and support?

Open access publishing was considered the most important OS practice by academics in the sample and it was also **most applied**; 90% of respondents indicated to have published open access at least once. What are 'good practices' that have contributed to the rapid and successful adoption of open access publishing among a large proportion of academics in this sample? How can we translate lessons learned to other OS practices, which are considered less important? **Pre-registration and pre-prints** were considered the least important OS practices by academics in the sample and were also **least applied**; 70% and 54% of the participants, respectively, indicated to *have never applied* this practice in their research. Why are these two OS practices less applied by UU and UMCU employees, and how should we move forward?

In the data we observe that over half of the respondents (53%) indicates to **have never or rarely shared data**. The UU Open Science Programme, National Programme Open Science (NPOS) and the European Commission state that data should be 'As open as possible, as closed as necessary'. What are the researchers' considerations in the process of deciding whether or not to open up their data?

Finally, the OS practices that show the largest attitude-behavior gaps differ across faculties. What **tailor-made OS policies, programmes and practices per faculty** should be in place to address employees' needs? (See Chapter 3)

OS practices for whom? PhD candidates and women report the most and the largest OS attitude-behavior gaps

On 9 out of 10 OS practices, PhD candidates in the sample reported a significantly larger attitude-behavior gap compared to academics at higher function levels. While PhD candidates were generally equally positive about OS practices, their reported application into daily research practice was often lower compared to academics at higher function levels. What is the cause of this lack of access to, and/or application of OS practices in research routines among this group of junior academics? How are OS practices embedded in educational programs, reward structures and performance assessments of PhD candidates?

Senior academic staff members (Associate and Full Professors) reported to engage most in **collaborative OS practices** (and perceived them as most important). By contrast, academics with a vulnerable research position (i.e., temporary contract, PhD candidate), were less positive about **team science** compared to the senior, tenured staff. Is it a desirable situation that junior staff members seem less likely to take on collaborative OS practices? And why is this the case? How can collaborative OS be better integrated in the workflow and reward structures of early-career academics holding temporary contracts?

For 6 out of 10 OS practices, women academics in the sample reported a significantly larger attitude-behavior gap. While women academics' attitudes towards OS practices on **data reproducibility and transparency**, were similarly

[2] www.uu.nl/sites/default/files/UU-Recognition-and-Rewards-Vision.pdf

positive compared to men's, women reported their application in daily research practice as significantly lower compared to men's. Indeed, gender differences exist with regards to women's contributions and access to open code and open source software development. With respect to nationality, while non-Dutch academics reported positive attitudes towards OS practices, the data showed a higher attitude-behavior gap relative to Dutch academics on open source software and research with societal stakeholders.

We conclude that while group differences in OS attitudes and behaviors are generally small in this dataset, they are – in some cases – structural. In light of future OS monitors, we need to investigate whether these outcomes signal that for vulnerable groups of academics at UU, equal access to and/or involvement in the transition towards more reproducible, transparent and collaborative science is not always guaranteed, or whether such gaps are closing. Importantly, how can we ensure that OS equals inclusive science? (See Chapter 3)

The perceived promises and pitfalls of OS practices according to different groups of academics

In the table below, opportunities and barriers to OS practices as measured in the survey are displayed. (See Chapter 4)

Table 1.1: Opportunities and Barriers to OS practices measured in the survey.

Engaging in open science practices has the *opportunity* to…	**An important *obstacle* that would prevent me from engaging in open science practices is that…**
… improve the quality of scientific knowledge	… my workload is too high to integrate these practices
… detect unethical behavior in research practices	… there is insufficient practical support and training available in my department about this
… increase societal impact	… I do not get time within my contract hours to do / learn this
… improve fairness in reward and promotion systems in academia	… it is not the norm to do this in my department (my colleagues don't do it)
… improve diversity and inclusion in academia	… I do not get recognition from my supervisor for this
… create more career opportunities for young academics	… my research does not allow for it due to embargos and patent issues
	… I would lose autonomy and freedom in how I do my research

In general, academics in the sample responded with stronger agreement to the opportunities of OS relative to the obstacles; **perceived promises of OS seem to outweigh the pitfalls**. There was a clear top and bottom 3 in perceived opportunities of OS; academics in the sample strongly agreed that OS can (1) improve quality of science, (2) increase social impact and (3) help to detect unethical research practices; most respondents (>70%) strongly agreed with all 3 statements. By contrast, over half of respondents (>54%) were skeptical towards the promise of OS for improving (1) fairness in rewards and promotion, (2) diversity and inclusion, and (3) career opportunities for young academics. In general, women were more positive about all potential opportunities of OS compared to men. Early career academics in the sample (PhD/Post Doc) were more optimistic about OS's promise to improve fairness in rewards, promotions and career opportunities relative to senior staff (Assistant/Associate/Full Prof.). Yet it is the senior staff who hold the positions of power and decision-making to help fulfil this promise. What is needed to improve this situation?

The most important obstacles to engagement in OS were the **high (extra) workload** and **the insufficient practical support and training from the department** (directly followed by a **lack of formal contract time** allocated to the extra effort that OS research requires). Relatively few academics in the sample indicated that loss of autonomy/freedom, or embargo/patent issues in their research prevented them from engaging in OS (<14%). There were also differences in reported barriers across groups of academics. We highlight a few below.

Assistant professors reported a **lack of time** within contract hours to learn or apply OS practices and a **lack of recognition** from the supervisor as the most significant barriers to engage in OS. How can we create time within contract hours for assistant professors to work in an OS way, and recognize this?

Similarly, academics with a **fixed-term (i.e. temporary) contract report lack of formal contract time** to be a stronger barrier to engage in OS compared to academics in the sample with a permanent contract.

Finally, **women** report **lack of support from their supervisor** as a stronger barrier to engage in OS compared to men. Why is this the case? What should supervisors and leaders at UU and UMCU do to ensure that women and men academics feel equally supported to transition to OS research practices?

We conclude that the academics in this sample are generally hopeful with regards to the promises of OS for the future of academic research. Yet we also see that they report OS to be a lot of (extra) work, which is not always recognized by supervisors, and does not always fit those with already busy schedules, or those with limited contract time. To close the "promise – practice" gap, we should focus on how we better connect and tailor the current OS support systems at UU/UMCU to the needs of academics in order to make OS work in concrete practice. And help departments and supervisors with what they can do to broaden the scope of opportunities for especially early and mid-level career academics to implement OS in their daily work.

Introduction

Why an open science Monitor?

In 2018 Utrecht University presented a comprehensive open science plan that set ambitious goals for the period 2019-2021, closely followed by the launch of the open science Programme and the start of the open science Programme Team. Open science as being one of the five defining principles of the strategic plan 2021-2025. The open science Programme is assigned with a considerable transition towards more open, transparent and inclusive academic practice. To monitor whether the proposed transition is taking place and to be able to steer the programme accordingly, regular evaluation is explicitly part of the programme. One of the measures to take for this evaluation is the open science monitor. With this monitor insight in the level of awareness of open science practices, the attitudes towards open science and academics' actual engagement in open science Practices is provided. This offers the open science Programme and the Executive Board of the University of Utrecht tools for policy adjustments.

Structure of the open science Monitor

The following structure was created to build the monitor. In chapter 1 an overview of the research set-up and the sample is provided. In chapter 2 we provide insight in the awareness, attitudes, and behaviours towards 10 key open science practices. In chapter 3 we discuss the potential benefits and barriers that academics in this sample see to engaging in open science practices. In chapter 4 we close with a conclusion and discussion of the most important findings.

Chapter 1: Research design & sample

Highlights:

- Approximately 7% of the approached population of academics at UU and UMCU participated.
- The response rate across faculties and function levels varied between 4% and 10%.
- 92% of the sample was involved in empirical research.

Research design & procedure

In the period June/July 2020 a survey was conducted among the academic staff of the UU and the UMCU. Within each faculty, the academic staff was invited to participate in an online questionnaire entitled "open science Survey" built in Qualtrics. The complete survey can be found on the open science website (www.uu.nl/en/research/open-science/reports-articles-and-presentations). This survey was approved by the Ethics Committee of the Faculty of Behavioral and Social Sciences (code: 20-122) and pre-registered on AsPredicted.com (Code: # 41394). Invited academics could click on a study link in the invitation email and were immediately directed to the survey. Upon participation, respondents first agreed to an informed consent, where (amongst others) it was explained that participation was completely voluntary, and respondents were free to stop their participation at any time without giving any reason. It was explained that while some demographic questions would be asked, the protection of potentially personal identifiable data was ensured following the data storage protocol of the UU. At the end of the questionnaire, participants again were given the option to retract their data from further analysis. It took about 15 minutes to complete the questionnaire, respondents did not receive a reward in return for their efforts.

Sample

A total of 517 academics responded to the survey. After applying exclusion criteria[3], N = 394 participants were included for analysis. This is approximately 7% of the approached population. In terms of gender, 48.0% (N = 189) identified as a man, 47.7% (N = 188) as a woman, and 4.3% (N = 17) indicated other/I'd rather not say. The majority of the sample, 71.1%, indicated Dutch nationality (N = 280). Of the non-Dutch academics, 28 different nationalities were represented, of which the majority (N = 82, 73%) came from other EU-countries and the United Kingdom. In terms of employment conditions, 50.5% (N = 199) held a permanent contract, and 48.5% (N = 191) held a temporary contract (N = 4; 1.0% missing). The vast majority (80.2%; N = 316) worked full-time[4] and a minority of 18.8% (N = 74) worked part-time (N = 4, 1.0% missing). Figure 1.1 shows the response rate in percentages (%) per faculty. The absolute number of responses can be found below the bars. The response rate per faculty varied between 4% (Faculty of Medicine) and 10% (Faculty of Behavioral and Social Sciences).

The sample included N = 111 PhD candidates, N = 51 post docs, N = 107 assistant professors and N = 99 associate/full professors (N = 26 missing). Figure 1.2 shows the response rate in percentages (%) per function level. Note that the response rate per function level did not include the Faculty of Medicine, as the number of academics per function level in the approached population at the Faculty of Medicine could not be obtained from their HR system in a way that corresponded with the categorization of function levels as obtained with the survey in the current sample. The response rate per function level varied between 7% (post docs) and 11% (associate/full professors).

[3] We used the following exclusion criteria: (1) participants who did not give informed and active consent to use answers for (scientific) research; (2) participants who fell outside the academic job profile PhD candidate, postdoc, assistant professor, associate professor, full professor, or a combination thereof

[4] Note: a workweek of 36 hours or more is considered full-time according to the "Collective Labour Agreement for Dutch Universities".

The sample consisted of 16% (N = 63) OSCU members [5] and 84% (N = 330) non-OSCU members (N = 1 missing). This means that the proportion of OSCU members in the sample was slightly overrepresented relative to the population, which is perhaps not surprising given their interest in the topic (at the time of the survey, ~5% of the academic staff at UU and UMCU was OSCU member). Moreover, the vast majority of researchers was involved in empirical quantitative or qualitative research (92%; N = 364). We also asked those who indicated to be involved in empirical quantitative or qualitative research whether the data collection process involved human subjects. This was the case for over half of the academics involved in empirical research (57%; N = 208).

Many UU academics did not respond to the survey; only approximately 7% of UU and UMCU academics. Therefore, caution is advised in generalizing the results in this survey to the full population of UU and UMCU academics. Still, all faculties and function categories are represented in the sample, though not representative proportional to the population, the Faculty of Social Sciences is slightly overrepresented.

% RESPONSES PER FACULTY

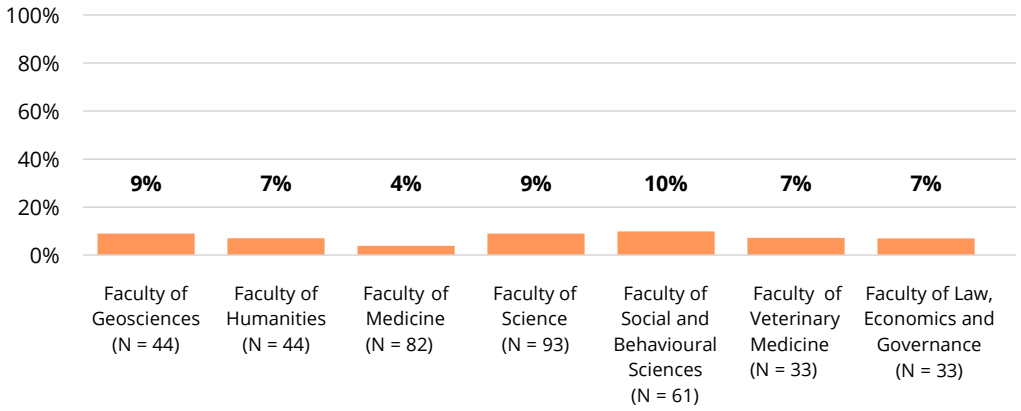


Figure 1.1: % response per faculty. Percentages are calculated by dividing the total number of academics per faculty by the number of respondents per faculty. *Percentage of respondents of the Faculty of Medicine is an estimation, because the survey was sent out using a forwarding email system and no reliable insight in the total of academics in the UMCU. Note: N = 6 academics did not indicate their faculty.

% RESPONSES PER FUNCTION LEVEL (excluding faculty of medicine)

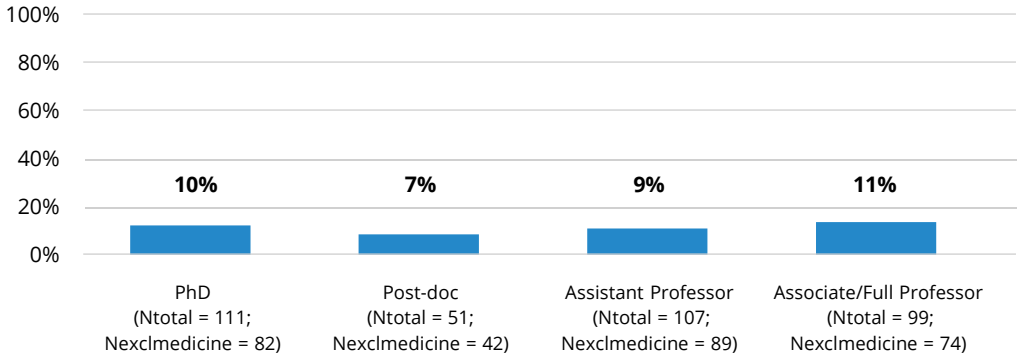


Figure 1.2: % response per function level. Percentages are calculated by dividing the total number of academics per function level by the number of respondents per faculty. *Response rate excludes the Faculty of Medicine, because of the way of administration of academics' function profile at UMCU could not be translated to the categories above. Note: number of respondents with missing values $N_{missingtotal}$ = 26; $N_{missingexclmedicine}$ = 19).

[5] The Open Science Community Utrecht (OSCU) is a grassroots community of UU employees and students with an interest in Open Science. More information at www.openscience-utrecht.com.

Chapter 2: Awareness, Attitudes and Behaviours towards OS practices

Highlights:

- Respondents are highly aware of open access publishing, open source software, open data, and public engagement.
- Respondents are least aware of pre-registration, open materials, and team science.
- Respondents consider open access publishing the most important OS practice; 90% of respondents indicate to have done this themselves at least once
- More than half of the respondents (53%) indicate to rarely or never open their data and 32% indicate that open data is of limited importance, or not at all, for their research.
- Respondents consider pre-registration and pre-prints the least important OS practices; 70% and 54% respectively indicated to have never used this practice themselves.
- Across all 10 OS practices, its perceived importance was higher than the behavioral application: this attitude-behavior gap is largest for OS practices on reproducibility of data (open source software, open code, open materials)

Introduction

In the first part we provide an overview of the general awareness, attitudes and behaviours towards 10 key open science practices. In the second part, we explore the *differences* between academics' attitudes and behaviours towards OS practices (see also Christensen et al., 2019). This sheds light on the question: do and can academics practice what they preach -that is, do their behaviours align with their attitudes towards OS practices?

Step 1: General Awareness, Attitudes and Behaviours regarding OS practices

Awareness of OS practices

A primary purpose of the OS monitor was to measure academics' awareness of 10 open science practices at Utrecht University. A list of 10 open science practices was provided to respondents and each practice was described. Note that in itself, this already served an educational/informative purpose. In Figure 2.1 the OS practices and their description are displayed and the percentage of respondents that had heard of/ was aware of the practice is indicated. A vast majority was aware of all open science practices. In particular, respondents were strongly aware of open access publishing (99%), open source software (92%) and open data (90%). Respondents were relatively less aware of Pre-registration (61%), open materials (64%) and team science (64%), and respondents were mostly aware of pre-prints (86%), open code (73%), public engagement (83%) and research with societal stakeholders (77%). Even though our data indicate that there is still room for improvement in the awareness of practices such as pre-registration, open materials and team science, the vast majority of respondents was aware of all practices.

Attitudes toward OS practices

The second purpose of the OS monitor was to gain insight in academics' **attitudes** towards open science practices. For each of the 10 OS practices, we asked: "How important is this practice for the quality or impact of your research?".

Answer options were: 1 = not at all important; 2 = of limited importance; 3 = quite important; 4 = very important. In general, except for Pre-registration and pre-prints, academics in the sample held positive attitudes about OS practices; a majority of the sample considered 8 out of 10 OS practices as 'quite' or 'very' important to the quality and impact of their work. Notably, **open access publishing** was most often considered as 'very important' to academics' work (51%), followed by **open source software** (34%), and **open data** (34%). The OS practice that was considered least important was Pre-registration (a mere 8% indicated this to be 'very important' to their work). See Figure 2.2 (left panel).

Behaviours toward OS practices

The third purpose of the OS monitor was to gain insight in open science **behaviours**. For each of the 10 OS practices, we asked: "We are now interested in your engagement in open science practices behaviours in your work as a researcher. To what extent is this practice part of your workflow in your research?" Answer options were: 1 = I have never done it; 2 = I rarely do it; 3 = I do it for some of my projects; 4 = I do it for (almost) all my projects. See Figure 2.2 (right panel). The OS practice that stood out as most often being part of academics' regular workflow was open access publishing (42% indicated to do this for almost all research). This was followed by team science (21%), open data (18%) and public engagement (17%). The OS practice that was least often part of academics' workflow was Pre-registration (70% indicated to never have done it). Moreover, more than half of the respondents indicated that they had never used pre-prints (54%), open code (54%), open materials (50%), and open source software (50%).

YES, I AM AWARE OF THIS PRACTICE

Pre-registration (I)
Writing down study predictions or planned analyses (time-stamped) in advance of analyzing your outcome data. Pre-registration occurs prior to data collection and can be made public prior to or at the same time as the corresponding journal article. Pre-registration is used to warrant that hypotheses were formulated prior to analysis (also know as a pre-analyis plan) and that experiments and analysis were carried out according to that plan.

Pre-prints (II)
Pre-prints are full drafts of journal articles that are published prior to peer-review. They are open for feedback, citable, and are intended to accelerate the dissemination and uptake of new findings. Examples of platforms where pre-prints are uploaded are bioRxiv and PsyArXiv.

Open Access Publising (III)
Publishing journal articles or books in a manner which makes the content freely accessible to everyone to read and re-use. No journal subscriptions are required to access the document. Publishing Open Access can be achieved in many ways e.g. publishing in Open Access journals (Gold Open Access), choosing for Open Access in subscription-free journals (Hybrid-Gold Open Access) or archiving your article or book in a public repository (Green Open Access).

Open data (IV)
Posting data online for a research project. Posting data might be "raw", meaning in the form it was collected, or "cleaned", meaning corrected for errors, transformed into scales or into coded themes, etc. Ideally open data should also adhere to the FAIR principles, meaning that the data is Findable, Accessible, Interoperable and Reusable. Typical platforms where data can be shared are the Open Science Frameowork, DataverseNL, and YODA.

Open Materials (V)
Examples of materials that can be shared are: stimulus materials presented to participants, questionnaires, participant instructions, experimental intervention materials, lab protocols and other documents used to gather data.

Open code (VI)
Code (or syntax) relates to coding files used to analyse or clean the quantitative data, or in the case of qualitative data, transform the data into themes. It can be shared using platforms such as GitHub or Zenodo, or by sharing it along with your data.

Open source software (VII)
By open source software we mean software that is freely available for anyone to use, without universities or individuals having to pay a licence or membership fee to access that software. Moreover, open source software allows users to view and make adaptations of the source code of the software.

Public engagement (VIII)
Direct interaction (i.e., not mediated by press or mass media) with general, non-academic audiences, e.g., school visits, debates, public or cultural events, or citizens contributing to data collection, data analysis or research agenda-setting (citizen science).

Research with societal stakeholders (IX)
In these research projects, researchers, often from different disciplines, collaborate closely with non-academics from private or public sectors, to co-produce knowledge on an issue or societal challenge.

Team Science (X)
In Team Science, researchers collaborate in a team where each team member has its own expertise. For example, one team member may be responsible for data collection, while another team member is responsible for statistical analyses, while yet another team member is responsible for writing and communication. Team Science is the opposite of one researcher being responsible for all aspects of a research project.

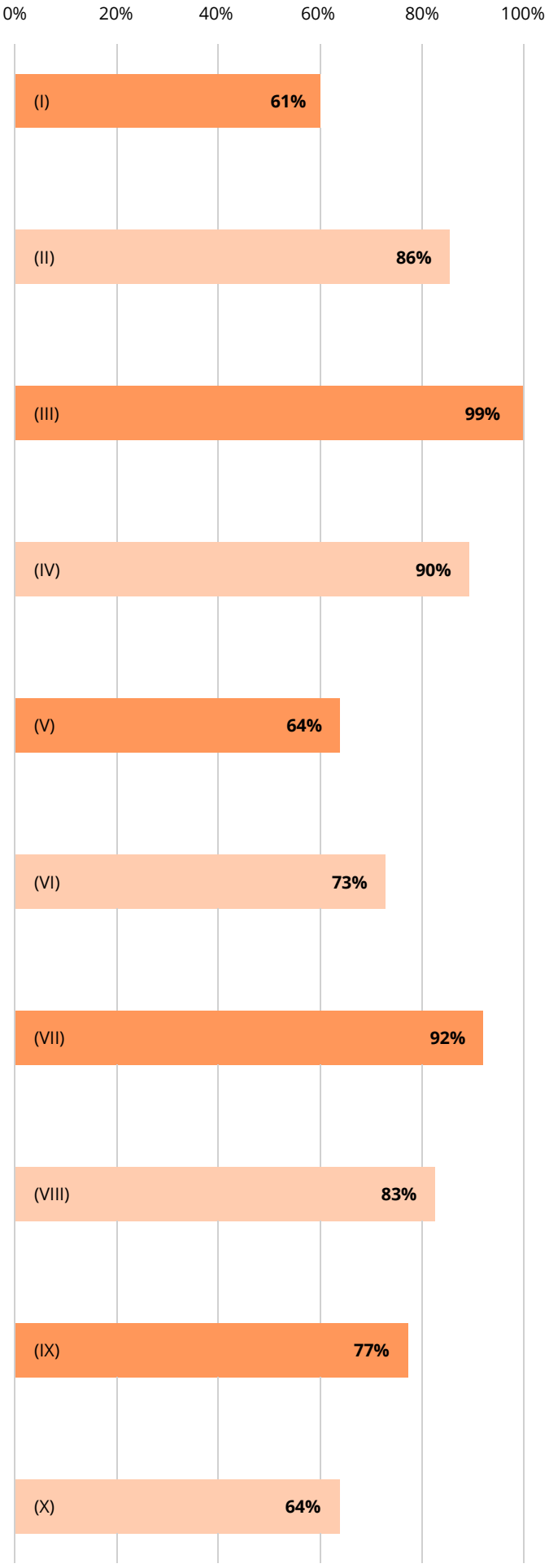
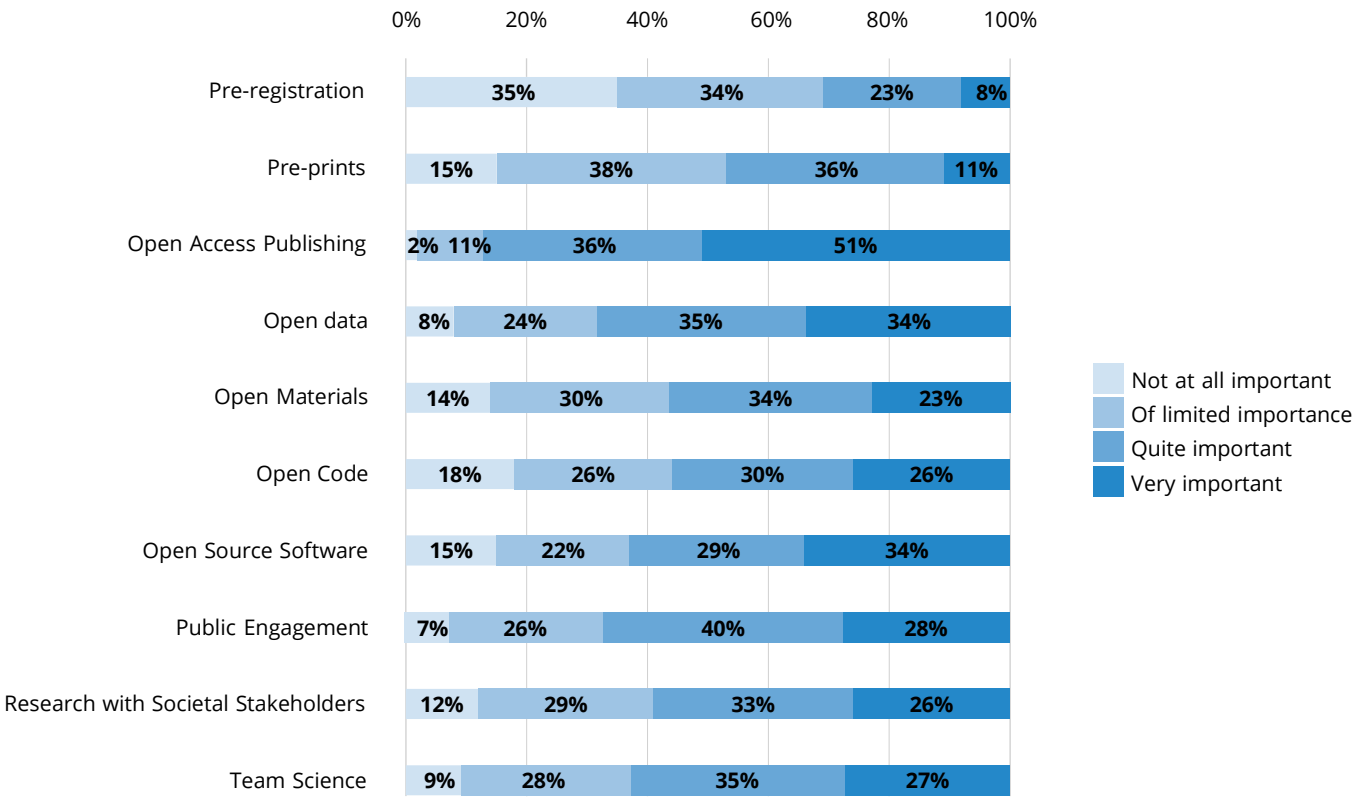


Figure 2.1: Percentage of the sample that is aware of 10 OS practices.

HOW IMPORTANT IS THE OS PRACTICE FOR YOUR RESEARCH?



IS THIS OS PRACTICE PART OF YOUR WORKFLOW?

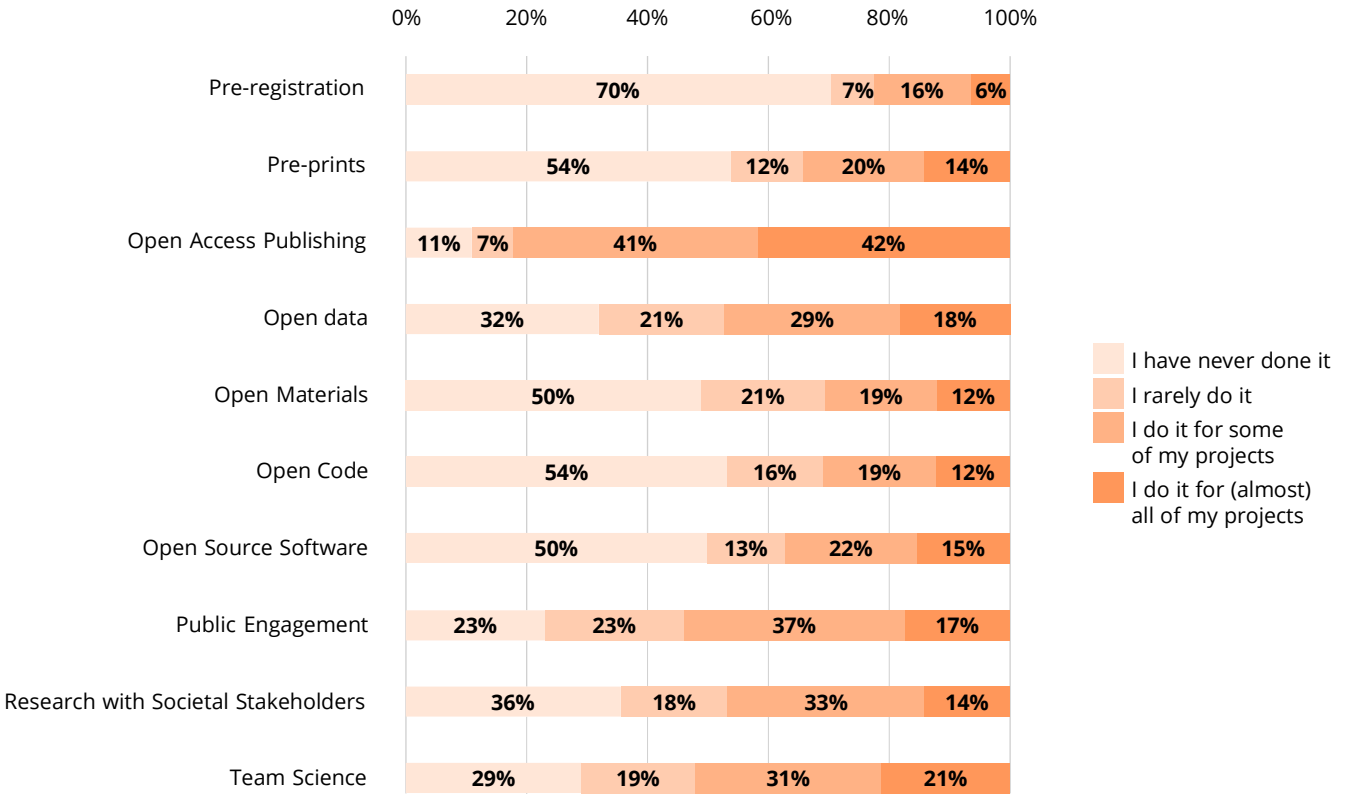


Figure 2.2: Attitudes (top panel) and behaviours (bottom panel) towards of OS practices.

Step 2: Do attitudes about OS align with behaviours?

While respondents reported to hold (moderately) positive attitudes about most open science practices, a majority of them indicated to have never or rarely applied many OS practices in their daily workflow (Figure 2.2). Indeed, mean scores on attitudes were structurally and significantly higher compared to mean scores on behaviours (Figure 2.3). Specifically, on a scale from 1-4, the discrepancy between OS attitudes and behaviours was, on average, half a scale point ($M_{difference}$ =.5, range: 0.3 - 0.8), with effect sizes varying from medium (e.g team science [6] and public engagement [7]) to large (open code [8]; open source software [9]; and open materials [10]). This could mean that there is gap in academics' ability or opportunity to translate their relatively positive attitudes towards OS into behaviours. In our sample, we further note that the attitude-behavior gap is particularly large in relation to OS practices to support reproducibility of data (i.e. open source software, open code, open materials) and to lesser extent in relation to collaborative science practices (i.e., public engagement, societal stakeholders, team science).

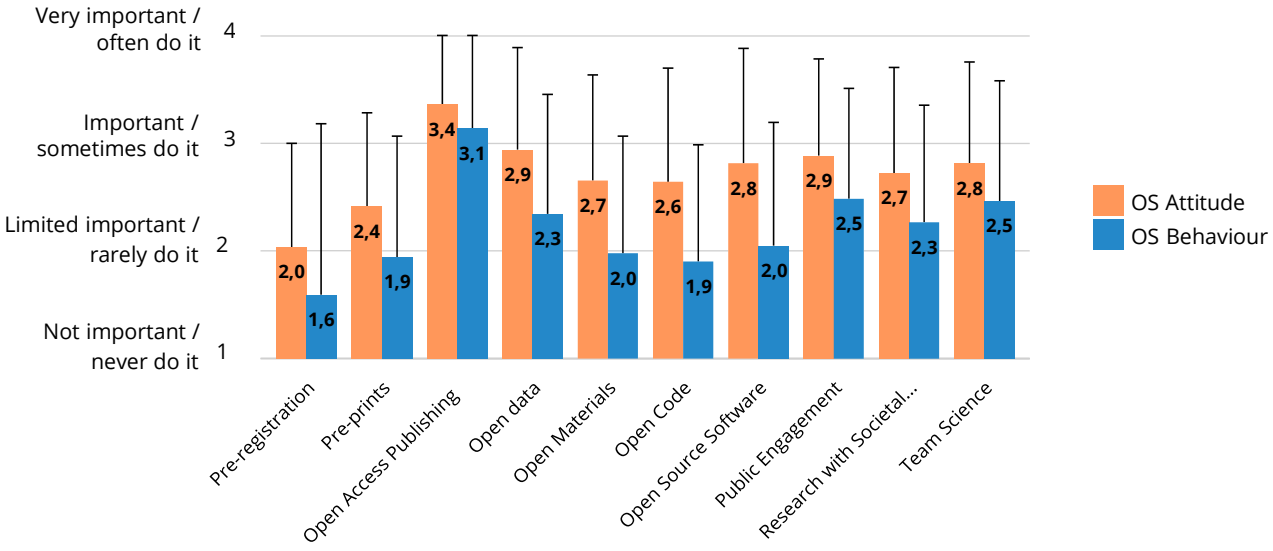


Figure 2.3: Mean scores (1-4 Likert scale) on OS Attitudes and Behaviours and their average discrepancy.

[6] $\eta^2 p$ = .140
[7] $\eta^2 p$ = .176
[8] $\eta^2 p$ = .350
[9] $\eta^2 p$ = .323
[10] $\eta^2 p$ = .301

Discussion questions from Chapter 2

- Across all OS practices, there is a **large discrepancy between academics' attitudes and behaviours**. What is needed from UU and UMCU to optimize the translation of academics' positive OS attitudes into practice?
- Some **attitudes to OS practices are low**. Is there no beneficial effect of this OS practices or is this not known among the academics?
- **Pre-registrations and pre-prints** are considered least important OS practices by academics in the sample and are **least applied**. What are the controversies around these OS practices at the UU and how should we move forward? Are these relevant OS practices for all types of researchers?
- The attitude-behavior gap is larger among OS practices that concern data reproducibility and transparency (e.g., open source software, open code) compared to OS practices that concern collaborative research (e.g., public engagement, team science). Are there sufficient amounts of time, energy and resources available to **resolve this attitude-bahavior gap** among academic staff? How can this be more structurally and properly addressed by UU to support the transition to OS data practice?
- The UU Open Science Programme, NPOS and the European Commission state that data should be 'As open as possible, as closed as necessary'. What is a realistic estimate of the percentage of datasets that should be open and how does that relate to the observation that over half of the respondents (53%) never or rarely shares data?

Chapter 3: OS attitude-behavior gaps between groups of academics

Highlights:

- In 6 out of 7 faculties, the attitude-behavior gap in open source software was among the top 3 largest gaps in OS practices.
- PhD candidates report the strongest attitude-behavior gap on 9 out of 10 OS practices relative to academics at higher function levels.
- Associate/Full Professors engage significantly more in collaborative OS practices relative to academics at lower function levels.
- Women report a greater attitude-behavior gap than men on 6 out of 10 OS practices.
- Non-Dutch academics are more positive about 7 out of 10 OS practices compared to Dutch academics.
- Academics with fixed-term contracts report lower attitudes and behaviours towards team science.

Introduction

In Chapter 3, we investigate whether groups of academics differ in their attitudes and behaviours towards the 10 OS practices. Specifically, we explored whether OS attitudes-behavior gaps were different depending on the background characteristics of the respondents:

- Demographic background (gender, nationality).
- Function category (PhD/Post Doc/Assistant Professor/Associate or Full Professor [11]).
- Type of contract (permanent/temporary). [12]
- Faculty (Natural Sciences, Medicine, Veterinary Medicine, Behavioral and Social Sciences, Geosciences, Humanities, Faculty of Law, Economics and Governance).

Note that we additionally control for whether respondents were an OSCU member (yes/no) and the type of research they conduct (empirical research with/without human subjects) as in general, OSCU members and researchers conducting empirical research with human subjects scored higher on OS attitudes and behaviours. Below we discuss the most notable differences between groups of academics across OS attitudes and behaviours. [13]

Demographic background

Women report a greater attitude-behavior gap than men on 6 out of 10 OS practices, namely open access publishing, open materials, open code, open source software, public engagement and team science (see dark bars in Figure 3.1). Notably, particularly for 3 OS practices concerning data reproducibility and transparency, namely open access publishing, open code and open source software, women's and men's reported attitudes were similarly positive, yet women reported that their behavioral engagement in these OS practices was significantly lower compared to men's. These gender differences in engagement in open code and open source software is in line with research showing that gender biases exist with regards to women's contributions and access to open code and open source software development (Nafus, 2012; Bosu & Sultana, 2019; Terell et al., 2017; Wired, 2017). In contrast, for the collaborative OS practices public engagement and team science we see a different pattern of results. Namely, while men and women equally engage in public engagement activities, men's attitude towards public engagement is significantly lower compared to women's. For team science, data

[11] Note that respondents that could not be categorized in a function category (other) were not included in these analyses.

[12] Note that we also explored differences in OS practice attitudes and behaviours for groups of academics with different contract size (part-time/full-time), but this factor did not explain significant variance in OS attitudes and behaviours above and beyond factors described here.

[13] Note that we only investigate main effects on group differences (between-subjects) in relation to respondents' attitude and behavior (within-subjects) per OS practice. We do not investigate interaction effects between groups of academics due to the small sample size.

showed that women reported a higher discrepancy between their attitudes and actual engagement in team science compared to men. Finally, note that while a statistically significant attitude-behavior gap exists for both men and women on all OS practices (indicated by a grey vs. orange color contrast in Figure 3.1) there was one notable exception to this: Men in this sample did not report an attitude-behavior gap on open access publishing; this is the only case where (statistically speaking) attitudes and behaviours align (indicated by removing the color contrast in Figure 3.1; both bars are blue).

ATTITUDE-BEHAVIOR GAP × GENDER

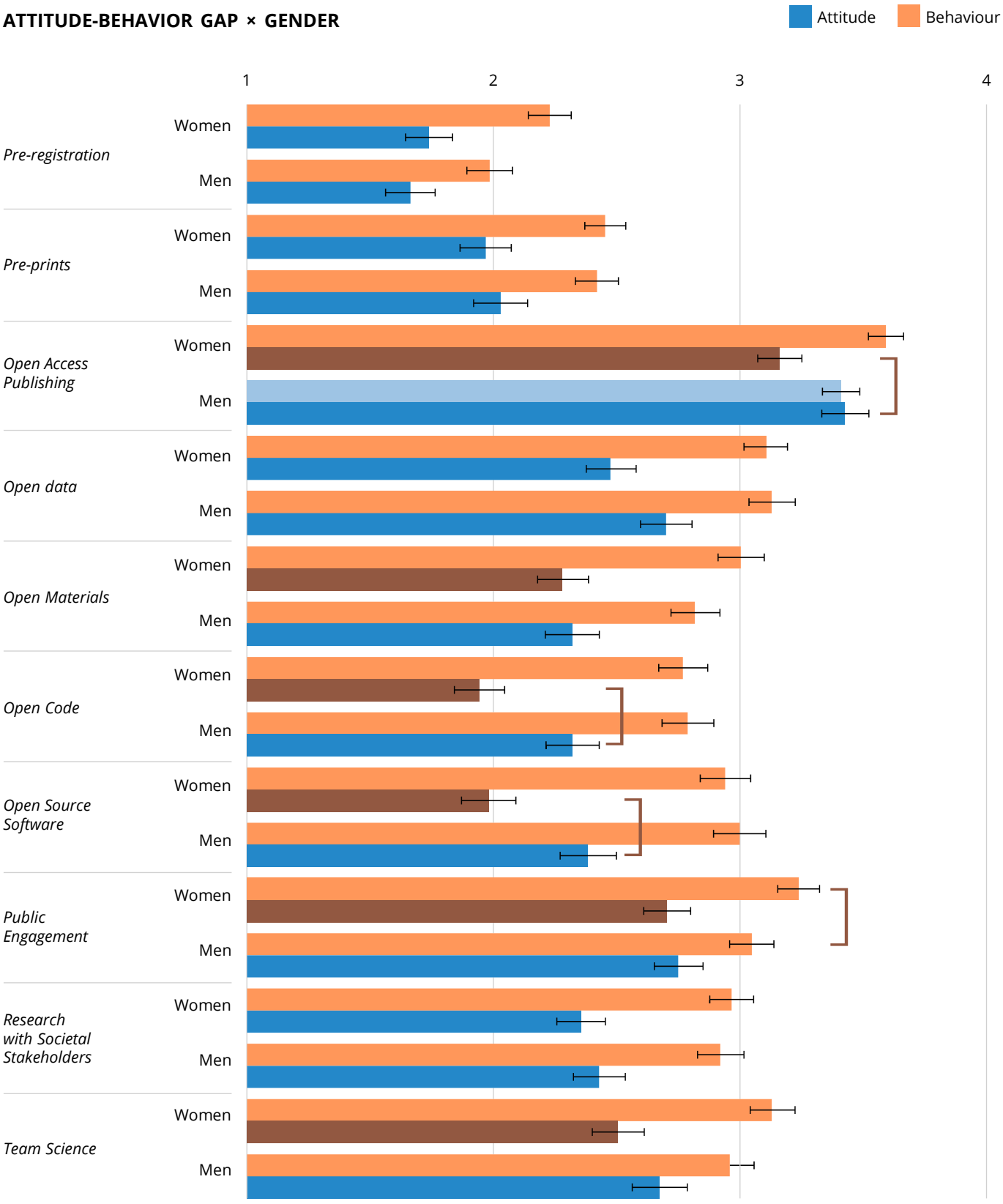


Figure 3.1: Attitude-Behavior gap depending gender for OS practices. Note that the dark bars for women indicate that for this OS practice, their attitude-behavior gap was significantly larger compared men. The attitude-Behavior Gap was significant within each gender category (as indicated by a grey-orange contrast in color coding), except for men with open Access publishing (as indicated by similar orange color coding). The accolade indicates whether the gender x attitude-behavior gap manifested specifically on attitudes (i.e., public engagement) or behaviours (i.e., open access publishing, open source software, open code).

Dutch academics report lower attitudes and/or behaviours of 7 out of 10 OS practices than non-Dutch. On 7 out of 10 OS practices, academics with the Dutch nationality indicated significantly less positive attitudes and/or less behavioral engagement compared to academics with a non-Dutch nationality. Specifically, for pre-prints, open data, open materials, open code, and team science, attitudes and behaviours were higher among non-Dutch, compared to the Dutch academics in the sample. Note that the attitude-behavior gap was not different on these OS practices. For open source software, data showed that particularly non-Dutch academics' attitudes (but not behaviours) were more positive than Dutch academics', causing a larger attitude-behavior gap on this practice for non-Dutch academics. Similarly, for research with societal stakeholders, non-Dutch academics also indicated a larger discrepancy between their generally positive attitudes and their behavioral engagement in research with societal stakeholders, compared to their Dutch colleagues. Potentially, even though non-Dutch academics see the potential of stakeholder research (i.e., a positive attitude), it is more difficult for them to access local stakeholders in the Netherlands to collaborate with (i.e., behavioral engagement), due to cultural and language barriers. In Figure 3.2 we show the 10 OS practices per nationality and indicate where we find statistically significant differences on attitudes and/or behaviours.

Function category

PhD candidates were equally positive, yet less likely to engage in OS practices compared to academics at higher function levels. While PhD candidates' attitudes towards OS practices were generally positive and similarly so in comparison to academics at higher function levels, their reported behavioral engagement in OS practices in their daily work was considerably lower relative to their attitudes, and in many cases, also lower relative to OS behaviours of academics at higher function levels. **Specifically, for 9 out of 10 OS practices (with exception of open source software) PhD candidates report a higher attitude-behavior gap in OS practices compared to academics at higher function levels.**

For OS practices related to **transparency and reproducibility of data**, attitudes were generally moderately positive and there were no significant differences in this attitude across function levels. Yet PhD candidates structurally reported the largest gaps between their behavioral engagement in these practices relative to their positive attitudes, and also relative to academics in higher function categories. Note that academics at higher function levels also report a statistically significant gap in translating their attitudes into actual OS behaviours here, yet their attitude-behavior gap is less large. For example, for open materials, open Data and open code, PhD candidates report the largest attitude-behavior gap, yet note that Post Docs, Assistant, Associate and Full Professors experience a statistically significant, yet smaller gap between their attitudes and actual behaviours too.

For the collaborative OS research practices public engagement, research with societal stakeholders and team science, PhD candidates again report the largest discrepancy between attitudes and behaviours, and this gap generally declines as function level goes up. And again, this gap was largely due to PhD candidates' lower level of behavioral engagement in collaborative OS research practices relative to academics at higher function levels, not so much their attitudes. The data patterns also suggest that behavioral engagement in collaborative OS practices is more prevalent among senior or tenured academic staff members (Associate/Full Professors), compared to more junior researchers. Moreover, for collaborative OS practices we see attitudinal differences across function levels too;

for example, attitudes towards team science are significantly more positive among Associate/Full Professors compared to PhD candidates and Assistant Professors. A similar pattern is visible for public engagement, where attitudes are most positive among Associate/Full Professors. Moreover, Associate/Full Professors did not report a significant discrepancy between their positive attitudes and their level of behavioral engagement in Research with Societal Stakeholders and public engagement. Assistant professors in turn, did not report a significant attitude-behavior gap in team science and public engagement (as indicated by similar-colored bars in Figure 3.3). For research with Societal Stakeholders, there were no attitudinal differences across function levels, yet again, the actual engagement in this OS practice seems more accessible for senior staff, because Associate/Full Professors score significantly higher in behavioral engagement in Stakeholder Research compared to all other lower function levels.

Notably, regarding **open access publishing**, both Post Docs and Associate/Full Professors did not report a significant discrepancy between their attitudes and behaviours while PhD candidates (higher attitude than behavior) and Assistant Professors did (higher behavior than attitude). Again, PhD candidates score lowest in open Access publishing behaviours compared to all higher function categories. This might be surprising compared with the PNN PhD Survey were PhD candidates report that they are mostly encouraged to publish open access (Matthijssen & van Doorn, 2020)

In sum, academics at different function levels show similar levels of perceived importance towards most open science practices regarding data transparency and reproducibility, yet senior academic staff members' (i.e, Associate and Full Professors) actual engagement in OS practices is often higher compared to junior researchers (PhD candidates). While it could be expected that a new generation of PhD candidates is at the forefront of implementing a change towards open Science (while more resistance to such norm change could be expected from an older generation of academics) in this sample we see an opposite trend, where senior researchers score higher on behavioral engagement in OS practices compared to academics at lower function levels. Corroborating these findings, the OS monitor among N = 2787 Social Scientists at Northern American Universities by Christensen and colleagues shows a similar pattern of results (Christensen et al., 2019).

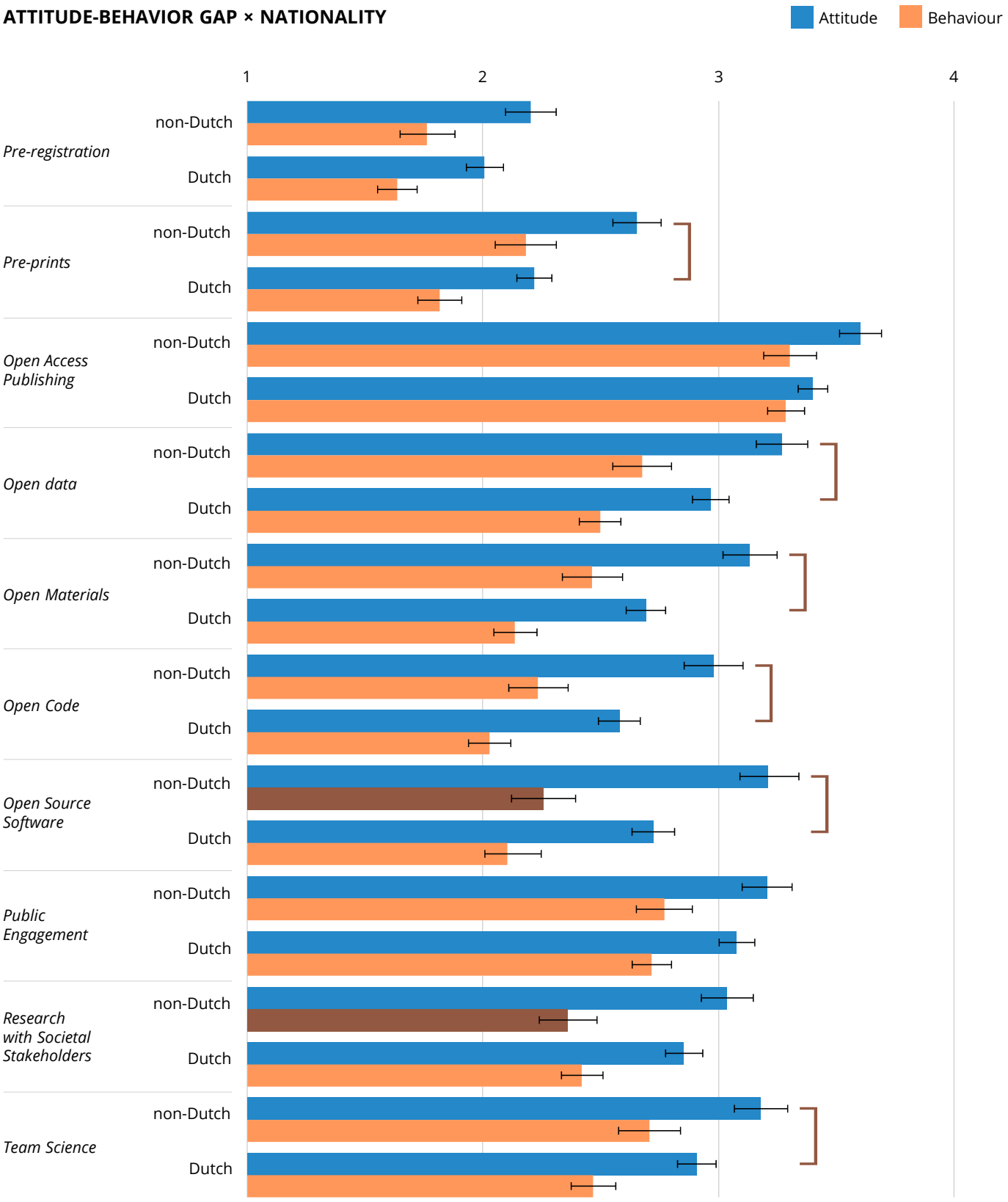


Figure 3.2: Attitude-Behavior gap depending nationality for OS practices. Note that the dark bars for non-Dutch indicate that for this OS practice, their attitude-behavior gap was significantly higher compared to Dutch. The Attitude-Behavior Gap was significant within each category as indicated by a contrast in grey-orange color coding of bars. The accolade indicates the main effect on nationality.

ATTITUDE-BEHAVIOR GAP X FUNCTION LEVEL

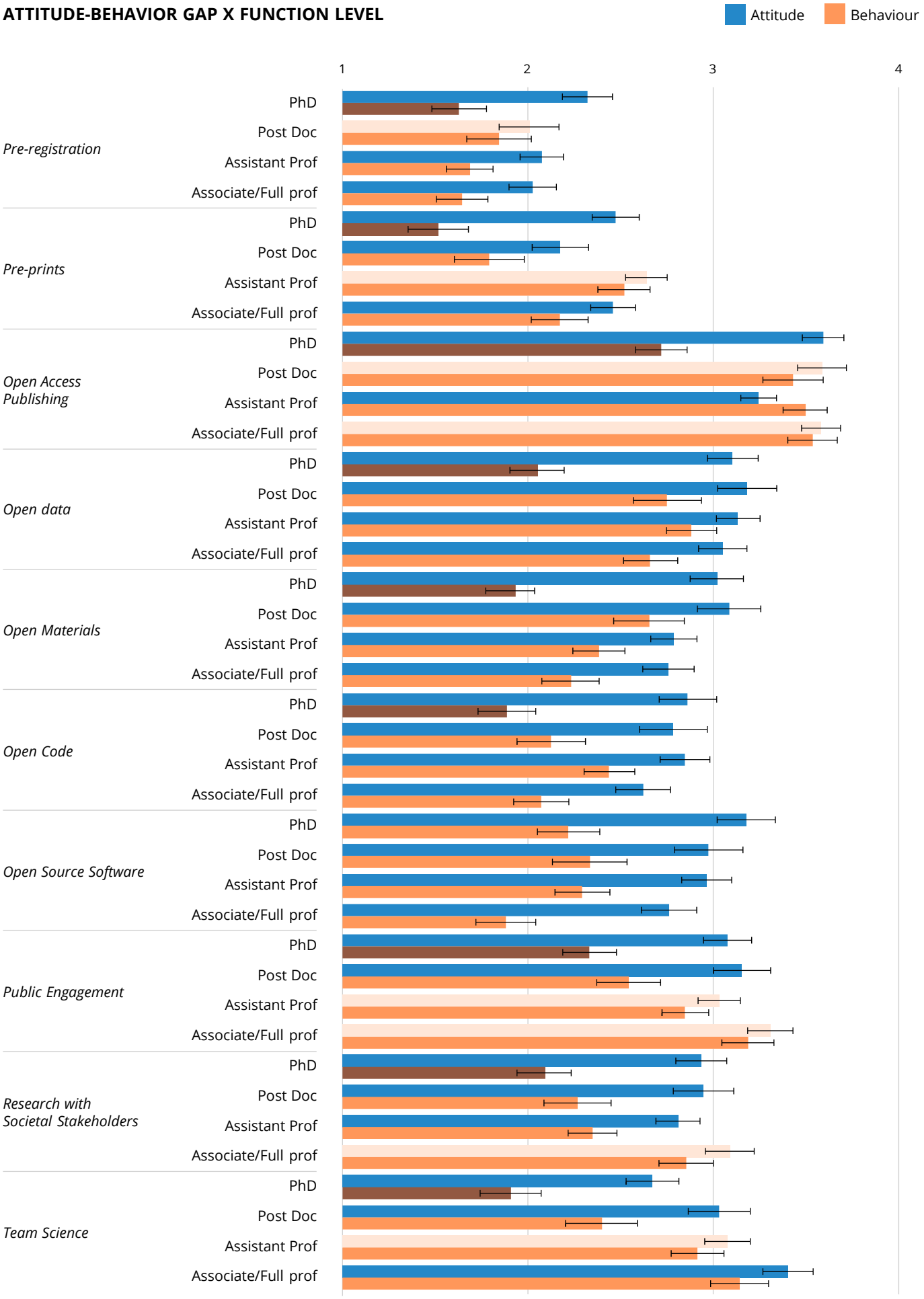


Figure 3.3: OS Attitude-Behavior gap depending on function profile. Note that the dark bars for PhD candidates indicate that for this OS practice, their attitude-behavior gap is significantly larger compared to academics at higher function levels. A statistically significant attitude-Behavior Gap within each function category was indicated by a grey-orange contrast in color coding). Absence of statistical evidence for an attitude-behavior gap within function category was indicated by similar orange color coding. We did not provide further specification of statistical main effects with accolades to ensure readability of the figure.

Type of contract

Academics with temporary contracts scored lower on team science than with permanent contracts. With regards to job security, above and beyond the variance already explained by function level [14], there was one OS practice for which academics with fixed-term contracts indicated lower scores on attitudes and behaviours relative to those with permanent contracts, namely **team science**; a small [15] yet significant difference ($M_{attitude\text{-}behavior\ gap}$ = .36). In line with results for function level, likely (junior) researchers with low job security still need to 'prove' their individual excellence in direct competition with their peers, which might make attitudes and efforts to engage in collaborative team science less appealing and rewarding for their individual careers in academia (Ellemers, 2021).

Faculty

We report the top 3 of largest attitude-behavior gaps per faculty as shown in Figure 3.4. We do want to re-emphasize here, that per faculty, a mere 4% - 10% of approached academics responded to the survey. Therefore, interpretations of reported effects are applicable to this sample of respondents per faculty only, and caution is advised in generalizing results to the entire faculty. This is also the reason why we now focus how systemic or unique attitude-behavior gaps are in OS practices across faculties, rather than on absolute mean differences in direct comparison between subgroups.

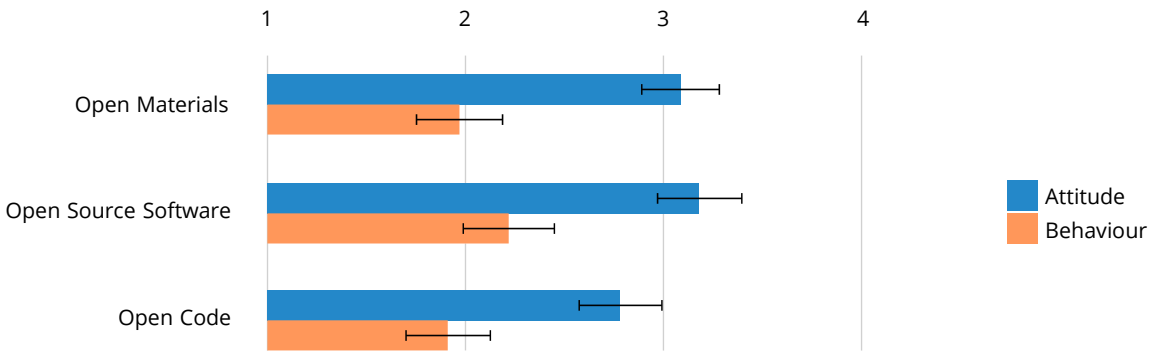
For 6 out of 7 faculties (with the exception of Humanities) respondents indicated that open source software was in the top 3 of largest attitude-behavior gaps in OS practices. As quantitative data analyses is less common in the humanities, it might be that this OS practice is relevant for only a subset of this faculty, e.g. Digital Humanities. Yet for the other faculties, where quantitative data analysis is more prevalently part of the core business, the perceived importance of open source software is high, yet there is a large discrepancy between this attitude and academics' actual application of this practice in their research.

For 4 out of 7 faculties, (Science, Geoscience, Medicine and Veterinary Medicine), respondents indicated that the use of **open code** was in their top 3 of attitude-behavior gaps. For 3 out of 7 faculties (Science, Geoscience, and Social and Behavioral Sciences), the attitude-behavior gap on **research with societal stakeholders** was in their top 3. For 3 out of 7 faculties, (Medicine, Veterinary medicine, and Humanities) the discrepancy between attitude and application of open materials was in respondents' top 3. In the sample, there were also attitude-behavior gaps that were unique per faculty. For Law, Economics and Governance, respondents indicated that the attitude-behavior gap of the OS practices **open data and team science** was in their top 3. For Social and Behavioral Sciences, respondents indicated that **public engagement** was in their top 3 of largest attitude-behavior gaps. Finally, for Humanities, respondents indicated that the attitude-behavior gap on the OS practice **pre-prints** was in their top 3. Note that in general, the perceived importance of OS practices (and application) was somewhat lower among respondents from the humanities. As a final note, respondents did not indicate pre-registration and open access publishing in their top 3 largest OS practice attitude-behavior gaps in any of the faculties. Note however, that for open access publishing both attitudes and behaviours are highest of all OS practices, while in contrast attitudes and behaviours towards pre-registration were lowest among respondents across all faculties (see also Chapter 2).

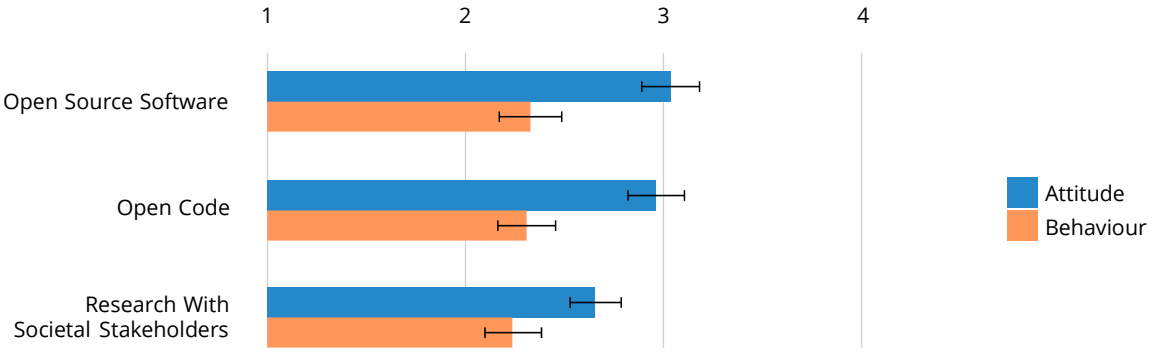
[14] The percentage of PhD candidates holding a fixed-term contract is 96% and the percentage of Post Docs holding a fixed-term contract is 90%. In contrast, the % of Assistant Professors holding a permanent-contract is 79%, and the percentage of Associate/ Full Professors holding a permanent contract is 96%.

[15] $\eta^2 p$ = .013)

FACULTY OF VETERINARY MEDICINE



FACULTY OF SCIENCE



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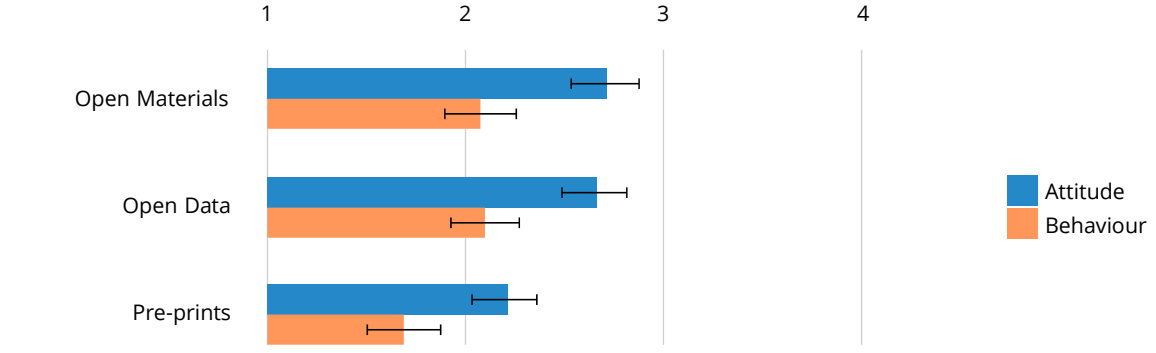

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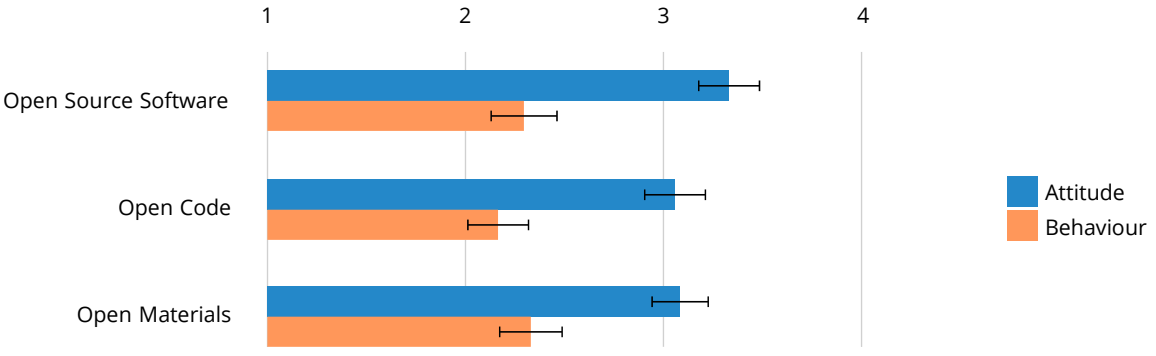

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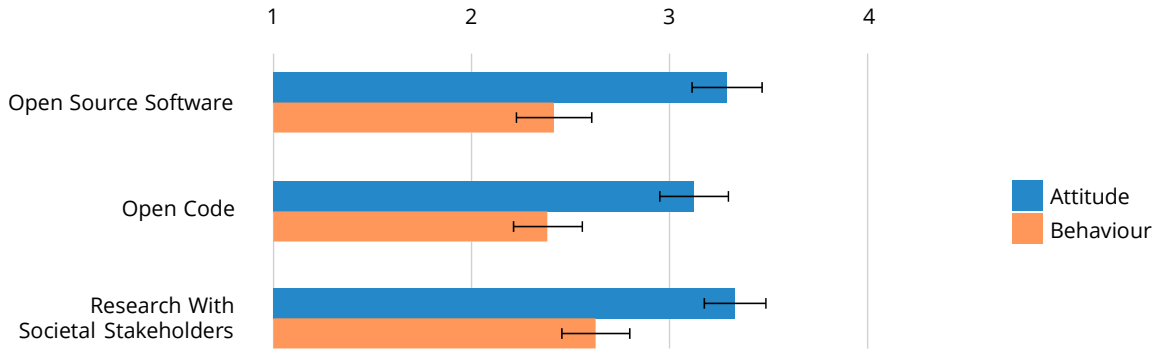
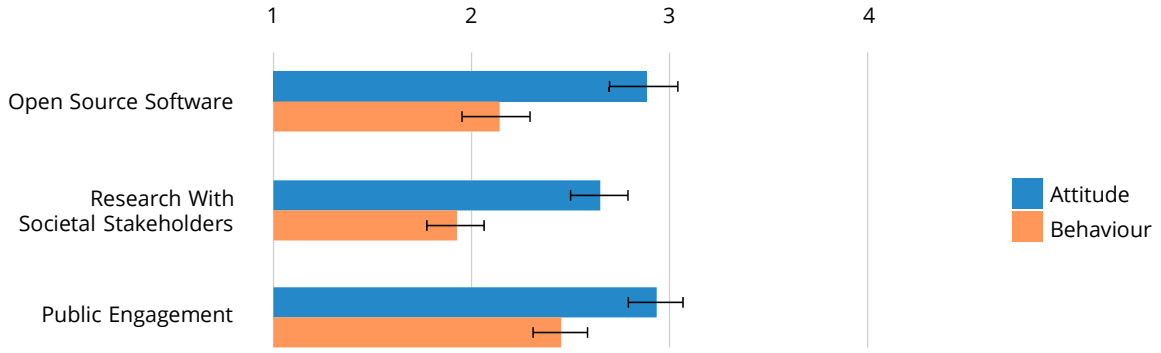


FACULTY OF SOCIAL AND BEHAVIORAL SCIENCES



FACULTY OF LAW, ECONOMICS AND GOVERNANCE

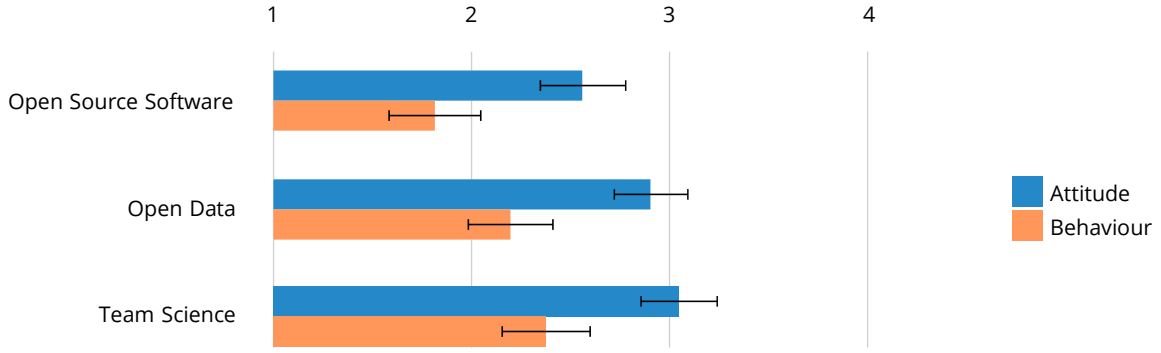


Figure 3.4: Top 3 largest Attitude-Behavior Gaps on OS practices for each faculty separately (seven panels)

Discussion questions from Chapter 3

- Considering that **open access publishing** is perceived as the **most important** OS practice among academics the sample, why do particularly PhD candidates experience a large gap in applying this (e.g., are there barriers in knowledge, funds, time)?
- The most notable outcome in group comparisons is that **PhD candidates** structurally report the largest **gaps** between their **OS attitudes and behaviours** on 9 out of 10 OS practices. What is the cause of this lack of access to and/or application of OS practices in research routines among this group of junior academics? Are there lacuna's or accessibility problems in the educational programs that PhD candidates receive on OS practice training? How are OS practices embedded in reward structures and performance assessments of PhD candidates?
- Why are **collaborative OS practices** (Public Engagement, Stakeholder Research, Team Science) particularly executed (and perceived as most important) by senior academic staff members (Associate and Full Professors). Is this a desirable situation?
- While there are no differences in gender attitudes towards most OS practices, women seem less involved in OS practices about data transparency and reproducibility (e.g, open code, open source software). What can be done to make these **OS data practices more gender inclusive**?
- Why do **Dutch academics** in the sample **attribute less importance** to OS practices compared to non-Dutch (mostly other EU countries) academics in the Netherlands?
- Use of **open source software** was in the top 3 of largest attitude-behavior gaps among 6 out of 7 **faculties**. Wat can be done to close this gap and translate perceived importance towards open source software into daily practice?
- Across faculties, there are different OS practices that end in the top 3 of largest attitude-behavior gaps – What **tailor-made OS policies, programs and practices per faculty** should be in place to address these needs?

Chapter 4: Perceived Opportunities and Barriers to open science

Highlights:

- The greatest perceived **opportunities** to OS were **improved quality of scientific knowledge** and d**etection of unethical research behavior**.
- The greatest perceived **barriers** to OS were the **high workload** and **insufficient availability of training and support in the department**.
- **Female academics** were **more optimistic** about the potential **opportunities of OS** compared to male academics.
- **Junior academics** (PhD/post docs) were more optimistic **about OS as an opportunity to improve fairness in reward and promotion systems**, and to improve career opportunities for young academics compared to senior academics (assistant/associate/full professors).
- **Assistant professors** reported a **lack of time** within contract hours to learn or apply OS practices and a **lack of recognition** from the supervisor to be a strong barrier to engage in OS.
- Academics with high **job insecurity** (i.e., a fixed-term contract) reported **lack of time** within their contract hours for OS practices to be more of a barrier compared to those with a secured position (i.e., a permanent contract).

Introduction

In this chapter we discuss opportunities and barriers that UU and UMCU academics in this sample perceive in engaging in open Science practices. Items addressing potential opportunities and barriers to open Science practices (See Table 4.1) were selected through discussion among the experts in the open Science Monitor team who produced this report, and in connection to research addressing the promises and pitfalls of the transition to open Science (e.g., Bahlai et al., 2019; Murphy et al., 2020; Nosek, 2019). First, we report the extent to which academics in the sample indicate opportunities and the barriers in general. Subsequently we explore whether groups of academics differently perceive opportunities and barriers to open Science practices.

Table 4.1: Opportunities and Barriers to OS practices measured in the survey.

Engaging in open science practices has the *opportunity* to…	**An important *obstacle* that would prevent me from engaging in open science practices is that…**
… improve the quality of scientific knowledge	… my workload is too high to integrate these practices
… detect unethical behavior in research practices	… there is insufficient practical support and training available in my department about this
… increase societal impact	… I do not get time within my contract hours to do / learn this
… improve fairness in reward and promotion systems in academia	… it is not the norm to do this in my department (my colleagues don't do it)
… improve diversity and inclusion in academia	… I do not get recognition from my supervisor for this
… create more career opportunities for young academics	… my research does not allow for it due to embargos and patent issues
	… I would lose autonomy and freedom in how I do my research

Step 1: What are the most important perceived opportunities and barriers to OS practices?

The OS Monitor asked participants to respond to six statements about the opportunities that engaging in open science practices may bring and seven statements about obstacles that would prevent them from engaging in open science practices (Table 4.1). Respondents indicated their agreement with the 13 statements on a 5-point Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Neither Agree nor Disagree; 4 = Agree; 5 = Strongly Agree). In Figure 4.1 the opportunities (left panel) and barriers (right panel) are displayed rank ordered by the extent to which respondents (strongly) agreed with them. Note that for ease of interpretation we re-categorized the scale into a 3-point scale (1 = (Strongly) Disagree; 2 = Neither Agree nor Disagree; 3 = (Strongly) Agree).

Respondents perceived the improvement of the **quality of scientific knowledge** as the greatest opportunity of OS (80% (strongly) agreed with this statement) directly followed by the detection of **unethical research behavior** (76% (strongly) agreed with this statement) and the increase of **societal impact** (70% (strongly agreed with this statement). Respondents were more divided about whether open science would live up to its promise to contribute to more fairness, equality, opportunity, diversity and inclusivity in the careers of (young) academics. This is also in line with results from Chapter 3 and previous research showing that for academics facing stigma (i.e., women) or academics in precarious positions (i.e., fixed-term/PhD's) the barriers to gain access to, or be included in actual engagement of OS practice are higher, for example in relation to OS practices to ensure data replication, robustness and reproducibility such as open code, Open Software, Open Data (Nosek et al., 2021; WIRED, 2017; Murphy et al., 2020).

While academics in the sample strongly perceived a potential of open science to improve the quality of scientific knowledge, they also indicated to experience obstacles that prevented them from engaging in OS practices. The most important obstacle was the **high (extra) workload** that prevented respondents to integrate OS practices in their workflow (45% (strongly) agreed with this statement), followed by **the insufficient practical support and training from the department** (45% (strongly) agreed with this statement) and the **lack of formal contract time** (39% (strongly) agreed with this statement) allocated to the extra effort that open science research requires.

ENGAGING IN OPEN SCIENCE PRACTICES HAS THE *OPPORTUNITY* TO…

AN IMPORTANT *OBSTACLE* THAT WOULD PREVENT ME FROM ENGAGING IN OPEN SCIENCE PRACTICES IS THAT…

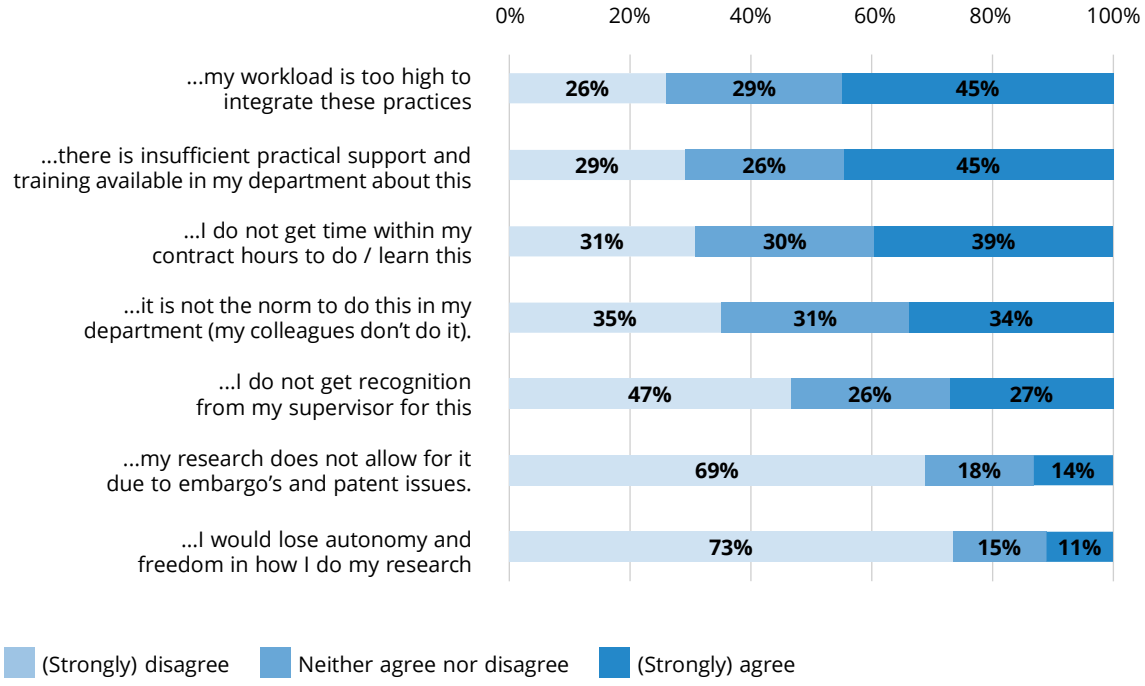


Figure 4.1: Response frequencies in responses on level of agreement with open science opportunities (top panel) and barriers (bottom panel).

Step 2: Different opportunities and barriers to OS practices among groups of academics?

In a second step, we explored whether subgroups of academics perceived more, or less opportunities or experience barriers to open science. With this information, we can target what the UU may be able to do, to take away these barriers for subgroups of academics. In our analysis we focus on the same demographic and work characteristics as we did in Chapter 3. In general, few and small group differences were observed in perceived opportunities and barriers to open science. We report the most notable outcomes below.

Gender

The most systematic difference across all perceived opportunities was that **female academics in the sample were more optimistic about all potential opportunities of OS compared to male academics**. And while all effect sizes were small, the effects were structural and most pronounced in relation to opportunities for more diversity and inclusion in academia and for improvement of fair reward and promotion systems in academia (See Figure 4.2). With respect to the barriers, on one dimension a significant gender difference was detected; **female academics in the sample reported a stronger lack of practical support and available training from the department to engage in OS practices compared to male academics**. This is in line with prior research among N ≈ 4000 academics in the Netherlands demonstrating that resources and support for research are systematically less available for women compared to men at Dutch universities (Van Veelen & Derks, 2019).

GENDER DIFFERENCES IN PERCEIVED OPPORTUNITIES FOR OS
Engaging in Open Science practices has the opportunity to...

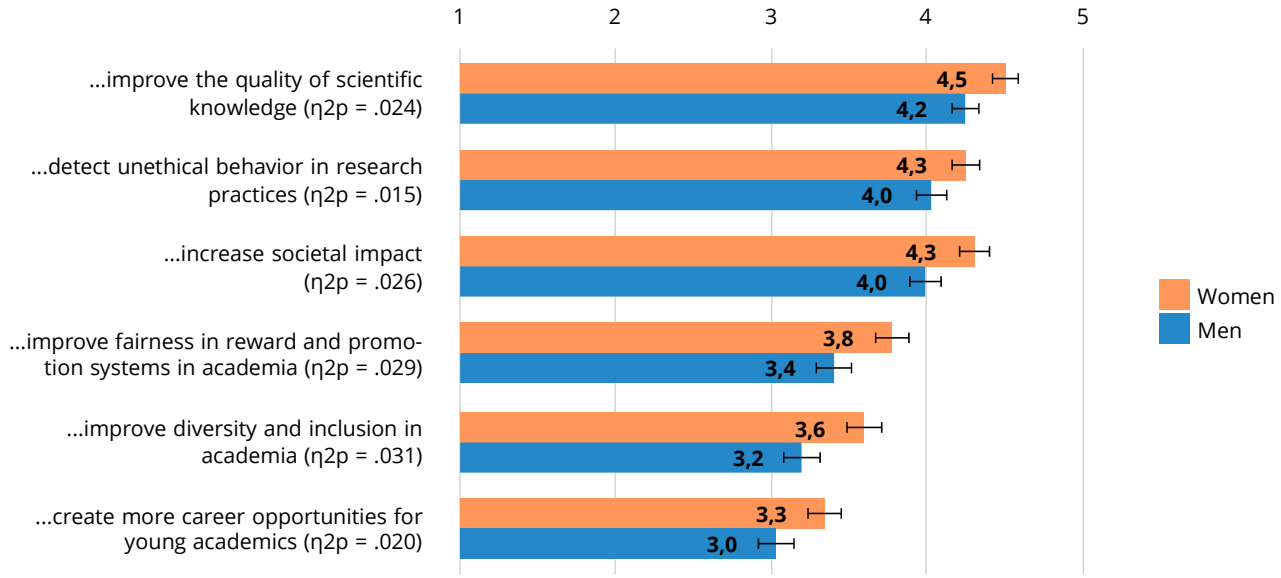


Figure 4.2: Small yet structural gender differences in perceived opportunities for OS practices (partial eta 2 for isolated effect size for gender differences; .01 = small; .06 = medium; .14 = large). Effects were corrected for nationality, contract type, function level, faculty, OSCU member and human-subjects researcher.

Function category

PhD candidates and Post docs were more optimistic about OS as an opportunity to improve fairness in reward and promotion systems in academia and to create more career opportunities for young academics compared to Assistant and Associate/Full professors. In their precarious and early careers, for PhD candidates and Post Docs fairness and opportunity in career advancement in academia are highly relevant. The data in this OS Monitor showed that junior academics (i.e., PhD candidates/Post docs) expressed more optimism about open science to contribute to that compared to more senior academics (i.e., Assistant/ Associate/Full Prof). It is worrisome that the more senior academics in the sample – who hold positions of power and decision-making with regards to the standards by which young academics are rewarded and promoted – are less perceptive to this opportunity of OS (Figure 4.3; upper panel).

Second, there were two barriers to engaging in OS practices where a significant contrast was detected between assistant professors on the one hand and associate/ full professors on the other. Specifically, **assistant professors reported a lack of time within contract hours to learn or apply OS practices and a lack of recognition from the supervisor as the highest barriers** to engage in OS, while associate/full professors reported these to be least of a barrier (Figure 4.3; lower panel). Again, this is worrisome because a lack of formal and informal support from organizations to engage in desired yet demanding work behaviours is shown to decrease employees' work engagement and increase work-related stress (Demerouti et al., 2001; Ray et al., 2017; Rich et al., 2010; Sofokles, 2020) .

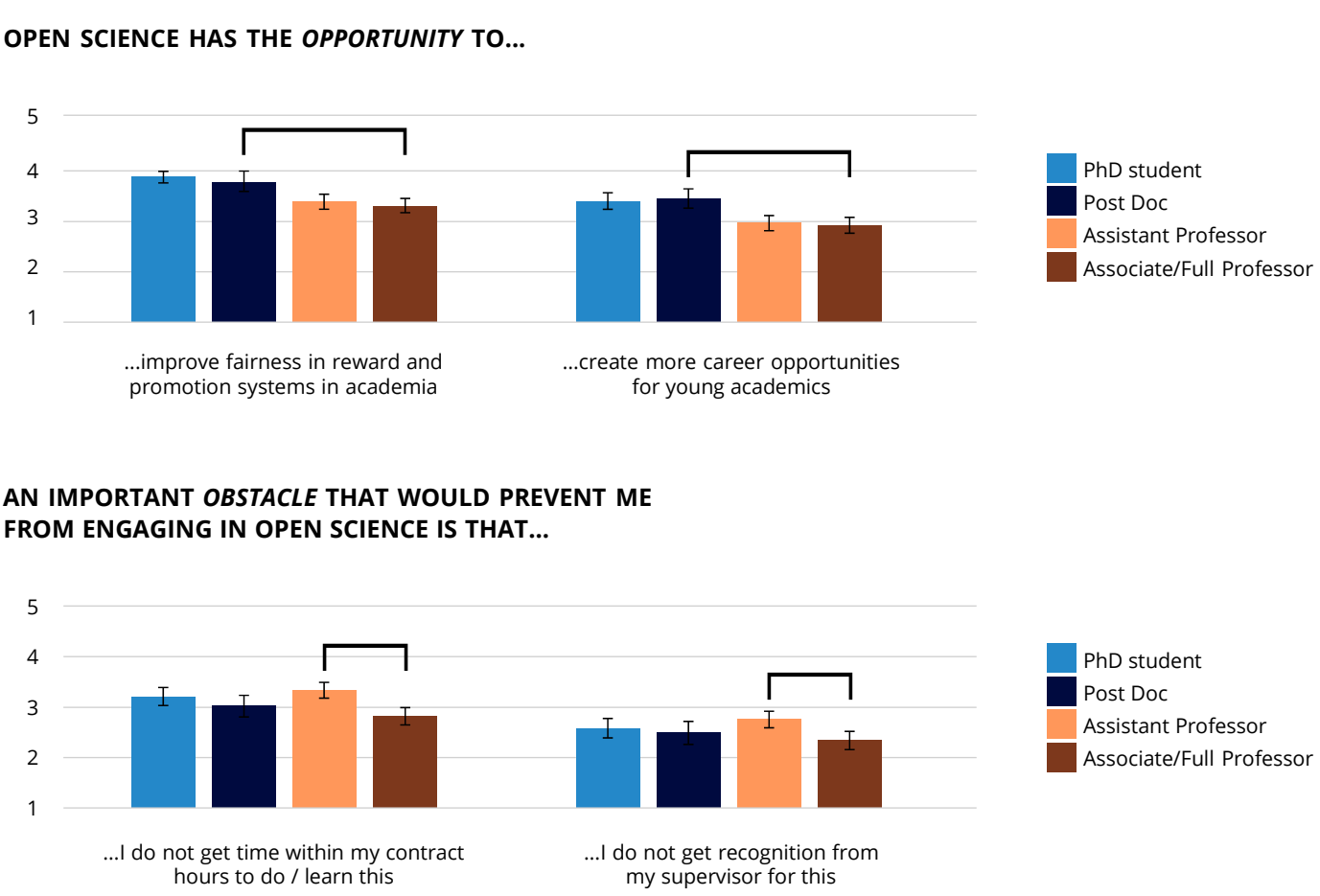


Figure 4.3: Differences in 2 perceived opportunities (upper panel) for OS and 2 perceived barriers (lower panel) depending on function category. The accolade indicates where the significant differences are. All effect sizes were small (η2p = .01).

Type of contract

Job insecurity forms a barrier for the formal contract time available for OS practices. One of the most prevalent barriers to OS reported by academics in the sample was unavailability of formal contract time to learn or apply OS practices (See figure 4.1, right panel). In particular for academics with a fixed-term (i.e., temporary) contract they reported this to be significantly more of a barrier compared to academics with a permanent contract [16].

Faculty

There were no statistically significant differences in the top 3 of opportunities and barriers to OS practices across faculties. However, there were differences across faculties in perceived potential opportunities of OS to **improve quality of science** and **detect unethical research.** Academics in the sample from the Faculty of **Humanities** were the least optimistic about open sciences' potential to improve the quality of scientific research, while respondents from the Faculty of **Behavioral and Social Sciences** were the most optimistic about this relative to other faculties. In contrast, respondents from the Faculty of Behavioral and Social Sciences were the least positive about open sciences' potential to detect unethical research practices, directly followed by respondents from the Humanities, while the Faculty of **Veterinary Medicine** was most optimistic about OS' potential to detect unethical research practices [17].

[16] $\eta^2 p$ = .020

[17] Note that all effect sizes on significant differences between faculties mentioned above are all small to medium and must be interpreted with caution as sample size for each faculty is small (N = 24-71).

Discussion questions from Chapter 4

- The two most important drivers to engage in OS practices are quite contrasting in their focus namely, to **improve** the quality of scientific knowledge (promotion-focused) versus to **avoid** unethical research behaviours (prevention-focused). How can such contrasting motivations be reconciled in OS policy development and implementation?
- Considering that the **high work load** is reported as the most important barrier for practicing OS, how can academics be relieved from/ better supported in the the extra task loads that engaging in OS practices takes?
- The opportunities to increase **fairness, diversity** and more opportunities are not (yet) felt as important opportunities of OS, particularly by academics at higher function levels. What is needed to fulfill these promises?
- **Women** report **lack of support from their supervisor** as a stronger barrier to engage in OS compared to men. Why is this the case? And what should supervisors and leaders at UU and UMCU do to ensure that female and male academics alike are included in the developments to transition to OS research practices?
- For **assistant professors** in particular, a **lack of formal contract time** and **lack of recognition** are strong barriers to engage in OS practices. Why is this the case for this group, and how can they be better facilitated?

Chapter 5: Conclusion

This first open science monitor gives insightful information about OS awareness, behaviours and attitudes among researchers at UMCU and UU. It should be kept in mind that due to a low response rate (only ~7%) and the possible bias towards open science positively minded academics, the distribution might be different in the whole university. In the future, our aim is to implement an annual or biennial OS monitor with the goal to approach a larger proportion of the population and to measure changes and developments in the transition towards OS more reliably and sustainably at UU and UMCU. Based on the current initial results, we focus on four general conclusions we draw from this first OS monitor that set the stage for future research on OS.

Raising OS awareness

In this sample, the proportion of academics that was aware of most open science practices was high. Notably, there were three OS practices that signal a potential need to raise awareness, namely open materials, team science, and pre-registration.

Open materials is relatively new in the open science movement. Potentially, more needs to be invested in communicating *why* it could be potentially beneficial to share research materials openly with others, with *whom* such sharing should take place (e.g., fellow academics, interested societal stakeholders, the public?) and *how* this can be done conveniently on different platforms suitable for different types of researchers and audiences. For example, awareness should be raised that – apart from publishing in peer-reviewed journals – sharing research tools and materials can be an important deliverable or performance indicator as part of current recognition and rewards standards. Importantly, sharing research materials openly may feel like 'giving away' (Savage & Vickers, 2009). Therefore, conversations about the sense of ownership, team science, the level of openness needed in sharing research materials is important to ensure that academics can collaborate with others while still being able to identify with and be driven by their own expertise in their work (Pierce et al., 2008)

In our sample, about one-third of respondents had never heard of team science as an OS practice. This year the new vision on Recognition and Rewards of the University Utrecht was presented (www.uu.nl/sites/default/files/UU-Recognition-and-Rewards-Vision.pdf). The TRIPLE model was formulated and stands for: Team spirit; Research; Impact; Professional performance; Leadership; and Education. The 'T' is deliberately put first. It emphasizes that, at Utrecht University, team spirit, characterized by contributing, cooperating and exchanging, is the default approach to working in academia. Our ambition for the next OS monitor is to establish whether the implementation of the TRIPLE Recognition and Rewards model at UU, and academics' experience with it in upcoming performance reviews, might contribute to an increase in awareness about team science.

In our sample, 39% of participants was not aware of pre-registration practices. Moreover, a mere 8% of the respondents indicated this as 'very important' to their research. In some fields, preregistration is already normal/standing practice, such as in clinical trials in medicine and in some subfields within social sciences (e.g., experimental psychology; socio-neuroscience), promoted by outright and high-profile fraud scandals such as Diederik Stapel. The rationale behind why preregistration could be important is multi-faceted, but examples are often avoidance of unethical practices such as HARKing (Hypothesizing After the Results are Known), p-hacking (continuing data analysis until a significant p-value is obtained), and selective outcome reporting. Other, perhaps more positive reasons are to avoid hindsight or confirmation bias (e.g., providing a "time stamp" for researchers to remind them what was a priori predicted versus what should be considered explorative data analysis), as well as publication bias (e.g., pre-registered studies being already conditionally accepted for publication by journals, despite their outcome). There is an ongoing debate about what the benefits and

downsides of preregistration are and if all issues raised can and should be solved by preregistration (Devezer 2020, Rubin, 2020). Notably, as we also see in our data, academics are generally a bit more skeptic about pre-registration. And indeed, the idea that we can build 'surveillance' systems to exert control over potential immoral research behaviours is unreliable (Derksen & Rietschel, 2013). In that sense, academics may feel uncomfortable affiliating with the negative connotations associated with this OS practice. It is however important to note that, OS practices do not discourage exploring data, or creativity in research, it solely aims to provide a solid base for doing research. It is still very much possible to explore data without commencing in questionable research practices for instance (Wigboldus & Dotsch, 2016). In a next step, more insight in the associations that academics have with pre-registration practices is needed and potentially, awareness needs to be raised on what pre-registration practices can offer in terms of fair publication practices (see also Banks et al., 2018; Hollenbeck & Wright, 2017).

Closing attitude-behavior gaps

The main finding of this OS monitor is that there is a structural gap between attitudes and behaviours across all OS practices. The largest attitude-behavior gaps were detected for OS practices regarding data reproducibility and transparency (e.g., open source software, open code). These OS practices often require learning new and sometimes complex skills (e.g., learning R or JASP statistical software programs) and may be time-consuming (e.g. sharing code, data and meta-data in a comprehensible manner). As such there may be knowledge gaps and time constraints at play in applying these OS practices into daily work. This also means that there is potential for the UU to help and support academics better to translate their relatively positive attitudes towards OS into behaviours. Our evidence for a gap between attitudes and behaviours towards open science at UU is in line with an earlier OS monitor exhibited in 2018 among academics in the Social Sciences in Northern America (Christensen et al., 2019).

In a next step in research on OS at UU, it is important to gain better insight in why for example more than half of the respondents indicated to 'rarely or never share data' (53%) and why almost a third of respondents (32%) indicated that sharing data is of 'limited importance or not at all important for their research'. UU policy advocates that 'data should be shared unless this is not possible'. But what that means in practice is complex. Sharing data can be valuable if it inspires other researchers to build further from the scientific knowledge-base and when it inspires collaboration among scholars. A good dialogue and trust relationship is pivotal as well as establishment of a constructive error culture. But if open data sharing is imposed to instill a culture of "blame-and-punishment" because we question academics' moral nature, this is very unsafe (Edmonson, 2004; Scholten & Ellemers, 2016; Van Dyck et al., 2005). Sharing data is a complex and nuanced process, and it is important to acknowledge that there is no 'one-size-fits-all' approach, because for example ethical and privacy reasons, on how to do this (Bahlai et al., 2019; Banks et al., 2018). We consider the high level of importance that academics in this sample attach to sharing data as very positive in itself, and recognize the complexity of its application.

Open science ≈ inclusive science

There are small but systemic differences in attitudes and behaviours towards different OS practices across, gender, nationality, function level and faculty. Three differences stood out:

(1) PhD candidates structurally reported the largest gaps between their behavioral engagement in 9 out of 10 practices relative to their positive attitudes, and also relative to academics in higher function categories. These results consistent with a recent PNN survey showing that PhD candidates are typically not encouraged to engage in most of the open science practices (Matthijssen & van Doorn, 2020). Graduate schools could play an important role to improve this, by identifying how their educational programs can be improved to include more open

science skill training. In addition, PhD supervisors could play an important role to ensure access to and training in OS practices for PhD students. A future OS monitor could tap more specifically into what PhD candidates would need to be able to turn their positive attitudes towards OS into practice.

(2) Women reported a greater attitude-behavior gap than men on 6 out of 10 OS practices. Notably, particularly for OS practices concerning data reproducibility and transparency, namely open access publishing, open code and open source software, women's and men's reported attitudes were similarly positive, yet women reported that their behavioral engagement in these OS practices was significantly lower compared to men's. By contrast, men in the sample attributed less importance to communal OS practices, such as public engagement. This is in line with other work showing that engagement in OS practices is gendered (e.g., Murphy et al., 2020) along the lines of gender the false stereotypical associations we hold about men (as agentic, focused on things) and women (as communal, focused on people (Su & Rounds, 2015; Eagly & Steffen, 2000).

(3) Finally, somewhat to our surprise Dutch academics scored slightly lower on attitudes and/or behaviours of 7 out of 10 OS practices than non-Dutch academics. It is interesting to explore where these differences come from. We could speculate about reasons, such do researchers from abroad value team science more because they come for collaborations? Or do Dutch researchers find it harder to let go of old indicators, such as Journal Impact Factors and H-indexes, because they score well on those? The non-Dutch academics could play an important role in making open science, inclusive science and by being more positive about open science, these academics will act as role models. Furthermore, connections to other parts of the world (open science is and should be a collective movement) might be strengthened by the positive open science attitudes of non-Dutch academics.

Promoting opportunities and removing barriers to OS practices

Respondents perceived the improvement of the quality of scientific knowledge, detection of unethical research behavior and the increase of societal impact as the greatest opportunities to engage in OS practices. Both opportunities for OS have a very different focus and it may be quite challenging to reconcile both into one OS policy, as the first is focused on making research more open and transparent (error culture), while the other is focused on exerting more control over the research process to detect potential misbehavior by academics (fear culture).

Particularly early career academics in our sample (PhD and Post Docs) express that they perceive OS to have the potential to improve fairness in promotion systems and to create more opportunities in the careers of young academics. This perceived opportunity was lower among more senior academics (Assistant/ Associate/Full Profs). An important question for the future is how we can ensure that for a new generation of researchers, the transition to OS can indeed live up to its promise to improve fairness and opportunity in academic careers.

While academics in the sample strongly perceived the potential of open science for their research, they also indicate to experience obstacles that prevent them from engaging in OS practices. The most important obstacle is the high (extra) workload that prevents engaging with open science practices, the insufficient practical support and training from the department and the lack of formal contract time allocated to the extra effort that open science research requires. It would be interesting to investigate what kind of practical support is needed to stimulate OS practices and whether they are already available or should be developed. At for example the University Library and the Center for Science and Culture there is support available for many of the OS practices such as OA publishing, sharing data and public engagement. But at present it seems this support is insufficiently reaching the academics in an effective manner. What is needed to make these OS collaborations between academics and support staff work? Future research in the OS monitor will dive deeper into this.

Conclusion

The UU OS monitor 2020 has, for the first time, provided data on OS awareness, attitudes and behaviours among academics at UU and UMCU. These numbers will serve as a starting point for conversations. Where do we, Utrecht University, want to head to with OS? How should we shape the conversation and the policy around sharing data? What does pre-registration mean for the improved quality of research and what do these systems feel like for different researchers? Should all researchers become experts and engage in all the OS practices? Do we require a tailor-made approach to OS implementation across subgroups of academics at UU? In the end, we want impactful science and education, for society as a whole. These conversations should be held at various levels and with various people. For instance, this survey was sent out to all academic staff, but not to the support staff. It is important to have the reflections of support staff on these results, and it would be of value to include the support staff in the next surveys as well. The Faculty open science Teams can play an important role in facilitating these conversations.

Developments within the open science movement and movements within the UU can go fast. For example, when the survey was issued the MERIT model was the model under consideration for Recognition and Rewards. Now, the MERIT model morphed with some adaptations into the TRIPLE model. In this model Team is at the starting point, should this OS monitor also include questions on team level and on diverse aspects of public engagement? Also, in this monitor no questions were asked about education on open science, open educational resources or teaching OS skills. The UU will include these subjects in the Open Science Programme, so it might be relevant to add questions about these subjects to the OS monitor.

To conclude, we are optimistic about the generally positive attitudes towards OS practices in this Monitor. However, attitudes are generally not aligned with OS behaviours. Also, there is likely no one-size-fits-all approach on how OS practices should be implemented for different researchers at different career stages. Therefore, there is room for improvement in the OS behaviours and this report can be used for defining the action to undertake to reduce the attitude-behavior gap.

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APPENDIX A: JUSTIFICATION STATISTICAL APPROACH

Statistical software & analytical strategy

Data analysis used descriptive statistics (e.g. means, frequencies, crosstabs) and inferential statistics (e.g. univariate AN(C)OVA, repeated measure AN(C)OVA,). An overview of the statistical tests in different sections of each chapter can be found in Table A.1. We used the IBM SPSS Statistics version 27 software program to perform the calculations. Data organization and cleaning was executed in R. Graphs were built in Excel.

When applying inferential statistics, we concluded that there was a statistically significant difference if the p-value associated with a statistical test was equal or less than .05 ($p < .05$) and/or if the 95% confidence interval around a mean difference did not contain zero. We provide effect sizes (which vary from small ($\eta^2p = .01$), to medium ($\eta^2p = .06$). Note that due to the small sample size, we did not specify between-subjects interaction terms across subgroups in our inferential statistics. Investigating statistical differences between subgroups, would not be meaningful. Bar graphs provide a visual representation of differences between attitudes and behaviours and/or subgroup differences in attitude-behavior gaps.

The complete questionnaire, syntax, output, meta-data are provided on the following Yoda repository: [link will follow]. On this link we also provide the data on awareness, attitudes and behaviours on the 10 OS practices as well as perceived barriers and opportunities to OS. Note that ethical concerns regarding the guaranteeing of anonymity of participants' identity did not allow us to share (a combination of) information on the demographic or work background of participants. This data does allow for exploring relationships among awareness, attitudes, behaviours, opportunities and barriers regarding OS practices, which was beyond the scope of the current report.

Table A.1: Overview of the type of statistical analysis in the report.

Chapter	Variabele	(Inferential) statistical test
1	Sample description	Frequencies *(N, %)*, Descriptives *(M, SD)*
2	Step 1: Awareness, Attitudes and Behaviours OS practices	Frequencies *(N, %)*
2	Step 2: Attitude-Behavior Gap OS practices	Repeated Measures ANOVA (within-subjects) per OS practice
3	Group differences in the Attitude-Behavior Gap	Repeated Measures ANCOVA (within- and between-subjects per OS practice)
4	Step 1: Opportunities and Barriers to OS practices	Frequencies *(N, %)*
4	Step 2: Group differences in opportunities and barriers	Univariate ANOVA (between-subjects, only main effects)