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DELIVERABLE 2.1

"I DON'T GO ONLINE, BECAUSE THAT IS WHERE THE SKEPTICS ARE."

A REPORT ON INCENTIVE AND DISINCENTIVE STRUCTURES FOR RESEARCH AND INNOVATION STAKEHOLDERS TO ENGAGE IN SCIENCE COMMUNICATION

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CHAPTER 1: INTRODUCTION

Open and productive interactions between science and society are vital for a healthy democracy. The relationship between science and wider society is a crucial aspect of how our society develops and addresses societal challenges. The aim of the EU-project RETHINK is to examine how science communication can contribute to a better science-society relationship. At the heart of the project lie two trends. First of all, that *boundaries between science and society are blurring* (Nowotny et al. 2001). First, science and society have become transgressive arenas, in which the boundaries between the two have become blurred. Society has started to speak back to science, also concerning the social and cultural implications of scientific and technological development. Furthermore, the interactions and interfaces between science and other fields in society such as economics, politics, art and culture have become more numerous and diverse. This has manifested itself in different forms of communication between scientific institutions, societal organizations and citizens in general. At the same time, the rising interaction of science and society brings about challenges: the range of actors involved in public discussions relating to science is increasing. This implies that the range of issues that are brought into such discussions also increases (Wynne 2001). Scientific knowledge is only one of the ingredients herein. Discussions on 'facts', i.e. on what is considered true or not, are always influenced by the values, ideologies and interests of the specific actor (Jasanoff, 2007). Evidently, this has made public discussions on science ever more complex. In this light, mutual trust between scientists and society is crucial. Even though trust in science institutions is still relatively high, in specific issues, such as climate change and biotechnology, trust in science varies significantly (Hendriks, Kienhues & Bromme 2016). In response to such challenges, (part of) the scientific community increasingly embraces public engagement as a means to generate and maintain trust (Bubela et al. 2009; Irwin 2012).

The second trend we consider – that strongly feeds into the aforementioned trend – is *digitalization.* The emergence of the internet and social media revolutionized the science communication landscape. and has fundamentally changed how scientists, other R&I stakeholders and a variety of publics interact and communicate (Bubela et al. 2009). The nature of the media system is disruptively altered, creating various new low-cost channels, resources and opportunity for a variety of publics to either find information or generate information themselves (Rutsaert et al. 2013). This may enable motivated citizens to learn about science and become involved in collective decision-making. At the same time, due to the fragmentation of the media landscape the public often reads and watches information about science from sources where the traditional media's editorial oversight and fact checking are lacking (Trench 2007). Indeed, digitalization also raises fundamental challenges. Consider for instance, the abundance of information available online on the Corona virus outbreak – accurate or flawed – which makes it very difficult for individuals to understand and evaluate the situation. In order to do so, citizens have to make sense of the complex reality they are facing, in which they are confronted with an overload of information that, additionally, can be inaccurate, incomplete or even biased.

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In this context, science communication is important. For the purpose of this study we employ a broad definition of science communication (or public engagement as we will elaborate below), spanning a broad spectrum of activities of scientists, journalists and other professionals aiming to disseminate scientific knowledge or facilitate public dialogue through which lay persons are encouraged to participate in science debates and policy. The practice of science communication thus aims to fulfil a valuable role in establishing and maintaining mutual trust and moreover in contributing to an open and productive relationship between science and society. Over the past decades, the theory and practice of science communication underwent fundamental changes, in which scholarly efforts played an important facilitating role. An important example hereof is the critique of the so-called 'deficit-model'. A dominant assumption among many scientists and policymakers is that ignorance, i.e. a lack of knowledge is at the root of public opposition against scientific developments. Accordingly, science communication initiatives are therefore directed at informing the public as to fill in the 'deficit' in knowledge, hoping that if members of the public only understood the scientific facts, they would be more likely to agree with the experts (Bubela et al. 2009). Yet the narrow emphasis of the deficit approach does not recognize that knowledge is only one factor among many influences that are likely to guide how individuals reach judgments; underlying interests, moral values and cultural beliefs play a fundamental role in shaping public views about science (ibid.; Nisbet & Scheufele 2009). In this light, about two decades ago, the science communication discourse shifted towards more interactive and participative models that emphasize deliberative contexts in which a variety of stakeholders and laypeople can participate in a dialog so that a plurality of views can inform research priorities and science policy, for instance through citizen juries or consensus conferences. The emergence of such models can also be viewed as a way to contribute to the quality of interactions between scientists and society that already take place in the wider public debate (Bubela et al. 2009; Jasanoff 2011; Van Est et al. 2012).

Yet, persistent challenges remain and new challenges emerge. For instance, as Nisbet and Scheufele (2011) pointed out, (at least part of) the scientific community still struggles with the aforementioned assumption that deficits in public knowledge are the central factor in social conflicts and controversies about science. The move from deficit to dialogue has become the "grand narrative" of the field of science communication. At the same time, that narrative is critiqued for misrepresenting both the historical and current diversity of activities and purposes in the field. The two different models have always co-existed and still do today. Alan Irwin conceptualizes the deficit and democratic models (those focussing on dialogue) of science communication as different 'orders' of thinking about the more general relationship between science and society. 'First-order' thinking, linked to the deficit model, is traced back to enlightenment thinking, highly values scientific and technical expertise and adheres to a rational, top-down expert-driven view on science governance. 'Second order' thinking, in contrast, emphasizes deliberation and participation, values different forms of expertise and propagates a pluralistic and democratic approach to science governance. The tension between deficit and dialogue models represents the tension between two competing normative ideologies about the public, science and their relationships.

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Furthermore, novel challenges arise for instance in the context of the emerging new digital media; scientific evidence can be disregarded as 'just another opinion', which can now be amplified through online echo chambers (Bubela et al. 2009). Evidently, this poses an important challenge for science communication scholars and practitioners alike. At the same time, the internet and social media have increased the possibilities for scientific institutions and individual scientists to engage in science communication themselves. Traditional journalists are no longer the 'gatekeepers' of science news, i.e. they are no longer "the principle arbiters of what scientific information enters the public domain and how it does it" (Trench 2008, p.141).

In sum, the current science communication ecosystem is widely diverse: science and society meet at multiple interfaces, communication takes place in several directions, and different models and ideologies are upheld. Moreover, digitalization intensifies the dynamics in this ecosystem in a fundamental manner. How can science communicators move forward purposefully and effectively in this highly complex ecosystem? From the perspective of RETHINK, we view the possibilities for scientists and scientific institutions to communicate and engage with the public and other stakeholders through the internet and online media as an important opportunity to strengthen science-society interactions. Evidently, scientists themselves play a pivotal role in strengthening the interaction between science and society, but in order to benefit from the opportunities of digitalization, they should be willing and able to engage with the public online. So, what motivates scientists to engage with the public, online or offline? What holds them back? The aim of this study is to provide insights into the *incentives, disincentives and facilitators and barriers for scientists to engage in science communication*. In doing so, we distinguish five different societal spheres of influence: *1) the individual sphere*, *2) interpersonal sphere, 3) organizational sphere, 4) science community and science policy sphere* and last, *5) the societal sphere*. It is important to distinguish such different spheres as to better understand where incentives or disincentives stem from. Scientists may be reluctant to conduct public engagement, due to a variety of reasons: they may for instance, relate to a lack of personal skills (individual), or because a lack of support from peers (interpersonal) the university they are working at (organizational) or that national policies do not have any support schemes, etcetera. Insight into such (dis)incentive structures and in which sphere they originate, will enable us to (better) identify possible points for intervention, for instance in terms of identifying trainings that are needed or recommended changes in (university or governmental) policies.

In order to examine (dis)incentives for scientists to conduct online public engagement, we conducted interviews with scientists stemming from the seven European countries that we focus on in the RETHINK project, as well as a literature review. The findings hereof will be discussed in this document. The document is structured as follows. First, we will briefly discuss our understanding of public engagement, and particularly online engagement, and introduce the socio-ecological model on (dis)incentives that we use to analyze our results. Next, we will discuss the findings of the literature review, followed by the findings of the interviews we conducted. Last, we will elaborate on our findings in a discussion section and share our conclusions.

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Furthermore, we point out that this document does not represent the final stop on RETHINK's research on (dis)incentive structures for scientists conduct online public engagement. Rather we see it as a stepping stone in this process and will continue to report on our findings through other means at later stages of the project.

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CHAPTER 2: THEORETICAL FRAMEWORK

In this study we aim to examine motivations of scientists to engage in online public engagement. First of all, we note that we mostly speak of public engagement, rather than science communication, since the term public engagement has become strongly associated with two-way (or multi-way) communication models, in addition to one-way communication approaches, which is important given the broad range of activities that we aim to discuss. In this chapter we first briefly outline our understanding of public engagement as well as how we understand *online* public engagement. Additionally, we will provide examples of public engagement practices. Furthermore, we introduce the analytical framework we employ to analyse scientists' motivations to engage in online public engagement. To this end we draw from the Social-Ecological Theory (SET), which helps us to understand the personal motivations of scientists towards online public engagement, but also allows us to place them in the broader context that surrounds the individual scientist and how this may influence their motivations.

2.1 CONCEPTUALIZING PUBLIC ENGAGEMENT

For the purposes of this study, we employ a broad definition of public engagement, spanning a broad range of activities through which scientists communicate with society, e.g. the public or stakeholders. On the one hand of the spectrum, we consider dissemination activities, aimed at the transfer of knowledge from science to wider society. Dissemination can be a legitimate and even necessary one-way transfer of science information, for instance to foster scientific citizenship. However, as mentioned in the introduction, since the 1990s, deficit thinking has been criticized extensively by social scientists both on empirical and theoretical grounds. Against this backdrop, new models and assumptions of science communication emerged, all of which have in common that various degrees of two-way (or even multi-way) communication are emphasized. (Davies and Horst 2016; Jensen & Hollman 2016; Trench 2008). Such models use a more contextual view of the science-society relationship. They emphasize the legitimacy of different sources of knowledge and ways of knowing and the inseparable role of values and ideals in complex societal issues. The shift towards dialogue models coincided with a more general call for public influence and participation in decision-making in response to a lack of trust in science and other powerful institutions including the government (Wilsdon, Wynne & Stilgoe 2005).

Given the different models of public engagement, and due to the increasingly blurring boundaries of science and society, contemporary public engagement practices and their purposes vary to a great extent. The contemporary public engagement (or science communication) ecosystem consists of a variety of actors and practices, all interconnected in different ways. It contains many niches in which different practices are sustained and different activities take place. Probably the most familiar is the media, with a focus on news coverage, the reporting and discussion of science. Another niche is constituted activities with a more educational or cultural orientation, for example oriented at fostering scientific citizenship. As a final example,

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there is the niche of deliberative forums, oriented at public engagement and dialogue to influence the research process, science policy and politics. These and other niches together make up a public engagement landscape that is dynamic and diverse.

2.2 CONCEPTUALIZING ONLINE PUBLIC ENGAGEMENT

For the purposes of our study we thus understand public engagement as a broad range of communication activities from scientists that include both one-way and two-way interactions with wider society. Furthermore, we need to elaborate on what we mean by *online* public engagement. The emergence of the internet and social media, i.e. the digital sphere, has radically changed the science communication landscape. While there has been a decline of science coverage in the traditional media, science content on social media, stemming from increasing variety of sources, have risen (Fahy & Nisbet 2011). Social media, comprising a wide range of digital communication platforms such as sites for social networking, video-and picture-sharing, blogs, and microblogs, give the public new means for receiving information about science, but also generate information themselves (Rutsaert et al. 2013). Digitalization turns everyone from being a passive audience into active producers of media content. This means that traditional journalists are no longer the 'gatekeepers' of science news. Journalists now compete with individual scientists herein. From the perspective of the scientist the emerging digital sphere provided novel opportunities for the aforementioned public engagement activities, both one-way and multi-way oriented (cf. Fahy & Nisbet 2011). For instance, scientists may respectively give online lectures or engage with stakeholders and the public through social media. In our literature review and interviews we focused specifically on such online public engagement. However, we note that it was our assumption that offline and online public engagement practices mutually shape each other. More, we see offline and online public engagement as a continuum as opposed to a dichotomy. For example, activities that scientist may undertake online might be informed by their personal experiences offline. Regarding offline and online public engagement herein would suggest a separate process that is not representative for the experienced reality of scientists. Accordingly, offline as well as online public engagement (or public engagement in general, for that matter) was discussed both in the interviews.

2.3 ANALYTICAL FRAMEWORK

To comprehensively understand scientists' involvement in public engagement, this study focuses both on the individual perspectives of scientists as well as incentives, disincentives, facilitators and barriers that reside in the broader environment of scientists. The Social-Ecological Theory (SET) can be used to understand what broader contexts surround individual scientists and how they might interact (e.g. Amel et al., 2017). Spheres are in dynamic interaction with each other and with the individual scientist (McLeroy, 1988). This study distinghuished where scientists' individual perspectives, skills or reflections on science-society interactions versus external factors played a role in science communication activities undertaken by scientists. To this end

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the social-ecological model was used as an analytical framework, wherein spheres were categorized in order of proximity to the scientist. This framework was used as a basis for the development of the interview guideline as well as analysis of interviews to identify incentives, disincentives, facilitators and barriers of scientists to engage in science communication on different spheres of influence. The spheres considered in this framework are outlined as follows:

1. Individual: The individual sphere entails factors that arise purely from within a person, such as skills, personality attributes and feelings. Individual factors are of importance as they reveal intrinsic motivations as well as personal interests, preferences and competence.

2. Interpersonal: The interpersonal sphere is relevant for acknowledging the social influences on scientists, i.e. all forms of interactions between individuals in their social network, including significant others, colleagues or students.

3. Organizational: The organizational sphere demands consideration as it relates directly to scientists' work environment, guiding their research-related activities, including the communication of it. The organizational factors include the infrastructure, policies or reward systems.

4. Scientific community, culture and policy: The scientific community and culture sphere forms a distinct sphere because it reaches beyond the organization and includes norms or guidelines by publishing companies, traditions and culture in science and/or perceptions of scientists on status within the scientific community. More, the policy sphere is considered because it provides guidance and is closely connected to norms and guidelines that are broader than the organizational. The policy sphere includes funding, agendas and procedures from a local to international level.

5. Societal: The societal sphere is highly relevant because the ultimate goal of science communication is to connect society with science, so motivational factors need to be identified for maximum effect. Examples include reactions from audiences, public trends or cultural aspects.

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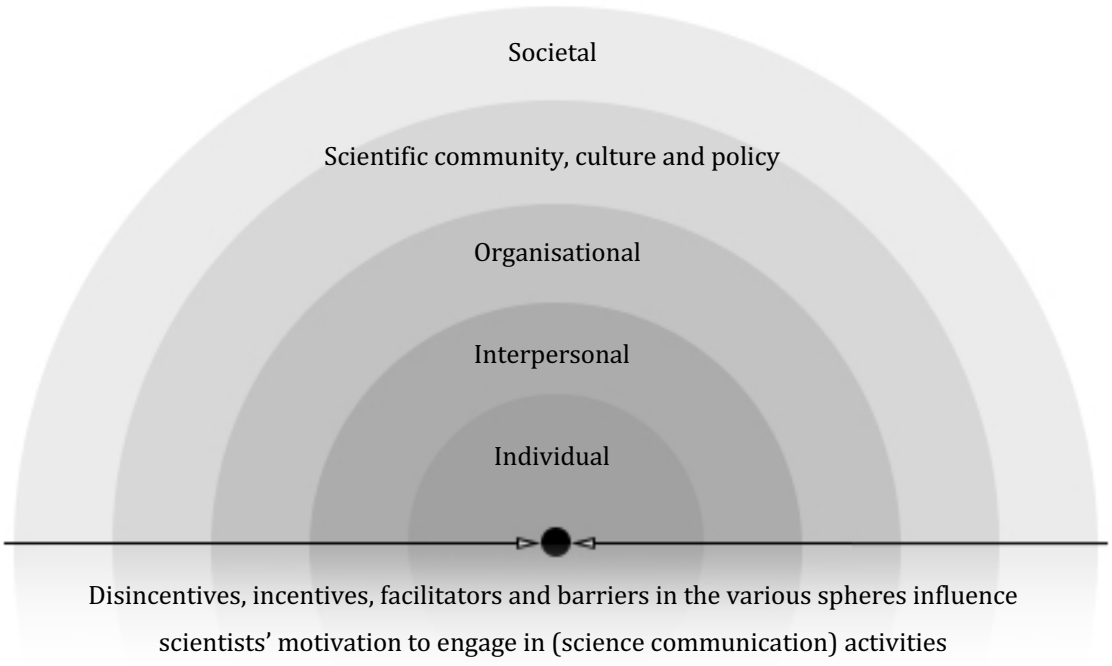

Figure 1: The social-ecological model describes that various disincentives, incentives, facilitators and bariers on within the depicted spheres of influence that surround individual scientists influence behavioral motivation. In this framework, the spheres wherein scientists are embedded are the interpersonal, organizational, scientific community, culture and policy and the societal sphere. They influence behavorial motivation: negative influences are disincentives and barriers, whereas positive influneces are incentives and facilitators for scientists to engage in science communication.

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CHAPTER 3: METHODS

The RETHINK project aims to provide an unprecedented view of the European science communication landscape, both online and offline, to reveal the barriers and inequalities that stand in the way of open and reflexive connections between science and society. As a part of this larger goal, deliverable 2.1 aims to zoom in on the (dis)incentives of scientists to engage in science communication. The main aim of deliverable 2.1 is to explore facilitators, barriers, incentives and disincentives on different levels. This chapter outlines the chosen study design, a description of the countries in focus within the RETHINK project, methods used for the conducted systematic literature review and interviews and an overview of study population.

3.1 STUDY DESIGN

This study deployed the combination of a systematic literature study and in-depth interviews with scientists, in order to: 1) obtain an overview of existing literature on (dis)incentives, facilitators and barriers in scientists' engagement in online science communication, and 2) obtain in-depth insights into the perspectives and experiences of scientists' engagement in both online and offline science communication, throughout Europe. The systematic literature search was conducted to obtain an overview of factors that facilitate or block scientists to engage science communication, and specifically focused on the digital sphere. Additionally, interviews were conducted to explore scientists' perspectives and their context or environment in detail.

3.1.1 LITERATURE REVIEW

A systematic literature search was conducted to obtain an overview of scientists' (dis)incentives, facilitators and barriers to engage in online science communication. The PRISMA 2009 checklist was used to ensure the quality of this search[1]. Subsequently, the search for relevant literature went through stages adopted from the PRISMA 2009 flow diagram: 1) Identification: potentially relevant articles were identified in SCOPUS and Web of Science based on the search strategy; 2) Screening: the title, abstract and keywords of each potentially relevant article were assessed based on predetermined criteria; 3) Eligibility: articles included after screening were assessed based on predetermined criteria to exclude articles not deemed relevant, and a definitive list of

[1] Preferred Reporting Items for Systematic reviews and Meta-Analyses (or, PRISMA) is a guideline for systematic reviews and meta-analyses. The PRISMA Statement consists of a 27-item checklist and a four-phase flow diagram. The checklist includes items deemed essential for transparent reporting of a systematic review. See Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, et al. (2009). The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. PLoS Med 6(7): e1000100. doi:10.1371/journal.pmed.1000100

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relevant articles for this literature review was made, and; 4) Analysis: the collected relevant literature was analysed, compared and discussed.

SEARCH STRATEGY AND INCLUSION CRITERIA

In phase 1 of this literature study, a scoping and pearl-growing search was conducted to better comprehend the context and terminology of this study's topic. Scoping articles help to better understand existing studies on the research' topic and help to develop a list of search terms that can be used in the full-scale search (Booth, 2008). Scoping and pearl-growing articles provided this study with relevant search terms (table 1). For example, scoping and pearl-growing articles indicated terms that characterize public engagement with science and synonyms that are often used in literature. A larger supply of relevant key articles was subsequently identified by 'citation analysis' – an analysis that identifies the impact of any author or article and yields the precise terms needed for a good search (Booth, 2008).

The search strategy in this study was based on search terms relevant to six key concepts included in the research question. Search terms were categorized into four major topics: public engagement with science, online, incentive, disincentive, facilitator and barrier (Appendix A). These terms are further defined and operationalized in Appendix A. Next to these key concepts also often used synonymes in literature were identified. For example, based on the definition of 'incentive' (i.e. factors that motivate or encourage someone to take a particular action) also terms such as 'motivation' or 'stimulation' would fit the concept 'incentive'. Therefore, the search strategy applied in this study included synonyms – which can be found in Appendix A. These synonyms were chosen based on their appearance in preliminary reviewed related articles. The full search strategy and search syntax can be found in appendix B.

Phase two of this study regarded in- and exlusion criteria for title and abstract screening and full text screening. The search only focused on peer reviewed articles and literature reviews. Only articles in English were included. Articles that mentioned science communication in the form of engagement and the use of online platforms were included. All articles that were not about science communication or communicating science in any discipline were excluded. This was based on the assumption that online science communication might work differently than other forms of online communication. This literature study focused on online science communication primarily, in order to identify facilitators, barriers, incentives and disincentives that regard the online sphere. Subsequently, only articles that regarded online activities were included. More, this literature study included articles that focused on a combination of science communication models. Hence, articles displaying a single focus on dissemination activities regarding science communication communication were excluded. Yet, articles that acknowledge and use multiple science communication models were not excluded, as long as the factors, whether these side with dissemination or other modes to science communication, could be distinguished. Articles that did not explicitly use the synonym terms were evaluated based on context and on the authors' description of the process of science communication. Here the division was roughly made by identifying whether the authors described science communication as one-way communication or two/multi-directional

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communication. Since the aim of this review was to provide a list of (dis)incentives, facilitators and barriers for practical application. Therefore, this review only included articles that provide factors which affect scientists to engage online science communication. This review focuses on factors affecting scientists engaging in online science communication within the European Union, which sets the specific context of scientists within Europe. However, data from other parts of the world were not excluded, for (too) little relevant articles were found that matched inclusion criteria and regarded the European context only.

INCLUDED ARTICLES

The review of the extracted data started with a characterisation of the articles by shedding a light on the type of digital sphere investigated, the used definition of science communication, a description of the authors' conclusion on scientists' engagement with online science communication and related (dis)incentives. In total, 539 articles were eligible for title abstract screening, after which 89 articles we selected for full text screening. Thirteen articles were included in the literature review. The aim of the literature study was to obtain an overview of (dis)incentives of scientists to engage in science communication, whereby a specific focus was put on the experiences of scientists with online platforms. Since an overview of existing literature and a review of the possible (dis)incentives of scientists was strived after, articles of all regions – not limited to the EU – were included. A list of articles and their characteristics can be found in Table 1.

Table 1: Included articles in the systematic literature review and their characteristics.

Authors	**Online platform**	**Research method**	**Research region**
Besley (2015)	Social web	Survey (n=431)	USA
Walsh (2015)	News channel	Case study	USA
AbiGhannam (2016)	Social web	Interviews (n=43)	Online community
Knight & Kaye (2016)	Twitter	Survey (n=181)	Online community
Dermentzi et al. (2016)	Social networking sites	Survey (n=370)	Europe
Ranger & Bultitude (2016)	Blog	Interview (n=7)	USA
Wang et al. (2017)	Social web	Review	NA
McClain (2017)	Facebook	Survey (n=203)	Online community
Scheliga et al. (2018)	Social web	Case study (n=12)	Germany
Dermentzi & Papagiannidis (2018)	Social web	Survey (n=205)	Europe

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Hara et al. (2019)	Reddit	Survey (n=70), content analysis (n=1,363)	Online community
Sajeev et al. (2019)	Blogs	Case study (n=1)	Austria
Jones et al. (2019)	Reddit	Interview (n=18), content analysis (n=11,859)	Online community

3.1.2 INTERVIEWS

Semi-structured interviews were conducted to obtain the perspectives and experiences of scientists on their motivation to engage in online and offline science communication. Selection criteria for scientists are described here below. Semi-structured interviews allowed the researcher to steer the interviews into a direction relevant for the research, without interfering too abundantly with the perceptions of the interviewee (Ritchie, J. & Lewis, 2003). To this end interviews were structured as follows: 1) Current dynamics in societal discussions on the interviewees field of research, for example topics that are discussed or science that is contested; 2) Practiced science communication activities (both online and offline); and 3) Facilitators and barriers to engage in science communication activities on a personal, interpersonal, organisational, policy and societal level. Additionally, the different spheres of influence that surround scientists was consulted as topic list. Semi- structured interviews therefore kept a focus on the research topics, and still provided the interviewee with the opportunity to elaborate on unanticipated yet relevant themes that were described in the theoretical framework under section 2.

PARTICIPANT SELECTION CRITERIA AND REQRUITMENT

The RETHINK project aims to cover the European science communication landscape. Hence, the RETHINK project has seven participating focus countries: Italy, the Netherlands, Poland, Portugal, Serbia, Sweden and the United Kingdom. Participants were included in this study if they worked in one of those seven countries. As the RETHINK project strives to provide insights into fields of science that are increasingly contested in societal discussions, this project has selected a number of cases. These cases focus on areas of science and technology development that are expected to contribute significantly to the resolution of important societal challenges, but are at the same time (potentially) contested in the public sphere. Based on criteria such as societal impact, relevance for lived experience, relevance for the participating focus countries within RETHINK, diversity in perspectives, level of (scientific) uncertainty, expertise and controversy, the cases covered in RETHINK are: climate change, AI and healthy diets. Scientists were included in this study if they are linked to these fields of research. Lastly, scientists were included both when they actively practice science communication online, as well as scientists who are familiar with online science communication but are not engaged in it themselves – for this study aims to capture both scientists' motivators as well as (perceived) barriers for online science communication.

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Third parties of the participating countries in the RETHINK project were given these participant criteria and subsequently recommended participants for this study. Participants were send information about the RETHINK project and the focus of this study, and an invitation through email. More participants were recruited through snowballing method, wherein the interviewed participants indicated to know scientists who we should interview as well. All interviews were held via skype, audio recorded and transcribed verbatim. In order to interpret the meaning of the data as emerged from the transcripts, some transcripts were first coded by using open coding. All transcripts were further analysed by axial coding – i.e. coding on basis of a coding book that is constructed with help of a the theoretical framework as described in section 2. In this study, axial coding was done according to the theoretical framework, and with the use of data analysis software ATLAS.ti. Categories that described the causal relation and the consequences of interactions between factors regarding relevant concepts of this study were included (Strauss, A. L., & Corbin, 1990). In conclusion, this study strived after a balance of scientists, who: 1) work in in fields related to the in RETHINK defined cases *climate change, AI and healthy diets, 2)* originate from one of the *seven European countries* covered in the RETHINK project, 3) who are in different stages of their academic career, and 4) who have, have little or have no experience with (online) science communication.

PARTICIPANT CHARACTERISTICS

Scientist from various countries, fields of research and organisations and in different stages of their academic career were included. In total, 26 scientists participated in this study, of whom eight scientists work in healthy diets related research, nine scientists work in research fields related to climate change and nine scientists in AI-related research fields. All participants indicated to do some form of science communication, either online or offline. This study aimed to cover all three research fields per country – which was achieved in all countries but Italy and Poland. In total, one scientist from Italy and two scientists from Poland participated. The rest of the participants covered the research fields once or even twice, as three scientists from Portugal, five from Serbia, six from Sweden, six from the Netherlands and three from the United Kingdom participated. Twelve female scientists and fourteen male scientists participated. We interviewed scientists in all stages of a researcher's career: three PhD-students, three post-doctoral researchers, five assistant professors, six associate professors and six full professors. Four researchers were categorised as 'senior researcher', because they worked in a research institute where no academic levels were distinguished. An overview of the study population characteristics can be found in Table 2.

Table 2: Overview of the participants' characteristics.

Respondent	Academic level	Country	Research field	Gender
1	Full professor	Portugal	AI	Male

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2	Full professor	Serbia	Healthy diets	Female
3	Full professor	Serbia	AI	Male
4	Full professor	Serbia	Climate Change	Female
5	Full professor	Sweden	AI	Male
6	Full professor	United Kingdom	Climate Change	Female
7	Associate Professor	Portugal	AI	Female
8	Associate professor	Serbia	Healthy diets	Female
9	Associate professor	Sweden	Healthy diets	Female
10	Associate professor	Sweden	AI	Male
11	Associate professor	The Netherlands	Healthy diets	Male
12	Associate professor	United Kingdom	Healthy diets	Male
13	Assistant professor	Italy	Climate Change	Male
14	Assistant professor	Portugal	Climate Change	Male
15	Assistant professor	Serbia	Climate Change	Male
16	Assistant professor	Sweden	AI	Female
17	Assistant professor	The Netherlands	AI	Male
18	Post-doc	The Netherlands	Healthy diets	Female
19	Post-doc	The Netherlands	Climate Change	Male
20	Post-doc	The Netherlands	Climate Change	Female

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21	PhD-student	Poland	AI	Male
22	PhD-student	The Netherlands	Healthy diets	Female
23	Senior researcher	Poland	Healthy diets	Female
24	Senior researcher	Sweden	Climate Change	Male
25	Senior researcher	Sweden	Climate Change	Male
26	Senior researcher	United Kingdom	AI	Female

3.2 ETHICAL CONSIDERATIONS

All respondents voluntarily took part and were fully informed of the purpose and content of the study. Consent was obtained for using their provided information and the respondents were free to withdraw from the study at any time. For an open and honest relationship, respondents have the freedom to contact the interviewer for questions, concerns and remarks, which are handled with care. The privacy of participants is protected by means of restricted access to the data and exclusions of personal and organizational details regarding respondents' identities. Personal and organizational details of participants are known to the research team.

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CHAPTER 4: RESULTS

PART A: RESULTS LITERATURE SEARCH

In this section we briefly discuss the results of a literature review on incentives, disincentives, facilitators and barriers for scientists to engage with the public online. In the systematic literature review we conducted, we identified over 30 factors that influence scientists' motivation for conducting public engagement. We organized them in overarching themes, discussed alongside the five different societal spheres of influence we outlined before. First, we will discuss themes relating to the personal sphere (4.1). The next paragraph is dedicated to the interpersonal, organizational and scientific community & policy spheres, which are discussed together (4.2). Last, we discuss the societal sphere (4.3).

4.1 PERSONAL SPHERE

On a personal level we identify a number of important incentives and disincentives to engage in online public engagement, which can be grouped under *intrinsic personal motivations, capability* and *professional personal reasons.* Last, we also share a number of observations on the *nature of the digital sphere* and how they relate to personal motivations.

4.1.1 INTRINSIC PERSONAL MOTIVATIONS AND BARRIERS

First of all, many scientists have intrinsic personal motivations that drive them towards online public engagement, connected to a deep passion or even love for science (Ranger & Bultitude 2016; AbiGhannam 2016). This drive is closely connected to the theme of *giving back to society,* which can take place in multiple forms. Jones et al. (2019) found that scientists for instance, want to comment on discussions and engage with questions from the public on online discussion websites (ODW), such as Reddit. Sajeev et al. (2019) even spoke of a sense of obligation to contribute. The second intrinsic reason is the aspiration to educate. Across the articles, this reason can be found in slightly different wordings, such as wanting to share scientific knowledge (AbiGhannam 2016), answering questions (Jones et al., 2019) and correcting misinformation (Hara et al. 2019). Lastly, AbiGhannam (2016) also mentioned the aspiration to make science entertaining for a broader public as an important reason for online engagement.

Conversely, connected to such personal motivations, disincentives arise as well. In the context of online discussion websites, Hara et al. (2019) found that 'not being able to answer all of the questions' as one of the least pleasant experiences when they try to answer scientific questions from the public. Such experience or fear thereof can even be an important reason for scientists to refrain from conducting online engagement.

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Furthermore, engaging in online media was mentioned to be a way to escape day to day work routine (AbiGhannam 2016) and thus provide a pleasant distraction. This implies also that such scientists reach out because they want to and not because they necessarily need to. Finally, the last general incentive is rather straightforward: some scientists are motivated by financial incentives.

4.1.2 CAPABILITY

Furthermore, capability – or self-perceived capability – to conduct online engagement is an important factor. Technical skills, i.e. an understanding of how online media function and being able to use them, is important in this regard. Besley (2015) and Dermentzi et al. (2016) identified that confidence positively affects them to engage online. Conversely, a lack hereof can also be a serious barrier (Dermentzi et al. 2016). Scientists may be unfamiliar with using online media. Dermentzi & Papagiannidis (2018) pointed out the possibility that some scientists experience this as emotionally challenging.

4.1.3 PROFESSIONAL MOTIVATIONS AND BARRIERS

The next set of incentives are related to driving the professional career of the scientists. First of all, we identified an overarching theme of *visibility and networking.* AbiGhannam (2016) found that reaching a broader audience o make the scientist more visible is an important motivation. Relatedly, creating and maintaining a network is important, not in the least part in order to interact with other scientists (Dermentzi et al. 2016; Knight & Kaye 2016). Creating and maintaining a professional image for both the general public (Dermentzi & Papagiannidis, 2018) as for academic peers (Dermentzi et al. 2016) is important in this regard. Social networking sites are in sum considered powerful tools to support visibility and networking. As mentioned hereabove, conversely, there is also a fear to damage this public image, by not being able to answer questions.

The next mostly career-driven incentive is the desire for personal development, as some scientists are motivated by learning and self-development through challenging themselves in science communication (Ranger & Bultitude 2016; Sajeev et al., 2019). For example, some scientists like to improve their capacity in writing, which is an important competence for science communication in general (Sajeev et al., 2019). Last, Dermentzi & Papagiannidis (2018) also observe the pattern of some scientists' interest in finding out the public's opinions and needs. This motivation is evidently, an important insight in light of RETHINK's aspiration to foster democratization and opining up science.

In sum, scientists may have several personal and professional reasons to engage in online public engagement. However, by lowering the barriers between the public and themselves through online media, some scientists fear the blurring of the 'personal/professional boundary' (Dermentzi & Papagiannidis 2018; McClain 2017; Knight & Kaye 2016).

4.1.4 THE MULTI-FACETED NATURE OF THE DIGITAL SPHERE

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In the preceding we discussed a number of reasons for scientists to engage in online public engagement, or hold them back. Some of these reasons may apply to public engagement in general, others are closely connected to the nature of the digital sphere. In this paragraph we will shed a brief light hereon, since the literature review also highlighted a number of interesting notions that relate specifically to the possibilities and limitations of what online media allow or how they function in a technical sense. In this light it is important to note that the digital sphere comprises of several online media. On the one hand, several online media may be relatively easy to use for both scientists and the public (Dermentzi & Papagiannidis, 2018; McClain, 2017; Hara et al., 2019) providing potentially an interesting meeting space. At the same time, different media each have their own peculiar traits. Twitter, characterized by its short 280-word posts, differs from vlogging on YouTube and curating a blog is widely different from the image-oriented Instagram. Jones et al. (2019) zoomed in specifically on the open discussion website Reddit, where the main purpose is to discuss, and hence '*enable*[s] *valuable dialogue*' and fosters more and broader participation from the public. On the one hand this feeds into motivations that scientist may have to conduct online engagement. At the same time, Reddit uses an up-vote system which means topics that inherently attract less interest from the public will get buried sooner and thereby creates a barrier for scientists from less popular topics to reach the public (ibid.). Blogs represent another medium, which predominantly aim at sharing information with the additional possibility to interact with the public through the comment section. Blogging is however, at the same time, very time-consuming (Wade & Sharp, 2012).

The main message we take from this, is that when we speak of the internet, social media or the online sphere, we actually mean a multitude of different media, each of them providing different limitations and opportunities, depending on what aims the scientist has. However, the very existence of these kinds of online platforms therefore lowers the barriers between science and society. As Scheliga et al. (2015) and Jones et al. (2019) describe, it allows individual scientists to engage and interact directly with a larger group and moreover makes engagement more accessible by allowing the public – and scientists – to engage wherever they are (Hara et al. 2019).

4.2 INTERPERSONAL, ORGANIZATION, SCIENCE COMMUNITY AND POLICY SPHERE

In this paragraph we discuss incentives and disincentives relating to three different spheres, namely the *interpersonal*, *organizational* and last the *scientific community & policy sphere.* The reasons to cluster these in one paragraph are twofold: first of all, the literature study showed less results hereon, in comparison to the personal and societal spheres. Second, these three different spheres relate strongly to each other (yet, they will be discussed in different sub-paragraphs in order to do justice to their specific role).

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4.2.1 INTERPERSONAL: ENCOURAGEMENT AND DISCOURAGEMENT FROM PEERS

A very direct barrier for scientists to engage in online science communication is the discouragement from peers or others. AbiGhannam (2016) found that some of her respondents find it hard to convince their peers of the importance of science communication, but this difficulty seems to differ per field of science. Conversely, this may be an important stimulant as well; encouragement of peers has been reported to have a significant positive influence on several occasions (AbiGhannam, 2016; Dermentzi et al., 2016; Dermentzi & Papagiannidis, 2018; Hara et al., 2019).

4.2.2 ORGANIZATIONAL SPHERE: INSTITUTIONAL COMMITMENT AND LACK OF TIME

Several incentives or disincentives for online public engagement originate predominantly at an organizational level. In relation to the former paragraph Besley (2015) showed that the more scientists contribute to debates, the more motivating it became for other scientists to be willing to engage. More specifically Hara et al. (2019) observed collaboration on an online discussion website between scientists also has a positive effect on their attitude toward online science communication. Again, on the flip side of the coin, some institutes are still hesitant about the legitimacy of online engagement activities as way to reach the public and consider this a 'volunteer activity' (McClain, 2017), which evidently does not motivate their scientists to engage.

Furthermore, time is an important – predominantly limiting – factor. Online science communication costs time, time that scientists might not have as the time pressure for their 'main job' is already high (Besley, 2015; Dermentzi & Papagiannidis, 2018; McClain, 2017; Hara et al., 2019). In this regard, Besley (2015) pointed to a need for guidance and materials for scientists to effectively engage the public: "just as policy actors often receive suggested speaking points and potential presentation materials from a range of groups…". (Besley 2015, p.211). Differences per field are also important in this regard, since the defining characteristics of a particular field may influence its perception and raise specific challenges. For instance, physics has quite a lot of difficult and complex terminology, while on the other hand biology has 'lower terminological barriers' (Johnson et al., 2014

4.2.3 SCIENCE COMMUNITY AND POLICY SPHERE: THE VIEWS OF FUNDERS ON ONLINE PUBLIC ENGAGEMENT

Furthermore, the literature review showed that science policy may be another factor inhibiting online public engagement. In this light McClain (2017) stated that some funders do not consider using social networking sites on the scientists' personal accounts on platforms such as Facebook being a legitimate way to increase outreach.

4.3 SOCIETAL SPHERE

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Above we discussed that 'giving back to society' is an important personal motivation for scientists. However, the (possible) response of the public or wider society is mostly not encouraging.

4.3.1 FEAR OF NEGATIVE RESPONSES FROM THE PUBLIC

First of all, anticipated negative public reactions can be very demotivating. Scientists are wary of personal attacks or being framed through suggestive questions (Hara et al., 2019). Moreover, potential criticism in general is an important barrier (Dermentzi & Papagiannidis, 2018). A related hesitance stems from possible low-quality comments from other users, which can lead to a decrease of participation and a distrust in scientists (Jones et al. 2019). Walsh (2015, p.659) notes that "commenters shape public opinion; public opinion shapes public policy; public policy shapes how and whether and what research gets funded - you start to see why we feel compelled to hit the off' switch".

4.3.2 FEAR OF WRONGING POPULAR CONSENSUS AND LOSING CONTROL

Connected to the former section, scientists are afraid of potentially wronging popular consensus (Walsh, 2015). Moreover, there are several accounts of scientists being wary of losing control of the posted content as this can be used or misused by others (Dermentzi & Papagiannidis, 2018; Jones et al., 2019; Sajeev et al., 2019). For instance, figures or quotes from scientific sources may be used out of context.

Against this backdrop, moving 'scientific reality to a social reality' is another issue (Wang et al. 2017). This is caused partially by the difficulty of visualizing or even simplifying scientific concepts, which in its own is also a barrier (see section 4.2.2). For example, Wang et al. (2017) noted that agencies struggle to visualize the societal aspects of climate change, and Jones et al. (2019) observed that on the online discussion website Reddit highly abstract topics are rather hard to gain interest from the general public.

4.4 TAKING STOCK

In this chapter we briefly discussed the results of a literature study on (dis)incentives for scientists to conduct online public engagement. This can provide an important point of reference to put the results of the interviews we conducted in wider perspective. Important points to take into consideration in this regard, are the following. First, to a large extent, scientists are motivated towards online public engagement on a personal level. However, important barriers arise in the wider spheres in which the scientist operate. The organisations they are working for may not see the added value of (online) public engagement, which may cause restraints in terms of time. This effect can be amplified due to the fact that funding organisations not always view online public engagement a legitimate form of dissemination or outreach. Last, while intentions of scientists may be genuine they may be held back by actual interaction with the public, since fear of negative responses, or wronging popular consensus are fundamental concerns that may cause them to refrain from online public engagement.

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PART B: RESULTS INTERVIEWS

This research aims to explore the (dis)incentive structures of scientists to engage in online science communication. This section describes the results of the conducted interviews. Firstly, the personal incentives, disincentives, facilitators and barriers of scientists are described. Secondly, this section illustrates such factors that scientists experience in interaction with their environment – and constitute the interpersonal sphere, organisational sphere and scientific community sphere. Lastly, the scientists' perspective on their role in science-society interactions is described, with a focus on scientists' interaction with members of society.

4.5 PERSONAL SPHERE

In this section, the personal (dis)incentives of scientists to engage in online and offline science communication are described. As described in the theoretical framework, personal incentives, disincentives, facilitators and barriers include factors that arise purely from within a person, such as skills, personality attributes and feelings. Individual factors are of importance as they reveal intrinsic motivations as well as personal interests, preferences and competence.

4.5.1 SCIENTISTS' PERSPECTIVE ON MOTIVATION TO ENGAGE IN SCICOMM

All participating scientists in this study indicated to find science communication a very important activity. The majority of participants hence stated to be engaged in some form of science communication, both offline and online. Scientists share their research in lectures and conferences, organise science cafes, talk to journalists, get their research reported in newspapers and on television. Scientists mentioned they increasingly explore the digital sphere, where they tweet, post on Facebook, seek to connect with their scientific community on LinkedIn and start forums and blogs. Most participants indicated to be engaged in science communication 'because it's fun'.

Other participants indicated to be engaged in science communication due to a large feeling of responsibility to communicate about science. This was linked to several topics. For one, scientists indicated to be largely intrinsically motivated to educate or inform audiences who could hugely benefit from scientific knowledge. More, digitalisation and the overload of information that is presented online raised awareness in many of the interviewed scientists of the importance of engaging in science communication themselves. Some scientists stated to be worried that the right information does not reach the right people and as such wanted to make sure themselves 'that the right information is out there'. On the question if scientists who communicate about research wouldn't contribute to more information presented online, some participants declared that the added benefit of scientists is to interpret and contextualise scientific information. Others stated that the added value of scientists, in comparison to, for example, journalists, is that scientists better understand the underlying

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processes that lead to new scientific information – and as such they might better convey the meaning of (their) science themselves.

4.5.2 BARRIERS TO ENGAGE IN #SCICOMM

Most of the interviewed scientists who practice science communication indicated to be self-taught. These scientists stated to enjoy talking or writing about their research and at one point decided to spend more time on these activities. Scientists engaging in science communication for the first time remembered a perceived lack of skills, such as not being able to formulate their research into non-scientific language, to be the most challenging aspect of science communication. Others indicated a perceived lack of time to be the biggest barrier to engage in science communication. This was strongly expressed by all participants in this study.

> "Usually I find myself too restricted in time to actually do [science communication] very good." – Postdoc, female, climate change, the Netherlands.

With regards to online science communication a different perspective on science communication was provided by participants. For example, scientists indicated that online science communication is 'fast-paced', 'quick' and 'can be done on many occasions'. This provided scientists with the opportunity to communicate about their research even if they would normally not feel to have sufficient time for this activity. However, many scientists also indicated that they did not like online science communication for the reason of online platforms being fast-paced, or shallow, as one participant illustrates:

> "I don't have [twitter], because I think it's a shallow way of communicating. (…) you can be very easily misunderstood, with only 150 words or characters." – assistant professor, male, climate change, Portugal.

This participant indicated to not find online science communication as satisfying as, for example, giving public speeches, lectures or going to conferences. He attributed his dislike of social media to being less able to establish 'a real connection with people' and jokingly stated 'I must be old'. For almost all participants who did not have social media accounts, the shallowness of interactions was a major reason to not engage in this type of science communication. Interestingly, none of the participants indicated a lack of skills in relation to online platforms to be a reason to not practice online science communication.

4.6 INTERPERSONAL SPHERE

In this section, factors that arise from scientists' interaction with 'others' and that influence scientists to engage in online and offline science communication are described. The interpersonal sphere is relevant for acknowledging social influences on scientists. Hence, it includes all forms of interactions between individuals and their social network, including significant others, colleagues or students.

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4.6.1 PLATFORMS FOR COLLABORATION AND SUPPORT FROM PEERS

Scientists included in this study indicated a need to connect, seek support and collaborate with peers. Participants linked this to science communication, since communicating about their work made them more visible. Many scientists included in this study indicated the scientific community to be an important audience to them, because this proved to be beneficial to their career. Twitter and linked-in were most often used for visibility purposes for its international reach and because it was a common medium for most scientists. It was also a justification for some participants to use Twitter because their colleagues were using it. Conferences and presentations also functioned as networking opportunities.

> "[Science communication] is about having good connections to certain people and research groups, that you need for cooperation and future proposals." – Assistant professor, male, AI, the Netherlands.

Interestingly, participants found online platforms to provide more opportunities for new collaborations and to find like-minded people. Some participants stated that they engaged in science communication to update others about their work, or to find peers who could relate to the kind of activities they were interested in. A professor from Sweden formulated this as follows: "*My local colleagues have not yet really understood what I'm up to.*" Having no direct colleagues on his topic, another participant stated the reason for him to engage in online science communication on a daily basis was to find likeminded people to discuss research-related topics with.

> "I am still the only researcher on my topic, but in this country now we actually started a formal scientific society. (…) There are people who are involved in social media [of this society], who are interested in science communication, and who ask the same sort of questions that I ask myself. With them I often discuss: how to reply to someone or how not to reply and stay put. There are a lot of frequent discussions." – Assistant professor, male, climate change, Italy.

Other scientists indicated to feel a lack of a solid network of scientists to share ideas or seek support with on science communication activities. This was most apparent in Serbia, where multiple scientists indicated a strong need to share ideas with peers, both on their own scientific topic and other disciplines, in order to reach a better understanding of the meaning of their own research for society.

> "My feeling is that we (e.g. [the scientific community in Serbia]) are somehow left divided. (…) I think that the Center for Promotion of Science needs a better approach towards the scientific community in Serbia, I think that would really be helpful. It could be very motivational for us." – Professor, female, healthy diets, Serbia.

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This professor indicated that she did not know many scientists who are equally interested in science communication and reaching out to society. Through the Centre for Promotion of Science, she tried to get in touch with Serbian researchers who also felt this need, yet she indicated that the scientific community in Serbia is too divided to find such connections with peers. Statements relating to having that network of like-minded peers suggest that such supportive networks are important motivators for scientists to engage in science communication.

4.6.2 FEELING RESPONSIBLE TO REPRESENT SCIENCE

Many scientists hinted to "feel responsible to represent science in a good way" (Professor, male, AI, Portugal). Well established connections with other scientists and 'fitting-in' were felt to be important in this respect. With regards to interactions with peers and well represent the scientific community, a participant remembered an online discussion he saw online of one of his colleagues with a climate change critic. After reading this discussion, the participant felt a common strategy was necessary to prevent individual scientists harming 'the image' of scientists:

> "I had one colleague who very rarely writes in comment or on social media. All of a sudden, he engaged into a one-to-one comment battle. It went on for maybe fifty or sixty comments. But it was ridiculous at some point, they were just insulting each other in public. He's a researcher in the same field as me, and at one point I was afraid that people would associate this kind of behaviour to the whole field." – Assistant professor, male, climate change, Italy.

The participant later declared that he had conversations with peers about needing to step in or stop the discussion, but decided to not interfere. It seemed that the participant felt a greater need to belong to the side of the scientist and his network, than to defend a good image of 'science'. This scientist's experience also illustrates the felt need of scientists included in this study to be part of the scientific community and the affiliated 'image' of being a trustworthy scientist, rather than be presented as a human who is part of society.

4.7 SCIENTISTS IN INTERACTION WITH THEIR ORGANISATION

This part describes the organisational sphere. This sphere demands consideration as it relates directly to scientists' work environment, guiding their research-related activities and includes online and offline communication activities of the organisation. Organisational factors include organisational regulations, communication strategies, infrastructure, policies and reward systems.

4.7.1 SCIENCE COMMUNICATION IS NOT A TOP PRIORITY WITHIN UNIVERSITIES

All participants mentioned that science communication was not something that is prioritised in the university they work for. This was different for the interviewed participants that work for a research institute other than

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a university – as participants working for a research institute stated that their organisation focused on outreach and were clear on communication strategies. However, both participants working for universities and for other research institutes mentioned that their organisation for scientists specifically prioritises scientific output higher than other types of science communication.

> "It [science communication] is not important for our career (…). We are evaluated on the basis of papers and citations of our work." – Assistant professor, male, climate change, the Netherlands.

For the majority of scientists this meant that science communication, and online science communication in particular, is done voluntarily. Participants indicated that it is deemed 'normal practice' for a scientist to teach and go to conferences and that other science communication activities seemed less 'worthwhile' to organisations. Hence, many scientists indicated that a major hampering factor to engage in online science communication is time, as time for science communication is not often allocated to scientists via their research institutes. Others indicated that science communication was not something taken up in their job description nor facilitated their academic career.

> "I feel [science communication] is a wheel that is just spinning around. If you want your popular science article to be better, you think you need to have a higher scientific degree. But that requires spending more time on research and publish scientific articles – which is also what my supervisors want. And if you spend time on your research, you don't have time to start that blog or write on Facebook." – PhD-student, female, healthy diets, Poland.

This participant indicated to have tried starting up a blog on healthy diets for mothers in Poland on several occasions, yet only got the blog started after she just recently finished her PhD trajectory. She described that even when her supervisors were enthusiastic about her ideas for this blog, she would just never get it live, as she was more worried to finish her PhD in time. Participants in all stages of their scientific career complained that no time was provided for science communication and often stated that "as a research institute you need to be more appreciative if research takes more time, because you also include the science communication activities". Many requests were made that institutes needed to acknowledge and provide the time that it takes to practice science communication in addition to research activities and that it must not create disadvantages compared to scientists focusing purely on research.

4.7.2 COMMUNICATION DEPARTMENT ESSENTIAL IN PROVIDING SUPPORT

Even though scientists indicated that research organisations do not prioritise science communication, and that this leads to their engagement in science communication to be largely voluntary or 'a hobby', still participants indicated that they largely felt supported by their research institute. This support would come both in the form

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of practical and technical support, such as workshops or a network of professional science communicators. Participants with time allocated to science communication mentioned to be 'an exception to the rule' within their department. Other participants mentioned to receive support from their organisation or in the form of mental support by colleagues. The following participant indicated support she received from her research institute after she received hate comments from audiences that questioned her legitimacy as a scientist:

> "There were some people in my organisation that said, you need to get in contact with the security department of the hospital. So, I did that and I got very, very much support. I got the advice from the security department that I should not go out in public and do public lectures. And it's a pity, because as a university and a university hospital, we are obliged to communicate our science to the public. So, I did not do that for some years and those people who has sent me mail and so, they stopped" – Associate professor, female, healthy diets, Sweden.

Interestingly, this participant indicates that she felt very supported, yet also received the advice to not interact with audiences at all. It seems that this organisation rather than finding opportunities to interact in a constructive way, had a strategy to avoid interaction and not engage with audiences. Another participant seconds the felt support from colleagues and more explicitly indicated the apparent lack of strategy of the organisation when it comes to interaction with audiences.

> "There are colleagues who are involved in social media and who ask the same sort of questions that I ask myself. We often discuss strategies, how to reply to someone or how maybe to not reply. There is a lot of frequent discussion. For example, last week I read another round of ugly discussions online and a lot of my larger group of colleagues were asking me if they should write something or intervene. That made it was necessary for me to at some point try and think about a common course of action. (…) At some point, I wrote an email to all my colleagues and suggested an etiquette for how to behave or not to behave on social media." – Assistant professor, male, climate change, Italy.

In this quote the participant indicated to benefit from colleagues in the same organisation. However, this participant also illustrates that there was no consensus or 'etiquette' on how to best interact with critics or online audiences in his organisation. This led to a less coordinated approach, wherein different scientists would communicate differently. More, this participant illustrated that individual scientists often need to figure out how to interact with online commenters themselves. Multiple scientists display a need for organisational guidelines on how to do online communication. Contrastingly to clear guidelines to be a facilitator for scientists to engage in science communication, some participants also indicated that guidelines could make science communication more difficult.

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> "You should of course be careful, because you represent science and you represent your university or your institute. You should know how to behave accordingly to the communication policy from your employer." – Senior researcher at a citizen science project, male, climate change, Sweden.

This participant indicated that he felt he needed to overthink what or how he communicated, since his statements would be affiliated with the organisation he works for. Other scientists, particularly those working in the field of AI, mentioned that they found it difficult to engage in science communication due to the nature of their research. They mentioned that their organisation was clear in guidelines on what to publicly communicate, since much of the scientist's research is property of the organisation they work for.

Participants who – not yet – experienced difficulties with online science communication indicated to have benefitted much from workshops and guidelines that were implemented in their organisation. In relation to workshops, guidelines and science communication tips, almost all scientists mentioned their close contact with their organisation's communication department. This department would be consulted when in doubt about their own communication activities. Others depicted to not be engaged in science communication themselves, since there would be a communication department to do this activity. However, and specifically in relation to online scicomm, communication department were indicated to lack in clear and transparent online scicomm strategies. This did not help the scientist trust that science communication was done properly – and resulted in scientists rather doing the science communication themselves.

4.8 SCIENTIFIC COMMUNITY, CULTURE AND SCIENCE POLICIES

This section describes scientists' interaction with a larger scientific community, scientific or academic culture and science policies. The scientific community and culture sphere form a distinct sphere because it reaches beyond the organization and includes norms or guidelines by publishing companies, traditions and culture in science and/or perceptions of scientists on status within the scientific community. More, the policy sphere is considered because it provides guidance and is closely connected to norms and guidelines that are broader than the organizational. The policy sphere includes funding, agendas and procedures from a local to international level.

4.8.1 TOO LITTLE FUNDING FOR SCIENCE COMMUNICATION

Scientists perceived a large barrier to engage in science communication to be the difficulty and competitiveness to receive funding for science communication activities. For many participants, this meant that either in their application for grants it was not necessary or obligatory to dedicate a specific part on science communication activities. Other participants stated that if they would allocate part of their project budget to science communication activities, this budget was often too little to properly execute the tasks. Reasons that scientists

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mentioned for too little funding could be that the research group did not find science communication to be as important as research activities, so when financial decisions needed to be made, they would more often be made in favour of research activities. Other participants, mentioned that the financial climate within their country was unfavourable for science communication activities.

> "The way of financing science in Serbia has changed; and for the last two years, and maybe this coming year also, it is, you know, we feel like… – we are floating. With no solid ground. The means of our financing have totally changed. We used to have the financing of projects and now we have something called 'institutional financing'. We are not sure how that will be like in the future, so we are a little bit distracted, you know, because we need to think about our survival. It's not the best moment to do scientific communication when you are pretty obsessed with the idea what will be with our financing of science." – Professor, female, healthy diets, Serbia.

This quote illustrates that in financially uncertain times, scientists do not feel they can focus on 'fringe' activities such as science communication. In such times, scientists indicated that their main job was to provide for excellent research – and science communication was at those times not perceived to be part of their job description.

4.8.2 DESIRE TO CHANGE SCIENTIFIC EVALUATION SYSTEMS AND CULTURE

Still, scientists indicated that they would like to see a change in this respect. Participants in this study described their desire for changes in the way they are evaluated to include science communication.

> "If in the world of science, communication activities and products would be sort of ranked, like the ranking of high impact journals, then I guess I would get motivated [...] because it becomes an expectation." – PhD-student, female, healthy diets, the Netherlands.

Interestingly, one participant indicated to have experimented with changing the evaluation criteria at their university:

> "We now inserted a line (e.g. [in regulations for evaluation of individual scientists]) saying that you have to show evidence of public engagement. (…) It's still small, clearly no one is going to not get promoted because of public engagement. But I think it's a start. Because now it means that people, when they're sitting there and filling in the box that says, 'will I get promoted?', they will think: 'O, what did I do about public engagement? I didn't do something, o, shoot, I better do something.' I think, for some people, it will never be very important, and that's okay. But for other people, I'd like to think they will start thinking about what they would like to do in terms of public engagement, and do a little bit more of it. We're trying to make it an official part of the promotion process.

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> Because I think it will motivate more people to do public engagement." – Associate professor, male, healthy diets, the United Kingdom.

The same scientist described his future outlook that changing scientific culture will be up to dedication of scientists themselves, as opposed to, for example, regulating science communication and public engagement in top-down processes through supervisors, research institutes or science policies.

> "At the end of the day, the head of the department, the dean of the schools, their job is to make sure they bring in enough money, to continue paying the bills and stuff. So, that's their motivation. You have to convince them that the reason you want to do public engagement is, because it helps them, continue to bring in the money and continue to hire the people. And if you do that and put it in structurally and annually, then you force change. And then in ten, fifteen years from now, people will be fighting to be good at public engagement, because it has evolved as a field. That I think is what we're going to do." – Associate professor, male, healthy diets, the United Kingdom.

Many respondents supported the idea of making science communication a permanent aspect to be included in evaluation systems, because they found it an important aspect of scientific work. Others considered it inappropriate to impose this on all scientists, as some are uncomfortable or uninterested in science communication. To this end, some participants proposed that a change in scientific culture is necessary.

4.9 SCIENTISTS IN INTERACTION WITH SOCIETY

This part describes the scientists' interaction with society. The societal sphere is highly relevant because the goal of many science communication activities is to connect society with science. Examples of factors that influence scientists' engagement in science communication include reactions from audiences, public trends or cultural aspects.

4.9.1 PERSPECTIVE OF SCIENTISTS ON IMPORTANCE OF SCICOMM

Many interviewed scientists indicated that their main motivation to engage in science communication was to inform or educate audiences. The goal of education or informing audiences varied; some indicated it was to bring science closer to society and to democratise science, others stated they wanted to deploy critical thinking or to 'change the world for the better'. Hereto, scientists indicated they felt digital platforms to benefit the collaborations they could establish with societal actors, such as NGOs and industry. Many scientists also indicated to practice science communication for their urge to contribute something to the societal debate on their research topic. With this, a wide range of scientists with different perspectives on science communication were included in this study.

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> "As a scientist I feel the responsibility to spread correct information that would lead to action. So, the ultimate goal is in fact to raise awareness and change behaviour or induce some kind of action." – Professor, male, AI, Portugal.

> "Citizens have the right to be informed about what is going on and eventually also participate in public discussion." – Professor, male, AI, Sweden.

> "The challenge with something like climate change is that we need societal-wide debate and engagement in how we tackle it. And while it's really valuable to have face-to-face — and potentially quite local-level — deliberations and discussions, it is also important to focus on local citizens' juries and citizens' assemblies to feed into science and policies." – Professor, female, climate change, the United Kingdom.

There existed some differences between the statements of scientists from different scientific disciplines. For example, scientists affiliated with health research on diets and nutrition indicated that form them it is important to raise awareness, as it could have a direct impact on an individual's health. Many times, lower educated or low SES individuals were indicated to be an important target audience, although the scientific community and policy makers were also often indicated to be important to reach. One participant specifically reflected on the role and responsibilities of a scientist herein:

> "We [scientists] have to be more aware of the things we are working on in our laboratories, within our four walls. We should go outside and have an impact on the people around us. I think that we are not fully aware of the fact that what we research may have a direct impact on people's lives. You can help people directly in some way." – Head of department/principal investigator, female, healthy diets, Serbia.

In the field of AI, scientists brought a slightly different focus to the feeling of responsibility of scientists to engage in science communication. Scientists indicated that it was important to combat misperceptions on the possibilities of (future) AI technologies; as they felt that both too positive and too negative characteristics are attributed to AI. Scientists felt that in addition to educating or informing their audience it is equally important to provide a realistic image of the science on AI, as it is part of many people's daily lives. Important to note here is that audiences were not only perceived to be citizens, but also the scientific community and politicians, as this participant states:

> "We should not only inform broader publics but also constantly update the scientific community constantly, because we are overloaded with information. It is important that scientists get the important information from the bulk of knowledge." – Associate professor, male, AI, Sweden.

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Researchers in the field of climate change seemed to be more concerned with climate change sceptics, combating misinformation and adding scientific facts to the societal discussion. Researchers overall showed a large drive to contribute to societal discussion, in order to be able to change people's behaviour, to steer towards collective action and therewith save our environments.

> "There is a really big, large percentage of people who are really worried about climate change. This is something that is completely different when we compare it with five years ago. Before, I was talking much more in conferences for like the science community. And nowadays I'm... almost every week I'm talking in front of some kind of association or people, different kinds of audiences. (…) I try to balance between accelerating change, to mitigate climate change of course, whilst at the same time not giving the idea that we cannot do anything about it. I belief that people can change things." – Assistant professor, male, climate change, Portugal.

As this quote indicates, scientists indicated changes in the societal conversation that people have compared to years ago. This was not only apparent in the field of climate change research. Multiple scientists seem to be motivated to engage in the societal discussions, often with the incentive to add scientific facts in the conversation.

4.9.2 SCIENTISTS ENCOUNTERING NEGATIVE COMMENTS

In order to constructively and scientifically contribute to the societal debate, some scientists indicated a felt need to clearly explain the distinction between scientific knowledge and personal experiences.

> "It is very important for me to distinguish personal knowledge from scientific knowledge. I use the personal knowledge of my patients in lectures or as ideas for new research, but this is definitely something else compared to scientific knowledge." – Associate professor, female, healthy diets, Sweden.

Multiple scientists indicated that they would receive comments that are directed at them personally, and not on their research. Shockingly, many participants in this research indicated to have negative experiences with online platforms. The few who did not, indicated that they have had colleagues who received hate comments. Naturally, for some scientists this meant that they stopped with their online communication activities, or never started with online science communication, even when they had indicated knowing about the benefits that online platforms could provide them with.

> "I do not engage in online scicomm because that's where the sceptics are." – Senior researcher at research institute, male, climate change, Sweden.

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> "Six or eight years ago, there were some people who send me mails and they put me on different websites. They asked me how much money I got for my research and if I was bought by the industry, and they commented that I was incompetent. And I got some threats. (…) I'm thinking about what I say when I communicate about science, and how to respond in a scientific way. You take some risks when you're out and communicating science, especially nutrition, diet and obesity. And that means that I don't have so many colleagues that will do that. Because they know the risks and they will not take that risk. And I think, it's important to communicate science. So, I'm continuing to do it. But I have chosen not to be on an online platform" – Associate professor, female, healthy diets, Sweden.

As the latter quote illustrates, negative experiences or hearing negative interactions with audiences from others blocks scientists to engage in science communication online. More, this participant indicates that she now needs to carefully think about how to communicate science, fearful of the comments she might receive. Participants explained that they had hoped to have conversations or inform about scientific knowledge, rather than having an interaction that is directed towards them personally.

4.9.3 ONLINE PLATFORMS NOT THE BEST WAY TO CONNECT

More, scientists felt that online platforms are not the right setting to communicate about science in the first place. Scientists felt that the digital world moves fast, accumulates more fake news than accurate science, is focused on sensational topics, and does not provide platforms where one could extensively go into depth.

> "It is easily picked up from me and then exaggerated in a wrong direction." – Head of department/principal investigator, female, healthy diets, Serbia.

> "Most people who read my blogs online, read them to reinforce their own opinion." – Professor, male, AI, Portugal.

This participant indicated that he extensively engages in online science communication for he beliefs it is important that scientists engage in the public dialogue on climate change issues and change public awareness; but increasingly he dislikes this activity. He noticed that where in real life he can have in-depth and interesting discussions, online interactions seem more hardened or people are in search for information to reinforce an already present idea on the topic. This went against him valuing being a critical thinker who questions and makes sense of information.

There seemed to be a mismatch between the desires of scientists to inform society of 'the science', to add to the societal discussions in their country and the felt lack of responsiveness of society to those facts. More, scientists feel that online interactions are not on topic and are more directed to them personally. With regards to this, many scientists illustrated how frightening it must be to put oneself 'out there' online. Still, most of the interviewed scientists indicated to continue with science communication regardless. "I have got a thick skin

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about it. Bad or good, I have got thick skin about it." It seems that the intrinsic motivation and feelings of responsibility of scientists to 'get science to society' beats the perceived lack of interest or outright criticism that scientists received.

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CHAPTER 5: DISCUSSION

The aim of this study was to provide an overview of incentives, disincentives, facilitators and barriers that influence scientists' engagement in online public engagement, and to explore the in-depth perspectives of scientists throughout Europe on facilitators and barriers to engage in, both online and offline, science communication. The results of this study have brought to light several important insights into the perspectives of scientists to engage or not engage in public engagement on various spheres of influence. This section will compare the conducted literature study and interviews, highlighting interesting findings and interpret those in the context of other literature.

5.1 PERSONAL SPHERE

It became apparent from the literature study and interviews that scientists experience science communication to be an important activity. In this study interviewed scientists displayed a tremendous intrinsic motivation to practice science communication, wherein a distinction can be made between participants who light-heartedly practice science communication for fun and as a hobby, and participants who feel a huge social responsibility or obliged to engage in this activity. Many studies describe that scientists feel responsible to take part in science communication (Davies 2008; Martin-Sempere et al., 2008; Besley, 2015). In their study, Loroño-Leturiondoa and Davies (2018) have found that scientists feel responsible for good experiences of both parties, thereby feeling public communication to be scientists' duty – which needs to be carried out for the sake of their audiences (Loroño-Leturiondoa and Davies, 2018). Whilst some discussions on science-society interactions have put forward the notion that scientists need to be persuaded to connect more with society, this study found that scientists already feel responsible or are intrinsically motivated to practice public engagement communication. In that sense, there is not so much a need for persuading scientists to engage in this activity, as there is into exploring in more detail how interactions between scientists and wider audiences can be intensified or established with higher quality or more constructively.

On the level of individual scientists, or personal sphere, results of the literature study pointed towards factors that block scientists to practice science communication. Those mainly concerned a perceived lack of skills, including a difficulty in finding the correct language or not knowing how to do justice to complex scientific knowledge online (Dermentzi & Papagiannidis, 2018; Jones et al., 2019; Knight & Kaye, 2016). Contradicting, scientists in interviews displayed confidence on science communication activities they would undertake and did not indicate a lack of skills. Rather a lack of agency and lack of time was perceived to be a barrier. Literature confirms that many scientists are unsure of how to communicate science and feel more inclined to do so when they feel more skilled (Gascoigne & Metcalfe, 2019). Lacking time is a strong demotivator that scientists commonly express (e.g. Royal Society, 2006; Gascoigne & Metcalfe, 2019). Yet, quantitative investigations showed that time constraints do not diminish the communication intentions (Poliakoff & Webb, 2007). It

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appears that, as one respondent put it, 'if you want to do it, you can always make time'. With regards to the needs for a specific skillset, experienced science communicator Paige Brown-Jarreau, stresses that it is a delusion that a new skillset is required; exposure and practice may be necessary to discard reservations, but scientists have all the qualifications (Benes, 2017). Similarly, in this study, participants who felt confident also indicated that they had learned by doing and noticed that practicing science communication rewards. To this end, the already largely felt responsibility of scientists in combination with the notion that one learns public engagement by doing, indicates that on a personal level many scientists are ready to engage in public engagement. It might be interactions between the personal sphere and factors in the surrounding spheres of influence that could really block or support individual scientists to engage in meaningful interactions with society.

5.2 INTERPERSONAL SPHERE

From this study, it became apparent that scientists benefit much from support from peers when engaging in online science communication. For example, this study showed that scientists perceive the benefits of online science communication to be maintaining or expanding their scientific network or find like-minded people. Literature showed that scientists also perceive social network to be useful to interact with audiences they would normally not reach, or use digital platforms to ask for feedback or input on their research (Scheliga et al., 2018). Digital platforms provide opportunities to quickly reach and interact with audiences (Dermentzi & Papagiannidis, 2018; McClain, 2017; Hara et al., 2019). In interaction with their environment, scientists indicated to enjoy and found it stimulating to interact with *peers*. In terms of incentive structures for scientists to engage in public engagement, it seemed that on the interpersonal sphere scientists felt instant rewards – for example when expanding their scientific network, gaining feedback on research activities or gained visibility. This was less clear with interactions between scientists and members of society, which will be discussed in more detail in section 5.5 here below.

5.3 ORGANISATIONAL SPHERE

Scientists in this study benefitted much from support given by their organisation – with the help and support from communication departments in particular. Even with most of the scientists mentioning they engaged in science communication for their intrinsic motivation and learning-by-doing, the communication departments were often mentioned to be an actor on which you could fall back on for practical and technical assistance. Herein, a distinction with the conducted literature study was found, in the sense that other research focused on organisational factors that influence scientists' engagement in science communication was more focused on the costs and benefits (AbiGhannam, 2016; Dermentzi et al., 2016; Dermentzi & Papagiannidis, 2018; Hara et al., 2019; McClain, 2017). For example, scientists feel their organisations depict clear-cut job descriptions, wherein researchers should stick to the science and not practice communication activities (McClain, 2017).

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This goes against the trend wherein scientists and research institutes increasingly cross the science-society divide and are expected to interact more with society and societal wishes (Nowotny et al., 2001).

Even more so, it seemed that most work cultures in organisations disfavoured online science communication. For example, some scientists are motivated by career advancements (Ali-Khan et al., 2017) as determined by career requirements. This study shows that science communication is tolerated and, in some instances, promoted, but are rarely backed up by formal requirements, such as evaluation criteria. Many participants in this study emphasised feeling discouraged in their pursuit to engage in science communication activities. Scientific publications and networking in the community are indispensable to increasing the impact of one's work, previous studies confirmed (Ali-Khan et al., 2017; Petersen et al., 2014). For example, Neresini and Bucchi's examination of support structures at research institutions described the following: 'while most research institutions have dedicated resources for engagement activities, [...] such activities are not yet considered essential' (Neresini & Bucchi, 2011). Scientists participating in this study mentioned they did not feel their organisation to prioritise science communication activities nor promoted scientists to engage in this activity. However, scientists active in science communication are in fact more productive in their academic and research work, causing no considerable effect on their career (Jensen et al., 2008).

In conclusion, organisations display double-sided motives, as on the one hand scientists hear they need to be visible as a researcher and disseminating research, whilst on the other side hear that they 'should stick to their research'. Organisations seem to be content with scientists practicing science communication voluntarily, as it increases the visibility of the researcher and has no negative influence on the research they are ought to conduct. However, This study noted that scientists who engaged in public engagement got new ideas and positive energy from their interaction with audiences. Hence, nog actively supporting public engagement was seen as a missed opportunity for organisations who do not appreciate scientists who expand their view beyond their research.

5.4 THE SCIENCE COMMUNITY, CULTURE AND POLICIES

Following-up on the organisational sphere, participants in this study emphasised that academic culture needs to evolve from a focus on scientific output, such as h-indexes, lecturing and publication of scientific articles, to a focus on matching societal wishes. Given that scientists are in fact more productive in doing research when also engaged in science communication activities, there have been reports of a disconnect between the changing expectations for scientists to communicate and 'organizational priorities as manifested in policies and practices' (Jacobson et al., 2004). Yet, if research institutions desire their scientists to be communicators, integrating science communication into assessment and promotion guidelines seems imperative. This also explains recurring demands that science communication activities should be considered in formal evaluation processes. Moreover, it has been pointed out that it should rather be viewed as aligning guidelines with societal needs (Moher et al., 2018), reminding of the ultimate goal of science communication. Thereby, there lies an

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opportunity in the gap between scientists, the scientific community, culture and policies, as this gap can be mended and transformed into a united, positive force on scientists' motivation.

Albeit few to no differences between nations were observed, with regard to a network or professionalised science communication field there were some international differences. For example, scientists in Serbia mentioned a lack of skilled science journalists as a motivating factor to practice science communication themselves. Scientists in Serbia and Poland referred to political instabilities that negatively influenced the science communication ecosystem in their countries. More, recent changes in science funding in Serbia has resulted in heightened insecurity for research projects – and consequently scientists mentioned science communication to drop in their list of current priorities. Overall, this study found the infrastructure for science communication in Eastern Europe decaying and in need of professionalisation. All in all, some countries towards the west of Europe indicated to benefit from a culture change, wherein science communication activities may be part of research funding schemes or career evaluation criteria; in the Eastern Europe a need for stable and professionalised infrastructures was found in this study.

5.5 SOCIETAL SPHERE

One of the major outcomes of this study was the intensity and amount of negative comments that scientists receive on their person. Almost all interviewed scientists indicated to have experienced bad interactions with audiences online or saw this happening with their peers and colleagues. In literature, also the fear of receiving negative comments and potential forming of popular consensus was indicated as a barrier for practicing online science communication (Dermentzi & Papagiannidis, 2018; Hara et al., 2019; Jones et al., 2019; Sajeev et al., 2019 Walsh, 2015). This study found indications that the expectations of scientists heavily influenced the way in which scientists were able to cope with negative responses by the public. For example, scientists in interviews and literature indicated to have a sometimes-negative view on the capability and knowledge of the public (Davies, 2008; Besley, 2015). This sentiment might be one of the factors that cause the anticipated negative reactions. For example, whilst scientists felt responsible or exited to inform and educate the public, this does not necessarily mean that publics feel equally excited about being educated. Subsequently, scientists may have high hopes of science communication activities and the connection with publics they might create, only to feel disinterest or negativity in comments of publics online.

5.6 CLASH OF THE SPHERES

With regards to this mismatch between the scientists' personal expectations and sentiment of society, the Social-Ecological Theory used in this study revealed some interesting dynamics between spheres of influence that surround scientists. Separation of the spheres was done in order to be able to distinguish factors that influence scientists to engage in science communication on different and interconnected levels (e.g. Amel et al.,

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2017). This part will display the interconnectedness of facilitators and barriers for scientists on personal level and show how these interact with factors that influence scientists in their environment to engage in science communication. This was most visible when comparing the scientists' personal sphere, the high intrinsic motivation, feelings of responsibility to engage in science communication and perspective of scientists on the vital importance 'to bring science to society' – all whilst complying to organisational guidelines, public policies and (scientific) cultural norms.

This study showed that scientists feel the boundaries between science and society to be blurring. For example, some scientists indicate the possibilities of digital platforms to find the publics opinion and needs (Dermentzi & Papagiannidis, 2018). Others feared publics would not be able to distinguish between professional and personal knowledge or expertise (Dermentzi & Papagiannidis, 2018; McClain, 2017; Knight & Kaye, 2016). At the same time, scientists indicated they liked to step outside of their laboratories into 'the real world' and connect with publics or like-minded people. The mental segregation of research-related and society spheres into opposing systems may be due to the traditional deficit mode that scientists still use, also recognized in previous studies (Dudo & Besley, 2017). This was demonstrated by the identification of the felt importance of scientists to inform or educate the public. Others felt they needed to engage in science communication to combat misinformation or share insights into 'the process behind scientific research'. Scientists ultimately aimed at increasing the acceptance and appreciation for science, which mimics deficit logic. This is an important finding, because the disappointment that scientists encounter when they notice that their organisation as well as scientific culture, regulations, guidelines and collaborations with society or societal actors are not always desire to be informed, it influences the scientists' motivation to engage in science communication. When considering ambitions regarding the governance of science, this shows that science is still some learning processes and adjustments away from truly involving society in joint co-creation.

5.7 CHALLENGES AND POSSIBILITIES OF THE DIGITAL SHPERE

In addition to the personal, interpersonal, organisational, science community, culture and policy, and society sphere of influence that surround scientists, this study would argue to add another sphere of influence to the scientists' environment. In researching (dis)incentives, facilitators and barriers of scientists to engage in online public engagement, it became apparent that a digital sphere complicates the first apparent order of spheres that surround scientists. For example, multiple scientists indicated a difference between communicating on their research online versus offline science communication activities. Online, interactions with 'others' seem to be more easily established and are abundant (Dermentzi & Papagiannidis, 2018; McClain, 2017; Hara et al., 2019). In this study, participants seemed to be aware of 'their image' online and mentioned examples of less favourable interactions they had experienced themselves or saw of peers. More, they mentioned to desire a strategy or etiquette that depicts how to interact online or how to practice online science communication, or, that they needed to obey communication strategies of their organisation. From such conversations, it became

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apparent that the digital sphere increased the interconnectedness of different spheres of influence that surround individual scientists.

When scientists engage in online science communication activities, scientific peers, colleagues or supervisors may easily follow and criticise the content one creates – which may already be challenging enough. Scientists repeatedly noted to be concerned with 'representing the scientific community well'. During this study, it became apparent that scientists may very well felt a clash between the activity they undertook, for example online science communication to a general audience (personal sphere), their perceived value of or importance to do this activity 'to represent science' or 'to bring science to society (personal and societal sphere); and what they actually experienced happening when doing this activity, which was mostly receiving comments from like-minded individuals, colleagues and/or the scientific community (interpersonal sphere). At the same time scientist need to regard organisational communication guidelines and policies (organisational sphere). Scientists seem to focus on reaching society, but reacted to comments with the scientific communication overlooking this conversation in the back of their heads. Whilst the possibilities that lie in the digital for science communication, this study also showed that the interlinked dimension of the digital sphere heavily complicates scientists' engagement with online science communication.

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CHAPTER 6: CONCLUSION

The contemporary science communication ecosystem is complex: science and society meet each other at multiple interfaces, communication takes place in multiple directions and moreover, the different actors may have widely differing ideologies and assumptions. In addition, digitalization is intensifying the – already complex – dynamics in this ecosystem fundamentally. At the same time, digitalization also offers novel possibilities for scientists and scientific institutions to communicate and engage with the public and other stakeholders, and henceforth contribute to a better science-society relationship. Against this backdrop, this study aimed to examine what motivates scientists to engage with the public through the internet and online media, and what holds them back herein.

Summarising our main findings per sphere, on the personal sphere this study concludes that a lack of skills or capacity is often mentioned in literature as a major barrier for scientists to engage in online science communication. Furthermore, scientists are often portrayed as laboratory inhabitants who need to be dragged to the outside world. In contrast, this study showed that scientists feel a tremendous responsibility to engage with audiences, are intrinsically motivated to practice science communication and increasingly explore digital platforms to engage in science communication. This study has however shown that scientists also encounter quite some challenging interactions with their environment that restrain them. Where scientists feel joy in finding peers and like-minded people more easily online, the digital sphere is also a place that asks from scientists to be transparent about their work, personal perspectives and ideas. Social norms or expectations in scientific communities with regards to the 'job description' of being a 'normal' researcher as well as specific communication guidelines from organisations delineate boundaries to the interaction that scientists may have with their audiences. Scientists indicated that they need a support structure of peers who are interested in public engagement, with whom they could exchange experiences. Organisations could contribute to this need by making the support and appreciation for scientists who engage in public engagement explicit, for example by paying attention to undertaken public engagement activities in evaluation criteria. On the societal sphere, there is an occasional mismatch between scientists' expectations when disseminating their research and the perceived lack of interest from society. On top of this, the presence of a digital sphere has added complexity to interactions that scientists encounter in their environment. For some scientists, this meant that they disliked digital platforms, for they do not provide in-depth interactions on their research. For others, the digital sphere represents a place where merely critics that place negative comments reside. In conclusion, whilst on the one hand, online science communication has provided an expansion in number of interactions and variety of audiences reached, on the other hand the quality of those interactions is not always regarded.

So, what does this mean for RETHINK and our aim to nurture interactions between science and society in an open and reflexive way? We conclude this deliverable sharing some thoughts on the implications for the further project. RETHINK will develop and test strategies for enhancing openness and reflexivity, that results in a

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catalogue of good and inspiring practices. In this regard, the project's Rethinkerspaces - the local communities of inquiry and reflective learning made up of SciComm practioners, scholars and other relevant stakeholders – play a crucial role. These Rethinkerspaces will experiment and pilot new approaches to science communication as a dedicated learning community. The insights from this study can play a valuable role herein. This particularly holds for overcoming barriers relating to (self-perceived) capability towards online media, as well as the mismatch between scientists that are willing to engage with the public online and expectations of what they may encounter in the actual interaction. Can we formulate strategies to facilitate scientists to become online media-savvy? And can we identify ways to help scientists deal with fears of negative responses in a constructive manner, since their presence in the digital sphere is important to us? Evidently, this also holds for the different SciComm training programmes, in which many project partners are involved.

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APPENDIX A

	PUBLIC ENGAGEMENT WITH SCIENCE	ONLINE	INCENTIVE	DISINCENTIVE	FACILITATOR	BARRIER
DEFINITION	*As a specific form of science communication, public engagement of science (PES) refers to activities that meaningfully involve the public during scientific or innovative processes through interaction.*	*The word 'online' has been defined in the dictionary as 'Controlled by or connected to a computer'. In the context of this review it refers to the digitalized environment in which scientists or communicators connect or interact with others such as the public.*	*As Silverman et al. (2016) described 'Under incentive interventions, individuals receive some tangible and desirable consequence (e.g., money, privilege) contingent on emitting some observable and verifiable behaviour.'*	*Disincentive refers to undesirable consequences that demotivate or discourage individuals to take a particular action. In the context of this review, disincentives are the anticipated consequences that prevent or discourage scientists to engage the public.*	*Facilitators are factors that support individuals to take a particular action. These factors can be personal, like skill sets, but can also be external factors like easy accessibility of an application or policies.*	*Barriers are factors that hinder individuals to take a particular action. These barriers come in different forms, such as hard to use applications, lack of necessary skills, or even public mistrust.*
SYNONYMS	Public dialogue (Stilgoe & Lock, 2014) Public engagement (Stilgoe & Lock, 2014) Public engagement with science (Chilvers, 2012) Public engagement with science and technology (Chilvers, 2012) Reflexive engagement (Chilvers, 2012) Science communication (Bullock et al., 2019)	Internet (Schäfer, 2012) Social media (Schäfer, 2012) Online media (Schäfer, 2012) New media (Brossard & Scheufele, 2013) Online public communication (Dudo & Besley, 2015)	Motivation (Silverman et al., 2016) Motive (Chilvers, 2012) Encouragement	Demotivation Discouragement	Instrumental role (Scheufele, 2014) Tool (Scheufele, 2014) Policy (Scheufele, 2014) Mediators (Chilvers, 2012) Application Support	Obstacle (Taylor & Dewsbury, 2018) Challenge (Taylor & Dewsbury, 2018) Difficult

APPENDIX B

Search strategy SCOPUS

1. #1 ((TITLE-ABS-KEY (incentive OR motiv* OR encourage* OR stimulat*))
2. #2 OR (TITLE-ABS-KEY (disincentive OR discourag* OR demotiv*))
3. #3 OR (TITLE-ABS-KEY (facilitator OR instrumental AND role OR tool OR polic* OR mediator))
4. #4 OR (TITLE-ABS-KEY (barrier OR obstacle OR challenge)))
5. #5 AND (TITLE-ABS-KEY (online OR internet OR "social Media" OR "online media" OR "new media" OR "online public communication")
6. #6 AND (TITLE-ABS-KEY ("Science communication" OR "public engagement" OR "Public Engagement with Science" OR "Public engagement with science and technology" OR "Public dialogue" OR "Reflexive Engagement" OR "science-society interaction" OR "knowledge brokering" OR "science-society relationship"))

Search query: ((TITLE-ABS-KEY (incentive OR motiv* OR encourage* OR stimulat*)) OR (TITLE-ABS- KEY (disincentive OR discourag* OR demotiv*)) OR (TITLE-ABS-KEY (facilitator OR instrumental AND role OR tool OR polic* OR mediator)) OR (TITLE-ABS-KEY (barrier OR obstacle OR challenge))) AND (TITLE-ABS-KEY (online OR internet OR "social Media" OR "online media" OR "new media" OR "online public communication")) AND (TITLE-ABS-KEY ("Science communication" OR "public engagement" OR "Public Engagement with Science" OR "Public engagement with science and technology" OR "Public dialogue" OR "Reflexive Engagement" OR "science-society interaction" OR "knowledge brokering" OR "science-society relationship"))

Search strategy Web of Science

1. #1 TS=(incentive OR motiv* OR encourage* OR stimulat*)
2. #2 TS=(disincentive OR discourag* OR demotiv*)
3. #3 TS=(facilitator OR instrumental AND role OR tool OR polic* OR mediator)
4. #4 TS=(barrier OR obstacle OR challenge)
5. #5 #1 OR #2 OR #3 OR #4
6. #6 TS=(online OR internet OR "social Media" OR "online media" OR "new media" OR "online public communication")
7. #7 TS=("Science communication" OR "public engagement" OR "Public Engagement with Science" OR "Public engagement with science and technology" OR "Public dialogue" OR "Reflexive Engagement" OR "science-society interaction" OR "knowledge brokering" OR "science-society relationship")
8. #8 #5AND#6AND#7

#- LA=(English)