Deliverable 2.3

Report on the Barriers and Opportunities for Opening Up Sensemaking Practices

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Executive Summary

A close relationship between science and society can only take place if its actors are responsive to one another – for there to be effective, recursive communication between them. This at the heart of the science policy framework Responsible Research and Innovation (RRI). RRI has implications not only for those within the science community and those communicating science, but also citizens who share responsibility for the 'collective stewardship' of science and innovation (Stilgoe and Owen, 2013).

Sensemaking is the process by which citizens develop an understanding of a complex reality. If individuals are reflexive in their sensemaking practices, they are aware of the assumptions that underpin their approaches to making sense and able to shape these processes. Openness in sensemaking requires individuals to be open to a wide range of information and opinion and willing to change their stance. This means that reflexive and open sensemaking practices enable citizens in their collective stewardship of science and innovation since they encourage citizens to be open to a wide range of perspectives and aware of how their own contexts and experiences inform how they source and interpret information.

Reflexivity and openness on the part of those communicating science can help in this process too. They make it more likely that communicators will share a wider range of information and opinion, exposing citizens to a wider range of perspectives to inform their sensemaking. Given that communication activities require sensemaking on the part of communicators, the requirements of openness and reflexivity are identical between communicator and citizen.

One strand of RETHINK (Work package 1) is exploring the nature of online science communication and the motivations and working practices of communicators. While another aspect of the project (within Work package 2) is to explore the sensemaking practices of citizens. Here the consequences of findings within both avenues of research (WP1 and 2) for open and reflexive sensemaking are considered.

A role typology developed by academics Declan Fahy and Matthew Nisbet (2011) for online science journalists is used as a framework to consider the consequences of the actions of those communicating science for open and reflexive sensemaking. Our analysis indicates that those who adopt the role of being a *conduit* of scientific information (Fahy and Nisbet, 2011), may limit opportunities for dialogue between communicator and citizen that would otherwise facilitate openness and reflexivity in these actors. Whereas those who act as *conveners* (Fahy and Nisbet, 2011) encourage openness and reflexivity. However, communicators who adopt roles that do not necessarily include dialogue may encourage openness and reflexivity if they encourage citizens to consider their perspectives and reflect upon how they interpret science-related information – something that can be achieved through the public intellectual or agenda-setter roles. The analysis also makes the case for new roles to be adopted by communicators, such as that of intermediary or mediator.

There is evidence of openness and reflexivity in the sensemaking practices of those citizens who we interviewed during RETHINK research. Working against this are the tendencies of sensemaking practices to be shaped by a citizen's context – who is in their family and friendship group, where they live and the online groups to which they subscribe.

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The findings here have implications for European Commission media literacy policy and make the case for it to be widened in scope so that in addition to its focus on encouraging citizens to assess information for its truthfulness and reliability, they are also encouraged to adopt sensemaking practices that are open and reflexive.

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1. Introduction

The central aim of the RETHINK project is to find innovative ways to open up research and innovation (R&I) to society by improving the quality and effectiveness of interactions between scientists, other R&I stakeholders, the media and the public. In doing this, the hope is to forge a closer integration of science and society.

In the spirit of encouraging a close integration of science and society, the Responsible Research and Innovation (RRI) science policy framework encourages the modulation of research and innovation trajectories to align them with the values, needs and expectations of society. In doing so, RRI emphasises the need for a reflexive and inclusive relationship between science and society (Stilgoe, Owen and Macnaghten, 2013). Responsible research has become a focus of academic endeavour through Science and Technology Studies (STS) and is also encouraged through European science policy (Stilgoe, Owen and Macnaghten, 2013).

At the same time, two interrelated trends have transformed the context in which research takes place. One is the blurring of boundaries between science and society as the range of actors engaged in public discussions about science increases. The other is digitization – the proliferation of online platforms and digital tools such as social media, blogs and apps that have democratized the communication of science; enabling anyone with an internet connection to tweet, post or even 'gamify' science.

The push for RRI on the one hand and the transformations in the nature of science communication on the other have increased the need to understand the connections between science and society. Added to this, there is the need for effective communication of pressing challenges such as climate change and the coronavirus pandemic. This involves understanding more about how science is being communicated today and the motivations and working practices of those doing the communication, as we are capturing in one part of the RETHINK project (Work Package 1). But also, exploring how citizens understand scientific and science-related information, as we are doing elsewhere in RETHINK (Work Package 2).

In this report, we attempt to draw these aspects of RETHINK's research together for the first time to consider the implications of the motivations and working practices of science communicators (WP1) and the ways in which citizens make sense of science (WP2) for the connections between science and society. This is achieved by exploring the barriers and opportunities to open and reflexive sensemaking practices. Sensemaking is the process by which we develop an understanding of a complex reality (Dervin, 1998). It is through open and reflexive sensemaking practices that closer, more effective interactions can take place between science and society, thereby facilitating RRI.

While sensemaking practices are undertaken by citizens as they interpret scientific information or information related to science, the actions of citizens *and* communicators have a bearing upon these sensemaking practices. So here the requirements for open and reflexive

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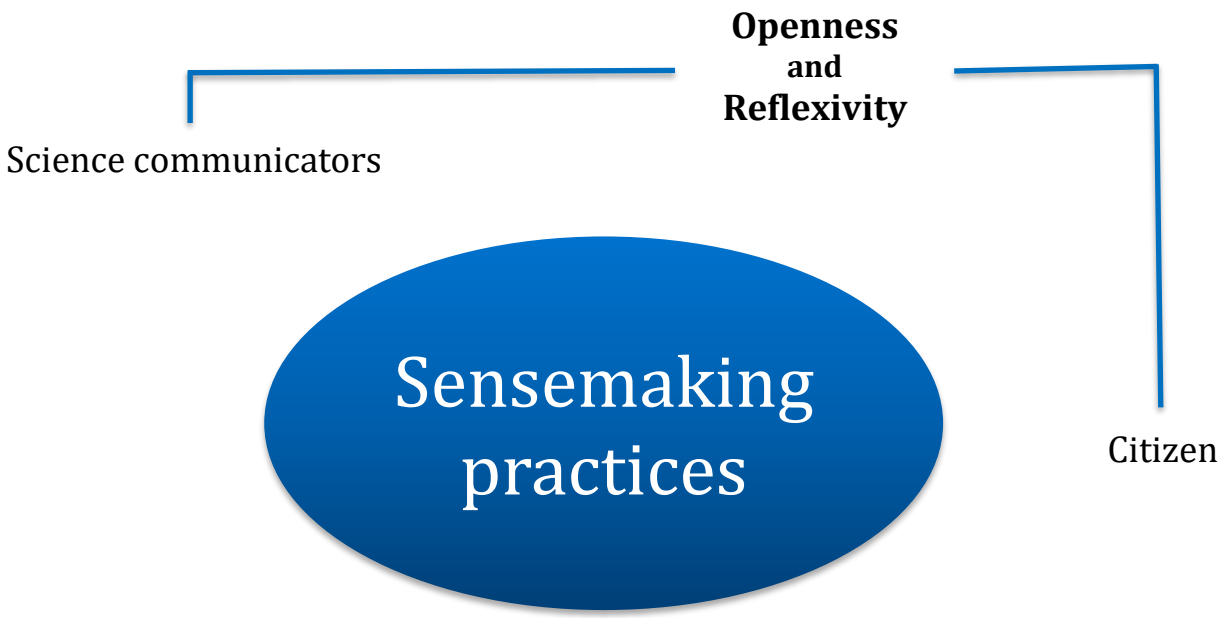
sensemaking practices shall be considered from two perspectives. Firstly, in terms of the requirements it places upon those undertaking the sensemaking, that is citizens. Secondly, the implications of the actions and motivations of science communicators on sensemaking will also be considered. This dual perspective is illustrated in Figure 1.

Figure 1. The requirements for and impediments to open and reflexive sensemaking practices will be considered from the perspective of citizens and science communicators.



This report is a synthesis of research already conducted within RETHINK, the results of which have been or will be reported more fully elsewhere. This research consists of:

- A scoping study of online science communication that captures which actors and communicating and on which platforms in relation to three topics: climate change, healthy diets and artificial intelligence (Milani et al. 2019).
- A survey distributed among science communicators in Italy, the Netherlands, Poland, Portugal, Serbia and Sweden exploring their working practices and motivations (Milani et al. 2020a and Milani et al. 2020b).
- Interviews conducted with citizens across Europe to understand more about their sensemaking practices in relation to coronavirus (in press).

This synthesis is not presented as a comprehensive analysis of barriers and opportunities to open and reflexive sensemaking practices. It is an exploratory analysis to inform the development and testing of strategies for the opening up of sensemaking practices that will take place later in the RETHINK project. Before undertaking this synthesis, openness and reflexiveness are defined as they relate to sensemaking practices.

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2. Sensemaking and the science-society relationship

While 'sensemaking' is a concept employed in a diverse range of fields of research including organisational research, artificial intelligence and science education (Odden and Russ, 2018), a clear definition has been lacking. Odden and Russ (2018) attempted to address this:

> *"...sensemaking is a dynamic process of building or revising an explanation in order to 'figure something out' – to ascertain the mechanism underlying a phenomenon in order to resolve a gap or inconsistency in one's understanding."*
> *(Odden and Russ, 2018, p.191-2)*

In a practical sense, sensemaking might involve an individual asking questions such as: what is true or not? How do I determine the truth? Who do I trust when I am trying to determine what's happening?

Central to sensemaking theory is the concept of the 'gap'; questions, confusions and concerns that may arise when an individual encounters new information or a new situation. The extent to which questions occur to the individual will depend on the situation (Reinhard and Dervin, 2011). Individuals may use their own internal resources such as thoughts, attitudes and beliefs to 'bridge' that gap and they may also draw on media content or the thoughts of others (Reinhard and Dervin, 2011).

This process of sensemaking can be illustrated using a schematic (Figure 2), developed from the conceptualisation of Reinhard and Dervin, 2011. Here an individual is presented with new information or a new situation, which presents a gap; questions, confusions and concerns. They then draw on both internal resources, such as their attitudes and beliefs that somehow relate to that situation to reach an outcome, which may be something they do, or a way they think about this subject. A sensemaking outcome is not a stable, static situation. Sensemaking theory sees individuals as being continually subjected to new situations and information, requiring reassessments and potentially, but not necessarily, new outcomes (Reinhard and Dervin, 2011).

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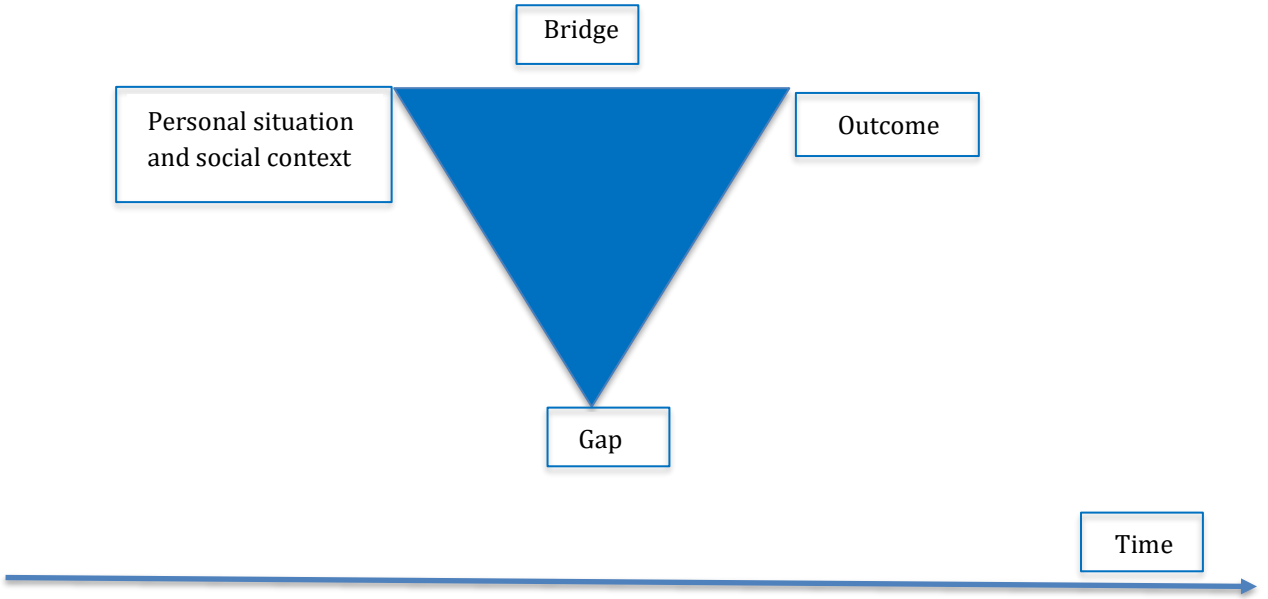
Figure 2. Conceptualisation of sensemaking that starts with an individual being confronted with a new situation or information



2.1 Critical reflection and reflexivity

The notion of reflexivity is connected with that of critical reflection. Critical reflection is the process of examining our assumptions, considering where these originate from, such as personal experience or our social background, re-evaluating these assumptions and potentially reworking what we do or think based on this re-evaluation (Fook and Askeland, 2006). So when considering a particular scientific endeavour, technology or issue it demands "…deep serious consideration of alternatives, unintended consequences, and so on." (Chilvers, 2012, p.295).

Reflexivity adds a self-awareness (Chilvers, 2012) and sense of agency on the part of the individual; a conscious recognition that they are able to influence a situation, or our understanding of the situation.

> *"This specifically involves: recognising the influence of ourselves as the lenses (physical, emotional, social and cultural) through which we see and interpret ourselves and our contexts; recognising that our own contexts themselves may influence what knowledge is available and how we interpret it; acknowledging the role of our own selves and perspectives in selecting the knowledge which we believe is important; and, finally understanding the reactivity element, that is, how the world we see may in fact be a direct function of the methods we use to*

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see it and therefore a function of the environmental reaction to our actions and presence." (Fook and Askeland, 2006, p.45).

In the context of sensemaking, reflexivity is therefore a requirement for certain attitudes and actions on the part of those doing the sensemaking (Table 1). Reflexivity is desirable in that it encourages a more open-minded approach to acquiring and assessing information that draws upon a wider range of information and perspectives than would otherwise be the case. At the interface between science and society, this reflexive approach will aid citizens in their 'collective stewardship' of science and innovation (Stilgoe and Owen, 2013) by encouraging a more considered approach to the information that forms the basis of that stewardship.

Reflexivity is also desirable in the working practices of those doing the communicating, since it encourages the collection of information and opinions from a wider range of sources, a more 'knowing' approach to the interpretation of this information and communication using a wider range of information and opinions. The communication of science can be considered as an act of sensemaking on the part of the communicators. So, reflexivity in communication places the same requirements on the attitudes and actions of communicators as it does on citizens when they are engaging in sensemaking (Table 1). The more diverse communication that results from reflexive communication can then be drawn upon by citizens when they are sensemaking.

Table 1. Requirements of reflexivity for those doing the sensemaking and those communicating with them.

Reflexivity attitudes	Recognise that our own contexts influence the information we find and how we interpret it.
	Reflect on how our own perspectives influence how we select knowledge we believe is important and worthy of trust.
	Understand that we each have our own assumptions and perspectives derived from personal, emotional, social, cultural, historical and political influences.
	Acknowledge that our actions influence the knowledge and perspectives of others and that these actions may in turn be judged through individual perspectives.
Reflexivity actions	Examine the assumptions embedded within our actions and experience.
	Consider the personal, emotional, social, cultural, historical and political influences on our assumptions.

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	Re-evaluate how our context influences the information we find and how we interpret it and potentially change our practices based on this re-evaluation.
	Consider how we select knowledge that we believe is important and worthy of trust.

This table draws from an approach to critical reflection or reflective practice in Fook and Askland, 2006.

2.2 Openness

Here openness is considered from the perspective of the mindset of the citizen engaged in sensemaking and those doing the communicating. It is taken to mean that an individual is able to take into account other perspectives, potentially even shifting their opinion based on the arguments and stories offered by other participants in a deliberation. Openness does not, however, require agreement. As such it has parallels with education and communications research into Actively Open-Minded Thinking (Baron, 1993). Actively Open-Minded Thinking has been defined as "…the dispositional willingness to seek out and thoughtfully engage with new and even threatening information." (Carpenter et al., 2018, p.562)

Table 2. Requirements of openness for those doing the sensemaking and those communicating with them.

Openness attitudes	Awareness of others' goals and perspectives.
	Open to and respectful of a wide range of evidence, new information and perspectives.
	Consciously considering adjustment; a willingness to change one's mind.
Openness actions	Take a broad range of perspectives into account instead of just their own experiences and perspectives.
	Consider information and evidence from a wide range of sources, some of which may counter their perspectives.
	Be prepared to revise their perspectives and actions based on information and evidence.

Adapted from the Actively Open-Minded Thinking Scale in Haran, Ritov and Mellers (2013).

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2.3 Reflexivity, openness and the science-society relationship

Responsible Research and Innovation (RRI) envisages a recursive relationship between science and society in which science and innovation are shaped by the values, needs and expectations of society. However, it also places a responsibility upon members of society to be responsive to science to facilitate a 'collective stewardship' of science and innovation (Stilgoe and Owen, 2013).

von Schomberg defines Responsible Research and Innovation as: "A transparent, interactive process by which societal actors and innovators become mutually responsive to one another with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)." (von Schomberg (2011, p.9)

RRI requires that the stakeholders, such as citizens and scientists, bridge the gap between them to form shared understanding of the research process (Felt, 2016); or at least form a closer understanding. This means that RRI requires change on the part of all actors involved.

> "…it requires scientists to recognise a new category of peer, citizens to bring their social claims into the world vision framing process, industry to negotiate its role into society as innovation carrier and, finally, policymakers to facilitate the institutional change expected by RRI, helping all actors to share its framework."

L'Astorina and Di Fiore (2017) p.169Given the requirements of RRI, the importance of openness and reflexivity in communication practices are most obvious when those doing the communicating are scientists. Openness and reflexivity on the part of scientists demands that they acknowledge, consider and even reflect perspectives on science and research that may be contrary to their own.

But open and reflexive communication by others, whether they are journalists, bloggers or other communicators, also plays a role since it allows wider perspectives on research and innovation to be seen or heard by citizens, making these wider perspectives more 'visible' and so more likely to have a bearing on the trajectory of science.

Reflexivity and openness on the part of citizens, those doing the sensemaking, equally opens them up to a wider range of information and perspectives from which to form their opinions and actions before they meet their responsibility for the 'collective stewardship' of science and innovation.

Given the importance of openness and reflexivity on the part of those communicating and citizens doing the sensemaking, the barriers and opportunities to this will be considered in the next section.

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3. Analysis

This analysis of the barriers and opportunities to open and reflexive sensemaking practices draws upon the findings of research within RETHINK. This research has explored the nature of online science communication through an online 'mapping' of the actors, the platforms they use and the nature of their communication. It has investigated the working practices of communicators, their motivations and their connections with their audiences. It has also investigated the sensemaking practices of citizens. This research is presented more extensively in other reports produced as part of the RETHINK project (Milani et al. 2019, Milani et al 2020a and Milani et al 2020b and sensemaking report in press). What is presented here is a synthesis of data that provides an insight into openness and reflexivity in sensemaking practices.

3.1 Communicators and open and reflexive sensemaking

Here results from research conducted in RETHINK Work Package 1 will be considered in terms of its implications for open and reflexive sensemaking practices amongst those communicating science and of citizens. This research sought to map online science communication (a digital science communication scoping study), explore the working practices and motivations of those communicating science, and investigate the connections they have with their audiences.

Scoping research on the digital science communication ecosystem (Deliverable D1.1)

The scoping study on the digital science communication ecosystem was conducted in seven countries – the UK, Italy, the Netherlands, Poland, Portugal, Serbia and Sweden – by applying a protocol developed by the UWE Bristol research team. Each country explored their digital ecosystem in relation to two of the following subject areas: climate change, artificial intelligence and healthy diets. The scoping study found a diverse range of actors sharing science-related content online, especially about climate change. The type of content shared differed depending on the digital platform, such as a blog, Facebook, Twitter, where it was published (Milani et al., 2019). Here, the results of the scoping study are interpreted to identify potential barriers and opportunities to open and reflexive sensemaking practices.

Opportunities for open and reflexive sensemaking practices

The scoping study showed how both professional and non-professional communicators, experts and non-experts, share content about science, technology and health online. Digital media have enabled a greater diversity of actors to communicate about the same topic and participate in science-related debates regardless of their formal education and academic background. This allows citizens to be exposed to different sources, either traditional (e.g. media, scientists) or alternative (e.g. activists).(Milani et al., 2019).

This rich, diverse online ecosystem of science material has the potential to facilitate openness in sensemaking practices by citizens by increasing the diversity of information and opinion

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citizens have access to and can take into account, in order to make sense of science-related issues; whether it's coronavirus, climate change or something else entirely. Similarly, it has the potential to increase openness by providing access to information and evidence from a wider range of sources. All of this has the potential the encourage citizens to revise their perspectives based on what they read or watch online. Reflexivity is also potentially increased by widening citizens' exposure to alternative information and ideas, potentially encouraging or at least facilitating an examination of the assumptions they use to underpin their opinions and actions and a re-evaluation of how their context influences the information they find and select. While the scoping research shows the *potential* for the openness and reflexivity of the sensemaking practices of citizens to be increased by the richer science communication ecosystem presented by digitization, it is not possible to ascertain from this data whether this actually happens.

Barriers to open and reflexive sensemaking practices

The digital scoping study showed that the diversity of actors and sources online depends on the topic communicated. For example, the climate change digital landscape was characterised by a vast number of actors, such as non-profit organisations, think tanks, activists, local and national governments, scientists, industries, journalists, media organisations, universities, research centres and so on. The artificial intelligence ecosystem was less diverse in terms of actors communicating about this topic. Variations in the diversity of actors and sources of information online between different subject areas also implies variability in the opportunity for open and reflexive sensemaking among citizens due to variations in the information and ideas they have at their disposal.

The social media and search engine APIs can also limit open and reflexive sensemaking practices among citizens by limiting the information presented in online searches. These algorithms posed a challenge to researchers when developing the protocol for the scoping study as they had the potential to skew or limit the diversity of actors presented in searches. For example, Google search tends to show websites and blogs that are better optimised for search engines, and that are more similar or in line with previous search results consulted by a user (Brown, 2017). Social media algorithms analyse users' behaviours, searches and interactions (e.g. likes) "to create a media environment that best suits each user's preferences" (Cohen, 2018, p.143). Therefore, citizens may be mostly exposed to content and sources of information that support their own opinions and beliefs, and not see content where different information is provided or opinions expressed. This challenge also applies to the science communicators themselves when they are undertaking online searches during their research.

Roles and action repertoires of science communicators (Deliverable D1.2)

A survey was conducted to investigate the roles, action repertoires, motivations and barriers of actors communicating science, either in a professional or non-professional capacity (Milani et

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al., 2020a). The questionnaire was designed by the researchers at UWE Bristol and distributed in the UK, Italy, the Netherlands, Poland, Portugal, Serbia and Sweden.

Barriers to open and reflexive sensemaking practice

Most of the survey participants said that their main motivation to communicate science was to share their enthusiasm for science. Others said they communicate science because they want to educate the public. While such motivations are understandable, by encouraging the championing of science they have the potential to limit the diversity of opinions and information presented to citizens to enable open and reflexive sensemaking (Roberson, 2020).

Many participants indicated that they want to inform and educate the public about science, thus assuming the role of *conduit* (Fahy and Nisbet, 2011). This indicates a potential lack of two-way conversation that would otherwise facilitate reflexivity among communicators in how they communicate by exposing communicators to the perspectives of others, enabling them to see how their own context (such as the social and political influences on them) has a bearing on their assumptions. It also potentially limits openness among communicators by restricting the perspectives and information they take into account. Similarly, this conduit role potentially limits openness and reflexivity on the part of citizen sensemakers. By limiting opportunities for discussion about science, it is firstly less likely that citizens will reflect upon how their own perspectives are formed, and secondly, less likely that they might be aware of or open to the perspectives of others.

That said, there is still the potential for an individual communicating science and not engaging in dialogue to encourage openness and reflexivity in the sensemaking practices of citizens. Writers such as Angela Saini and Ben Goldacre, for example, place science in a social context and actively encourage readers to re-consider their own perspectives (to be open) and evaluate how their initial perspectives were formed (reflexivity). Though rather than being 'conduits' to use Fahy and Nisbet's (2011) role typology, they could be more accurately regarded as a 'public intellectual' and/or an 'agenda setter'.

Lack of time, lack of resources, and organisational barriers, such as lack of funding, support and recognition for science communication work, were often voiced by the survey participants as barriers to communication activities. This effects audiences by limiting access to the information and ideas they are presented with, limiting their ability to be open to other information and perspectives and reflexive in their science communication practices. Some science communicators said they faced challenges in involving scientists or other stakeholders in science communication activities, further limiting the voices that can be heard by sensemaking citizens.

Most survey participants said they consult academic journals, university press releases, newspapers, science magazines, and personal contacts during their research when communicating science. Fewer consulted social media such as Twitter. Though traditional

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sources of information may be deemed to be more accurate and trustworthy, social media offer access to a variety of traditional and alternative sources of information at the same time. The focus on traditional sources has the potential to restrict opportunities for openness and reflexivity in communication practices and therefore access to a wide range of opinions and information among citizens.

Opportunities for open and reflexive sensemaking practice

Though many survey participants adopted the *conduit* role of informing and educating the public, around two-thirds indicated that they seek to encourage conversations between researchers and the public, thus having a *convener* role (Fahy and Nisbet, 2011). This has the potential to make citizens' sensemaking practices more reflexive and open.

Many survey participants said they use digital media to communicate with their audiences - Twitter, Facebook, YouTube and Instagram were the most commonly used social media platforms in a professional capacity. These platforms have affordances which have the potential to facilitate two-way interactions between communicators and citizens, encouraging reflexivity and openness by them both. Online forums such as Quora or Reddit were barely used by the participants. But they can provide a space for dialogue and two-way interactions between scientists, communicators and the public (Hara, Abbazio and Perkins, 2019).

Links between science communicators and their audiences (D1.3)

In addition to working practices and motivations, the survey of science communicators conducted within the RETHINK project investigated the audiences participants intend to reach (Milani et al., 2020b) and this has implications for open and reflexive sensemaking.

The connections communicators have with their audiences were also explored at Rethinkerspace meetings held in the Netherlands, Poland, Serbia, Sweden, Portugal, Italy and the UK. Rethinkerspaces are communities of practice that involve actors such as scientists who communicate science, press officers, journalists, bloggers and those responsible for organising public engagement activities.

Barriers to open and reflexive sensemaking practices

Many science communicators in the questionnaire indicated that they are aiming their outputs at audiences already interested in science, technology or health topics (24%) and a larger proportion indicated that some members of their audience are interested in science and others are not (74.4%). Only a small proportion (1.5%) said they target audiences not already interested in science, technology or health topics. This potentially limits opportunities to engage in open and reflexive sensemaking among those not already interested in science by limiting their access to science-related information.

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In the Rethinkerspace workshops, participants reflected on a lack of two-way interaction with their audiences on digital media - they reported that it is challenging to create conversations and find out what their audiences want. This is in spite of the potential for interaction afforded by social media platforms. This makes it challenging for science communicators to encounter and engage with other perspectives and therefore be reflexive in their communication and open to other perspectives. But taken in a positive light, it indicates a willingness on the part of science communicators to be open to the perspectives and information presented by citizens. It also demonstrates reflexivity on the part of communicators in that they are aware of how their context, the nature of their online interaction (or lack of it), is shaping their communication activities.

Opportunities for open and reflexive sensemaking practice

A participant of the Rethinkerspace workshops suggested that more intermediaries are needed to reach some social groups in communication activities, such as those living in rural communities. This suggestion is relevant to online environments. For example, Lutkenhaus, Jansz and Bouman (2019) suggested engaging with opinion leaders at the edge of anti-vaccine communities on Twitter in order to access these groups. By engaging with intermediaries and mediators of online groups, science communicators can improve their understanding of these groups, enabling reflexive communication approaches. It also provides the opportunity to increase the range of information and opinion available to these groups, in turn providing opportunities for open and reflexive sensemaking.

3.2 Citizens and open and reflexive sensemaking

Research on citizens' approaches to sensemaking was conducted by taking coronavirus as the central theme through which to explore how they make sense of science-related information. Interviews were conducted in Italy, the Netherlands, Poland, Portugal, Serbia, Sweden and the UK in which volunteers were invited to talk about 'micromoments' during the pandemic – moments when they were confronted with a new ambiguous, complex situation such as new social distancing restrictions being introduced by a national government.

Through these interviews it was possible to investigate:

- The sensemaking 'gap' – the experience or situation that raised questions in the mind of an individual.
- The 'bridge' - thoughts, information seeking, beliefs that informed how the individual sought to find answers to the questions.
- The outcome – how the individual acted and/or thought based on the sensemaking bridging they had undertaken.

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Here a case study approach is taken to these interviews exploring sensemaking practices in which three interviews, two each from the UK, the Netherlands and Serbia, are used as illustrative examples to explore sensemaking practices and consider the implications of this in terms of the apparent barriers and opportunities to open and reflexive sensemaking. The results of sensemaking interviews are presented as 'sensemaking triangles' that present the sensemaking gap, bridge and outcome in relation to one micromoment for each individual.

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Case study 1 – the UK

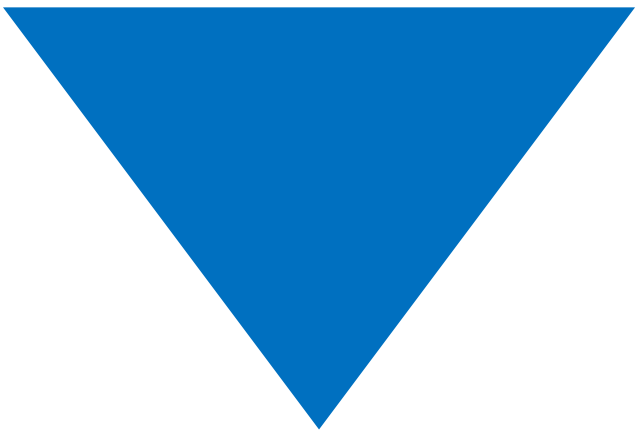
Interviewee: Male adult, 22-30years old, with a master's degree in environmental health, classed as high risk for covid-19 (had a kidney transplant), and has also had coronavirus.

Bridge

"All I say is just educate yourself, you know? Don't follow the news too much, you know? Go on the NHS website, you know? Do your own research, you know? Listen to podcasts, listen to the consultants, doctors, you know? And just follow the guidelines! Don't listen to bad advice."

"I tend to look at medical journals, medical articles." "I listen to [the transplant coordinator's] advice." "Little bit of government advice also, but not too much."

"Because a lot of the time I am just scrolling down [social media timelines] and I am thinking ok, that isn't true, that isn't true. You know, where did you get this information from? You know… so… for me, it's sort of about seeking the relevance."



Outcome

The participant said that he chose content on social media that is interesting and relevant for him. However, this content has to be from trusted sources and proven scientifically.

"It's just all about seeking the truth of it, you know. 100%. If it's proven, then I will listen to it."

Gap

"It makes me laugh. [My friends] say to watch like YouTube clips… watch the celebrities talking about this, you know, that [the coronavirus] is not real, it is fake, what the government says and everything like that."

"I was really frustrated with those people who said, you know, [coronavirus] is just fake, oh it's just a cold."

Micromoment: Friends talking about how they sought information about coronavirus from YouTube.

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Insights about openness

There is evidence of a wide range of sources of information being consulted rather than just this interviewee's own experiences and perspectives, providing some evidence of openness. That said, the sources consulted here are trusted scientific sources such as medical journals that fit with their experiences and education, and the sensemaker is less responsive to alternative sources such as YouTube and social media. The participant also indicated a preference for content that is of personal relevance and interest.

There is evidence that the sensemaker is willing to revise their actions based on what they see or read (through the quote: "If it's proven, I will listen to it"). But this openness is based around a ring-fenced selection of what are considered to be reputable sources.

Insights about reflexivity

The interviewee mentioned being aware that his degree influences how he seeks and interprets information about coronavirus online and so there is some evidence of reflexivity in his sensemaking practices.

Case study 2 – the UK

Interviewee – Mother of three who is a primary school teacher. She has relatives who work for the NHS and previously worked for the NHS.

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Micromoment – The UK government is pushing for a vaccine against coronavirus but developing a new vaccine takes years.

Bridge

"How can they say we can fast track this vaccine, but you can't fast track another vaccine … We haven't got a vaccine that completely eradicates, I don't know, measles". She said that the MMR vaccine has taken many years of trials, and even if several generations have been vaccinated, measles hasn't been eradicated yet. "How can they suddenly say...that...we are going to have a covid-19 vaccination, everyone is going to have it, and we are going to get rid of it straightaway?"

She doesn't trust the information given from the government because of the demands made by the government on schools during the coronavirus crisis and the practicality of these expectations. She doesn't know what to believe or not when she watches the news and has stopped watching it because of this. She does trust those "on the front line", such as the scientists working on the vaccine, her "friends and family who work in the NHS", the doctors and GP clinics. "Let's have the people on the front line that are actually doing the testing, rather than having somebody else who's somebody else who's somebody else, and then it's being announced."

Outcome

"I am in a quite high-risk category of…not of just getting Covid but actually getting it quite severely and... the long-term impact that would have on me and my family... So if they said, and it's all being properly trialled and everything else, and they said it's safe to have, then yeah, I would have the vaccine."

"They wouldn't administer it if it wasn't safe. You know, even the... with questions of how quickly this is taking place there are still strict, strict, strict guidelines that they have to adhere to."

Gap

"How effective is [the coronavirus vaccine] going to be? You know, we've only had this strain of coronavirus for just under a year?

"Normally it takes a good 3 or 4+ years just to make sure [the vaccine] is okay. For them to say we are going to have a vaccine by Christmas, I kinda go 'Really?! Are you really going to have it done by then? Do you really think it is going to be...worth it?'" "How much do I trust that it is been done properly, knowing that in the past it takes a very long time?"

"Would I risk getting it?"

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Insights about openness

The trusted sources are family and friends who work in the health service and others who are in keeping with the interviewee's background and context, such as doctors and other health professionals. This and the lack of trust in the government and media appears to indicate a lack of openness in the sensemaking practices. The participant is not open to sources that counter her perspectives and the participants' sensemaking openness appears to have been influenced during the coronavirus crisis.

Insights into reflexivity

The interviewee showed a certain degree of reflexivity in her sensemaking. She was aware that her previous experience with vaccinations, especially the flu vaccination, influenced her assumptions about the coronavirus vaccine. She was also aware that her distrust of the government (political influences) made her sceptical towards the coronavirus vaccine.

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Case Study 3 – The Netherlands

Interviewee: Woman, in her late 50s. Married to a medical doctor. Has watched the news closely since the first reports of coronavirus in China. She feels vulnerable because of her age and takes the restrictions seriously. She tries to empathise with how the pandemic affects other people.

Micromoment: The woman and her husband travelled to the US on a tour. Their tour continued but during the trip, she noticed that many Americans were not worried about coronavirus.

Bridge

She receives a lot of information from the international professional circle of her husband. This information is scientifically based and is trusted by the participant. She reads many different newspapers to be exposed to different perspectives.

She finds that the different voices in the media make the situation around coronavirus very confusing.

Outcome

She confronted Americans who were not concerned about the situation and came to the conclusion that the US has a different culture and they see coronavirus differently.

She and her husband followed the news about what was happening in The Netherlands.

They used their own protective measures such as keeping their distance and washing their hands because they felt vulnerable due to their age.

Gaps

“How can they not be not worried about it [in the US]?”

"I thought - am I the only one who is worried about this at the moment?"

“Am I now a scaredy-cat, or panic-mongerer?”

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Insights into openness

There are indications of openness in that the participant is willing to consider information from a wide range of sources – newspapers specifically. She also said that she tries to take others' perspectives and experiences into account. But at the same time, the information she receives is influenced by the participant's own circumstances, in this case her husband's job as a medical doctor.

Insights about reflexivity

The participant questioned her own perspective on the level of risk posed by coronavirus and the extent to which it was at odds with individuals she was encountering in the US. This indicates reflexivity on the part of the participant. However it is not possible to determine the extent to which the participant considered specific influences, such as her personal context, on her assumptions from the data.

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Case Study 4 – The Netherlands

Interviewee: 29-year-old university science researcher. Grew up in a rural environment. She feels young and healthy but is concerned about infecting others. At first she felt this only happens outside of 'the West'.

Micromoment: Confused that the coronavirus rules differ between countries.

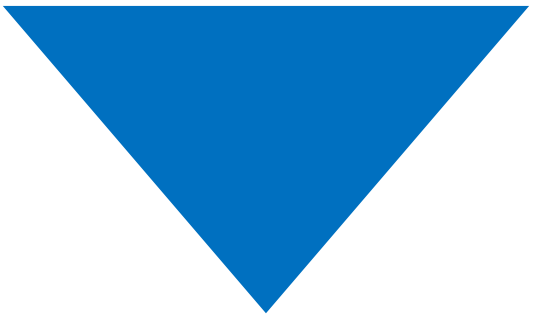
Bridge

"I had many conversations with my father. We lived at a farm. I remember how far clouds of dust travelled when we cleaned the chicken barn."

"I tried to search for information online."

"A lot more scientific knowledge is present now. This soothed my anxieties."

"I trust the expertise of the RIVM [institute for public health] a lot."



Outcome

"I decided to not attribute too much value to the situation, because not a lot was known."

"They know enough now for me to continue my daily routines."

Gaps

How do you know for sure how the virus spreads? How does the virus behave?

Is the 1.5 metre distance enough?

Insights about openness

The interviewee is open to a fairly wide range of information, drawing on personal experience, conversations with family, online search and in particular the Dutch institute for public health. The willingness to draw on information their own experience, of living on a farm, and a government-linked research institute indicates a willingness to be open to a range of perspectives.

Insights about reflexivity

It's not possible from the data to gain any insights about the reflexivity of the participant.

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Case Study 5 – Serbia

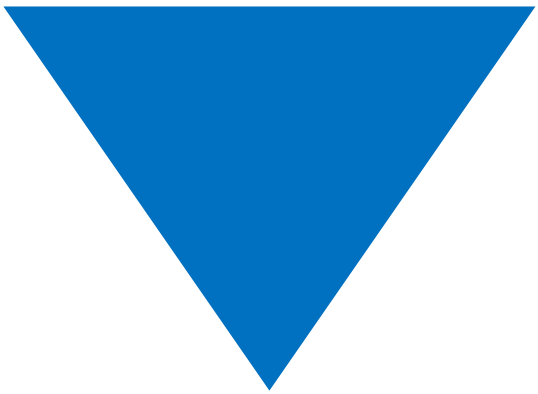
Interviewee: A 52-year-old who is a retired manager of a media company. He is a diabetic who has had two heart attacks. He lives with his wife and mother-in-law who is 82-years-old.

Micromoment: Living in a household of three individuals who are at high risk in relation to coronavirus.

Bridge

"As a person with a pre-existing condition who belongs to a high-risk group, I have to be careful".

"I did not search for the information. It came to me on its own, through online groups with which I interact."



Outcomes

"I don't believe the experts for political reasons. Someone needed elections to take place, so the decision was made to hold elections."

"Do you believe everything in the media or do you, as I do, check everything as many as five times, then come to your own conclusion?"

Gaps

Maybe this virus has long-term health effects?

On the one hand, no-one even knows anything about it, meaning that you do not have shared evidence on how dangerous it is and how it is transmitted.

Insights into openness

Sources consulted are influenced heavily by the individual's own circumstances, in this case the online groups he already interacts with. The participant is not open to perspectives from 'experts' and is also reticent to trust information that reaches him via the media. The reference to reaching his own conclusions indicates that he is likely to gravitate towards information and perspectives that are in keeping with his own perspectives.

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Insights into reflexivity

The participant is reflexive in the sense that he is aware of the approach he takes to interpreting information from the media and how that may differ with the approaches of others. But it is not possible to glean any further insights into the participants' reflexivity from the data.

Case study 6 – Serbia

Interviewee: A 30-year-old who lives in Belgrade and is currently completing his doctoral studies in law as well as working as an assistant at an academic institution.

Micromoment: Considering the long-term impact of the lockdown restrictions.

Bridge

"Here I felt how different life in the city and in the countryside is. Of course, I was aware of that before, but now I have really experienced it and started seriously to think about the meaning of life in the city."

"In the countryside, it seemed as if there was no pandemic. Almost no-one wore masks because there was no need. At that moment, no infected people were identified there. People moved and worked in the fields normally, even in the afternoon and evening when life in the city used to stop completely and everyone was locked in their houses."

Outcomes

"I realised how much life in the city depends on a bunch of factors while in the countryside you are much freer and more independent."

"Since then, I have been thinking intensively about buying a cottage in the countryside and even moving there for a few months."

Gaps

"When this all started, it made me think about what the economic situation will look like in the fall."

"How will this affect my functioning in society – my job as I work with a lot of students."

"After the first couple of weeks spent in the city, we had the privilege of leaving the city for two weeks. I went to the house in a village and experienced a kind of relaxation."

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Insights into openness

The participant relied on his own immediate experience and thoughts, potentially limiting openness to alternative sources of information and opinion.

Insights into reflexivity

It is not possible to glean any insights into the participants' reflexivity from the data.

4. Conclusions

Open and reflexive sensemaking and communicators

The actions of communicators have the potential to influence the openness of sensemaking practices of citizens by influencing the range of information and opinions clearly visible to citizens online. Similarly, a diversity of information and opinion may be seen to encourage, or at the very least facilitate, reflexive sensemaking.

The scoping study of digital science communication conducted within the RETHINK project demonstrated the diversity of actors now communicating about certain science-related topics, such as climate change online. Though the extent to which this potentially diverse range of information and perspectives is seen by citizens online is limited by social media and search engine APIs.

The working practices of science communicators also influence the range of information and opinions available, with academic journals, university press releases, newspapers, science magazines, and personal contacts consulted widely during research; social media less so. But here too, issues of trust and reliability of information are likely to be an important factor in approaches to research and so need to be weighed against the merits of exposing readers, viewers and listeners to a wider range of information and opinion.

The roles adopted by communicators may have an influence on the openness and reflexivity of citizen sensemaking. Informing and educating the public about science assuming the role of *conduit* (Fahy and Nisbet, 2011), limits opportunities for two-way dialogue with citizens whereas the *convener* role (Fahy and Nisbet, 2011) encourages it and so may have a beneficial effect on openness and reflexivity. Even as an information 'transmitter', rather than someone who engages in dialogue, there are still opportunities to encourage openness and reflexivity in the sensemaking practices of citizens. This is the case if science communicators encourage citizens to reconsider their perspectives and become more reflexive in how they interpret science-related information, adopting a public intellectual and/or agenda-setter role.

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The research presented here also demonstrates the need for new roles among communicators to facilitate open and reflexive citizen sensemaking. In particular, acting as an *intermediary* or *mediator* may enable science to reach audiences that are hard to reach due to language and/or cultural differences or other factors such as geographic isolation (Froonjian and Garnett, 2013). Individuals with existing connections to such audiences would be best placed to act in such a role.

Finally, the analysis presented here demonstrates the need for reflexivity on the part of communicators. There is an understandable tendency among communicators to want to champion science and demonstrate an enthusiasm for it. But this may limit the information and opinion communicated (Roberson, 2020) and the audiences reached.

Open and reflexive sensemaking and citizens

The extent to which conclusions can be drawn about openness and reflexivity in the sensemaking practices of citizens is limited because the sensemaking research conducted within RETHINK did not specifically ask about participants' openness and reflexivity in how they make sense of science-related information. Instead, it focused on their sensemaking practices using interviews that explored 'micromoments' relating to the coronavirus pandemic.

Nevertheless, this research into sensemaking practices does provide some insights into potential barriers and opportunities to openness and reflexivity in such practices among citizens. The sensemaking interviews provided evidence of reflexivity in sensemaking practices – one of the interviewees, for example, commented that their educational background influenced their approach to information retrieval and interpretation. However, further research would be required to explore the extent to which reflexivity is evident among different individuals. There is also evidence of openness in sensemaking in that some participants stated that they consulted a range of sources. Though in the case of one interviewee, this became a source of confusion due to exposure to contradictory information.

The research also demonstrated that citizens' sensemaking practices are influenced by their context – such as who is in their immediate family, where they are living, their profession, and the online groups to which they subscribe. This may be indicative of a lack of reflexivity to sensemaking in some instances and a lack of willingness to be open to alternative sources of information. There is also evidence of citizens seeking information that is of personal relevance and interest online, limiting the information they are exposed to. The role that an individuals' personal context plays in their sensemaking has implications for those communicating science who are encouraged to understand their audience before engaging in communication activities. Further research would be needed to investigate if a more nuanced picture of an audience is demanded by a knowledge of sensemaking practices, and equally, whether this could be operationalised within science communication activities.

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Openness in sensemaking practices is relevant to issues of trust and expertise in online information. In some sense, attempts to find trustworthy information, which some of the citizens interviewed were seeking to do, would be seen to work against the requirements of openness in terms of taking into account a wide range of sources and perspectives. However, trust and openness need not be mutually exclusive; it is possible to be open when sensemaking while also assessing the trustworthiness of information.

European Commission media literacy policy places an emphasis on critical thinking towards the media and in particular cognitive skills that allow people to evaluate content for its truthfulness and reliability (Viola, 2016). Openness in sensemaking practices would also require EC media literacy policy to encourage citizens to develop an awareness of factors that can work against their openness, such as solely seeking and relying on information from their existing groups and networks online. It should also seek to encourage citizens to become reflexive in how they seek and appraise science-related information online; aware that their approach is based on their assumptions and context.

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