2.   Responsible Innovation and Responsible Research and Innovation
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INTRODUCTION

'Responsible Innovation' (hereafter RI) and 'Responsible Research and Innovation' (hereafter RRI) are two linked discourses that have emerged in parallel over the last decade which challenge the epistemological norms and practices concerning the production and valorisation of scientific knowledge. This chapter will review and discuss the main features of these discourses and how they are being framed in both policy and practice. Both discourses 'sediment over' (Randles, 2017) and at times variously intersect with, reinforce or challenge existing de facto narratives and norms of responsibility[1] as these relate to scientific research, development and innovation (e.g. those relating to academic conduct and research integrity). In the case of RI the discourse most certainly enlarges, reframes and challenges these extant responsibilities (Douglas, 2003). RRI is a policy-driven discourse that emerged from the European Commission (EC) in the early part of the current decade. At a high level it aims to foster the design of inclusive and sustainable research and innovation, with an emphasis on co-creation and co-production with society ('science with and for society'). In this sense it strives to align research and innovation to the values, needs and expectations of society (with a strong emphasis on 'societal grand challenges' (see Lund Declaration 2009;[2] Rome Declaration 2014;[3] and Kuhlmann and Rip, 2014). It also seeks to anticipate and assess broader implications of research and innovation in an ethical, inclusive and responsive way. As we will discuss, in this regard RRI shares much with the discourse of RI, which has in contrast emerged largely from academic roots. Confined in the main to relations between science and society, RRI strongly reflects its origins in the EC Science in Society programme (Owen et al., 2012). As such it also more prosaically and instrumentally aims to forward and mainstream action lines originating in that programme: gender equality in research, open access to scientific results, ethics, public engagement and the promoting of science education. These so-called 'RRI keys' have become an increasingly predominant framing for the EC RRI discourse over time, and a source of tension in the academic community.

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We will argue that, while individually important, the EC policy keys represent isolated themes rather than a coherent discourse. They also do not substantively engage with innovation, or innovation systems, and seem to offer only little prospects for systemic, transformational change of these.

Proponents of the discourse of RI seem to advocate deeper institutional and systemic transformation in this respect, striving for innovation (and science aimed at this) that is more anticipatory, more reflexive, more inclusive, deliberative, open and, in total, more responsive. But RI remains largely an ideal, a guiding principle that can be perceived as being abstract and which remains unresolved in terms of its political, institutional and normative imaginaries and practices. It, like RRI, has been largely preoccupied with (techo-visionary) science and emerging technologies, rather than innovation per se, and notably innovation involving the corporate sector. Like RRI, its intersections with innovation systems remain little explored and, associated with this, how roles and responsibilities of actors should be (re)defined and how knowledge flows and institutions should be (re)configured. Likewise, there has been little engagement of RI with organisational studies and, associated with this, little consideration of how 'deep RI institutionalisation' can be fostered (Randles, 2017). What is clear is that RI is a discourse that is encountering significant challenges, and indeed resistance, as it runs headlong into political imperatives based largely on economic growth and productivity; vested interests; and engrained institutional norms, cultures, behaviours and organisational practices. After reviewing the main features of both discourses, we close with some thoughts on these challenges.

THE EMERGING DISCOURSE OF RESPONSIBLE INNOVATION

RI and RRI are often used interchangeably, and it is easy, but mistaken, to consider them as being the same thing. While they have emerged in parallel and share some common features, we need from the outset to make a clear distinction between these two discourses. We do this not through an indulgent desire to labour the reader with semantics, but because of significant differences that have emerged between them in recent years. The EC RRI discourse in its early formulation certainly shared much with the discourse of RI and vice versa (Owen et al., 2013; von Schomberg, 2012, 2013), and indeed vestiges of this earlier RRI formulation remain visible today (see below). But in recent years these discourses have progressed along increasingly divergent paths, and indeed these paths seem likely to diverge even further in the future as the EC moves to a '3Os' policy ('open

science, open innovation, open to the world').[4] What they most certainly share is their status as umbrella terms (Rip and Voß, 2013), as being interpretively flexible, as being politically malleable and as being contested discourses in the making.

The discourse of RI has strong academic roots. This is in contrast with the distinctly EC policy roots associated with the RRI discourse which we will go on to describe below. RI emerged at the beginning of the current decade but has historical foundations that go back many decades, and builds on discussions and debates concerning the social responsibility of science that have an equally long history (Genus and Stirling, 2018). In particular, such concepts (often emerging from science and technology studies (STS)) as anticipatory governance (e.g. Barben et al., 2008), ELSI/ ELSA (ethical, legal and social aspects of technologies) and technology assessment in its various forms (e.g. constructive and real time technology assessment) are notable foundations. Unquestionably RI also has links to concepts such as social innovation (Lubberink et al., 2017). Some authors have argued that in processual terms RI may look decidedly familiar, even that it is old wine in new bottles (Zwart et al., 2014). While we suggest this to be a little harsh, these foundations certainly suggest an evolutionary characteristic to RI and that it is a discourse that has not simply emerged from nowhere (Genus and Stirling, 2018).

Those looking for clues in terms of a distinctive identity for RI can find them in the term itself. RI should start with the word responsible and what being responsible in the context of innovation means (Owen et al., 2013; Stilgoe et al., 2013). The RI framework developed by these authors places emphasis on an approach that is rooted in a future-oriented notion of responsibility (Richardson, 1999; Pellizzoni, 2004; Grinbaum and Groves, 2013) emphasising dimensions of *care* and *responsiveness* (see Owen et al. (2013, p. 35) for a more detailed discussion of this). This acknowledges that innovation (and techno-visionary research leading to or aimed at this) always sits in a historical context. But it is its power to *create and transform futures* (reflecting what Jonas (1984) described as the 'altered nature of human action' mediated through technology (and innovation)) that requires a formulation of responsibility that goes 'beyond the ethics of the neighbourhood' (ibid.) and is future oriented. Acknowledging the power of innovation to create futures – and associated with these uncertainties and vulnerabilities – RI asks how we can and should meaningfully engage as a society with the futures innovation seeks to create, futures that are being created unintentionally or by design. For example, how the future world of work might be transformed by artificial intelligence and machine learning, or how our future world might be transformed by techniques intentionally aimed at engineering the climate at a planetary scale. But

RI goes further, asking how we can build on this engagement to respond and act in order for us to collectively take some measure of responsibility for those futures, rather than discount them, or leave them to chance and ourselves to moral luck. This makes RI as much about intended impacts, visions, purposes, political agendas and associated public policies as it does about understanding and responding to emergence, given the inevitable social, ethical, environmental and political entanglements, dilemmas, uncertainties and risks science and innovation present. These are uncertainties and entanglements we must expect to occur to varying degrees but often lack the knowledge and foresight to accurately predict.

RI therefore firstly asks what kind of future we want innovation to create, and secondly, given that the future is inherently uncertain and unpredictable, how we should proceed under conditions of ignorance, ambiguity and uncertainty. The second clue lies in the word innovation. It is quite intriguing that much of the literature on RI and RRI to date has focused on science and emerging technologies: it has paradoxically rather neglected innovation, which we can describe as a socially constructed process of knowledge mobilisation aimed at creating some sort of value (e.g. through new products and services), often but not always within a market ideology. Bessant (2013) describes innovation, which can be incremental or disruptive, as 'knowledge spaghetti'. This reminds us of the important innovation-systems macro frame within which innovation often sits, systems which are rooted in knowledge creation, integration, development, circulation and valorisation. Godin (Chapter 10 in this volume) notes that, as science, technology and innovation have become *coupled* within such systems, 'technological innovation participates in the market ideology'.[5] But of course, innovation systems can be configured in different ways and for different normative ends. This is a point we will return to later in the chapter, but for now we simply note the predominant market framing of innovation, a framing that RI, through a commitment to second order reflexivity,[6] aims to interrogate.

Stilgoe et al. (2013) define RI as 'taking care of the future through collective stewardship of science and innovation in the present'. While this implies that taking responsibility for the future necessitates some sort of action in the present, it leaves rather a lot of missing detail in terms of what 'collective stewardship' involves (who, how and when). It also embeds tensions and trade-offs, for example the balancing of stewardship with the strongly-held value of scientific autonomy, or balancing precaution and the risk of lost opportunities and benefits. Providing more detail in terms of process, Stilgoe et al. go on to describe the need to develop, integrate and embed competencies for *anticipation*, *reflexivity*, *inclusive deliberation* and *responsiveness* in and around the policies, processes and

institutions of science, technology and innovation. This implies a strongly *inter- and trans-disciplinary approach* as an adaptive, iterative, flexible and proportionate process of co-creation, co-production and mutual learning (Table 2.1).[7] It also implies deficits to our current approach to stewardship and governance of techno-visionary science and innovation. An approach reliant on governance by the market underpinned by (often risk-based) regulation – which is substantial in certain sectors (e.g. pharmaceuticals) – certainly has strengths and limitations. Regulation for example, while important, often lags behind innovation and is often de-limited to health, safety, managing environmental risks and, in some cases, issues of data privacy and security. RI also acknowledges the important but often narrow focus that current institutional processes of ethical oversight present and the lack of formal and systematic processes for engaging citizens and stakeholders with the purposes, agendas and politics of potentially disruptive science and innovation and their broader impacts on culture and society. It acknowledges the well-known dilemma of control that emerging technologies and innovation pose.[8]

Frameworks for RI in part reiterate the goals of earlier concepts such as ELSA and (e.g. constructive) technology assessment to *open up* techno-visionary science and innovation (Stirling, 2008) (e.g. to scrutiny, analysis, reflection and broader debate). But RI also places a premium on *responding*, acting on broadly configured knowledge so we can make innovation more accountable to society (Jasanoff, 2003), whether these are normative and ethical decisions relating to what future (or near present) we think is desirable, or keeping options open for future generations in the face of uncertainty.

Sitting beneath the dimensions described in Table 2.1 are specific tools, methods and techniques which support their translation into practice – for example, in the areas of anticipation, where foresight methods are well established; or in the reflexivity dimension, where experiments in so-called mid-stream modulation (Fisher and Rip, 2013) have been useful; or in the inclusive deliberation dimension, where there is a long history of methodological development and deployment relating to public and stakeholder engagement (see e.g. Sykes and Macnaghten, 2013); or in the responsiveness dimension, where, for example, the configuration of classic innovation stage-gating mechanisms can be broadened (Owen et al., 2013). A comprehensive review of these methods is beyond the scope of this chapter. However, two observations can be made. First, frameworks for RI emphasise *integration* and *institutionalisation* of these dimensions as a continuous process of adaptive learning. In fact, it is rare to find such integration and institutionalisation in practice. While RI invokes an epistemology that is inter- and trans-disciplinary in nature, one that

Table 2.1   Process dimensions of Responsible Innovation

Dimension	Description	Goals/Outcomes
Anticipation	Articulating and reflecting on potential intended and unintended applications, impacts and interactions. Articulating plausible outcomes, risks and associated uncertainties. Asking 'what if?' questions, considering contingency, what is known, what is likely, plausible or possible. Searching for alternative scenarios and options.	Critical engagement with visions and promissory statements of expected impacts. Better understanding of socio-technical and innovation pathways and scenarios. Better understanding of potential impacts, risks and interactions. Increasing resilience. Better capacity and basis for robust and legitimate decision making.
Reflexivity (1st order and 2nd order)	Reflecting on underlying purposes, motivations, values, what is known, what is uncertain, areas of ignorance, assumptions, motivations, commitments and ethical dilemmas. Reflecting on norms, socio-political contexts, agendas, institutional practices, behaviours and epistemologies.	Better understanding and articulation of motivations and purposes. Articulation of tacit assumptions, commitments, areas of ignorance and uncertainties. Critical and ethical engagement with broader dimensions of research and innovation. Alignment with social values. Better capacity and basis for robust and legitimate decision making.
Inclusive deliberation	Opening up the visions, purposes, processes and emerging impacts of science, technology and innovation to inclusive deliberation. Inviting, engaging and deliberating early and iteratively with a diverse range of stakeholders and publics in research and innovation agenda setting and practice. Creating more socially robust	Engaged stakeholders and publics. Raising debate. Understanding of different framings. Identifying opportunities for innovation. Making visible assumptions, commitments and intended impacts. Participation in agenda setting and defining societal challenges. Equitable decision making.

Table 2.1   (continued)

Dimension	Description	Goals/Outcomes
	knowledge and support for legitimate decision making. Inter- and trans-disciplinarity aimed at knowledge co-production.	Better capacity and basis for robust and legitimate decision making.
Openness	Open and free access to and communication of data, results, purposes, risks, uncertainties, applications and implications to facilitate inclusive deliberation.	Transparency. Equitable access to knowledge and reducing information and power asymmetries. Supporting informed debate. Better capacity and basis for robust and legitimate decision making.
Responsiveness	Ensuring that broadly configured anticipatory, reflexive and deliberative knowledge has bearing on and shapes the purposes, processes and impacts of innovation and research aimed at this.	Understanding and responding to emergence. Empowering social agency in choices relating to innovation and futures. Keeping options open for future generations. Alignment with societal values. Better capacity and basis for robust and legitimate decision making.

Source: adapted from Owen et al. (2013) and Stilgoe et al. (2013).

invites multiple ways of knowing, this is an approach that presents distinct challenges in its doing (see e.g. Felt et al., 2016). Second, there is the key issue of how these methods are configured and deployed – for example, how dialogue and deliberative exercises are framed, contextualised and undertaken and with what motivations (see Sykes and Macnaghten (2013) for a discussion of instrumental, normative and substantive motivations).

A number of initiatives and research programmes either formally labelled as RI or containing RI components have emerged in the last five years. In terms of public research funding organisations these include the Dutch Research Council (NWO) RI programme (MVI), which has an emphasis on 'identifying ethical and societal aspects of technological innovations – products and services – at an early stage, so that they can be taken into account in the design process'. In the UK, the conceptual

development of RI went hand in hand with policy development at the UK Engineering and Physical Sciences Research Council (EPSRC), the largest public funder of physical sciences and engineering in the UK (Owen, 2014). The EPSRC has been the first, and to date the only, public research funder in the UK to formally introduce a policy framework for RI (in 2013).[9] Although the EPSRC labels the RI dimensions slightly differently (Anticipate, Reflect, Engage, Act), the substance and meaning of these terms are largely consistent with those described in Table 2.1. The EPSRC frames RI around these as a 'process that seeks to promote creativity and opportunities for science and innovation that are socially desirable and undertaken in the public interest'. It 'acknowledges that innovation can raise questions and dilemmas and is often ambiguous in terms of purposes and motivations and unpredictable in terms of impacts, beneficial or otherwise'. It seeks to 'create spaces and processes to explore these aspects of innovation in an open, inclusive and timely way', stressing that 'this is a collective responsibility, where funders, researchers, stakeholders and the public all have an important role to play' and 'which goes beyond considerations of risk and regulation, important though these are'. The policy commits the EPSRC to making RI prominent in its strategic thinking and funding plans, including proposal assessment. In practice, while a growing number of its funding calls have signposted to the policy, RI has largely been taken forward within a limited number of key thematic areas, principally Information and Communications Technology (ICT), Quantum Technologies, Synthetic Biology, Healthcare and its Centres for Doctoral (PhD) Training. The impact on the EPSRC's programme of geoengineering research is one area where RI has had a notable impact (Macnaghten and Owen, 2011; Owen, 2014 and references within). Overall, in most countries, beyond a small number of research councils (e.g. NWO, EPSRC, Research Council of Norway) RI has yet to formally penetrate public policy to any substantial degree.

Despite its infancy, the discourse of RI has been subject to a growing body of critique. Within this, a neglect to critically and normatively engage with politics is perhaps one of the most significant criticisms. Van Oudheusden (2014), writing about the 'politics in and of deliberation', makes two relevant observations in this respect. He first cautions the need for RI to be sensitive to power dynamics and strategic behaviour, resisting the dangers of instrumentalisation (see also Genus and Stirling, 2018, p.63). Others are well acquainted with such questions of framing, motivation, power, legitimacy and institutional responsiveness, which have historically been levelled at public engagement activities (e.g. Stirling, 2008; Sykes and Macnaghten, 2013). It is perhaps van Oudheusden's other observation that requires deeper consideration, one which relates to

questions of (democratic) accountability (Genus and Stirling, 2018). He suggests that RI is politically biased in so far as it privileges a processual, Rawls and Habermas-inspired *deliberative* concept of democracy (in which there is a premium on deliberation, argumentation, procedural justice and mutual learning) over traditional expertise and representation – that is, where some are authorised as accountable individuals to speak, and make decisions, on our behalf. Partly the issue is one of effectiveness: from a procedural point of view he notes that deliberative processes have had mixed results in terms of their impacts on public policy. Glerup and Horst (2014) similarly note that 'several decades of work on deliberation and public engagement [concerning science and technologies] suggest that consensus . . . when under discussion by varied stakeholders, is at best difficult and at worst impossible'. It should of course be noted that consensus is not the inevitable goal of RI.

This also relates to issues of legitimacy (input and throughput). RI, as we have described above, not only advocates public participation and deliberation in terms of understanding the unintended broader impacts and interactions of innovation. It also focuses on intended impacts, purposes and the formulation of science and innovation agendas, for example the nature, configuration and substance of 'grand challenges'. In this respect, it advocates participatory agenda setting and the responding to inclusive, broadly configured and deliberative knowledge. But in this schema what should the balance be between direct and indirect democracy, between participation and representation? While RI can open up debate and inform policy, political decisions regarding the setting of science and innovation policy agendas, it could be argued, are best left to elected, democratically accountable politicians.[10] This is an issue that remains unsettled in the RI literature to date. Von Schomberg (2012, 2013) has, for example, on the one hand argued for a mutally responsive, deliberative approach (see below) but on the other also argued that the 'right impacts' of science and innovation should, at least in a European context, be grounded in *the normative anchor points that exist within the European Treaty*, these being legitimate as they have been arrived at through the mechanism of representative democracy.[11]

The critique of RI as being disconnected from politics links to the critique of it being unclear in terms of *its political ideology*. How does RI intersect with the predominant paradigm of the market economy and extant relationships between it, research and innovation (e.g. as innovation systems)? Does it seek to change these, and if so how? As we and others have noted (e.g. Schot and Steinmueller, 2018; Godin, Chapter 10 in this volume), innovation remains largely tied to a notion of Schumpeterian competitive destruction (or what Etzkowitz and Zhou,

Chapter 18 in this volume, refer to as 'creative reconstruction') in a market economy frame that has progressively gathered pace since the Second World War. It is the potential to commodify and valorise knowledge through innovation to produce novel goods and services, creating new markets, increasing market share and improving market competitiveness and productivity that makes innovation particularly attractive for governments (Whitley, Chapter 11 in this volume). It often also provides the rationale for sustaining expenditure on R&D at national and international scales (e.g. Horizon 2020 in the European Union). But this framing for innovation presents problems and tensions for RI (and vice versa). A key dimension for RI for example is openness and broad inclusion to make visible and reduce information asymmetries during the process of innovation (Table 2.1). But as Blok and Lemmens (2015) have astutely observed, it is exactly those information asymmetries that provide competitive advantage and on which innovation in a competitive market economy thrives. A company may choose to aggressively protect its intellectual property or selectively open up (e.g. through managed open innovation), but only under strict terms, those being what is in the company's (and not necessarily society's) interest. Concepts such as social innovation offer a different lens, invoking a more open and socially-motivated frame for innovation (Lubberink et al., 2017). Is RI then more like social innovation and social enterprise? How distant is the innovation in RI from innovation which is tightly coupled with the largely profit-driven and market-engaged knowledge economy? We shall return to this in the concluding parts of the chapter.

THE EMERGING DISCOURSE OF RESPONSIBLE RESEARCH AND INNOVATION

Responsible Research and Innovation (RRI), like RI, emerged as a discourse at the beginning of the current decade. Unlike RI however, it was from the outset a public policy discourse that emerged from within the European Commission (EC). Owen et al. (2012) describe the origins of the discourse, which we will briefly summarise here. Rene von Schomberg, then at the EC Directorate General for Research, was instrumental in initiating RRI as a policy discourse, which rapidly became adopted by the EC's Science in Society programme within the Research Directorate at the time. Leaning on ethics and technology assessment traditions, von Schomberg's first significant RRI contribution (eventually published in 2012) was pivotal in setting out a vision and framing for RRI in its early days. This vision and framing showed distinct similarities with the RI

discourse described above. This is clear for example when considering his definition for RRI, which has become by far the most cited:

> Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other 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, 2012, p. 50)

Articulating an approach that is anticipatory, reflexive, deliberative, inclusive, precautionary and with a strong emphasis on responsiveness, he states:

> The challenge is to arrive at a more responsive, adaptive and integrated management of the innovation process. A multidisciplinary approach with the involvement of stakeholders and other interested parties should lead to an inclusive innovation process whereby technical innovators become responsive to societal needs and societal actors become co-responsible for the innovation process by a constructive input in terms of defining societal desirable products. (Von Schomberg, 2012, p. 54)

In May 2011, the EC signalled its commitment to RRI and its intentions to undertake a number of RRI related actions, including the funding of a programme of research and coordination support actions within the remaining period of the 7th Framework Programme (FP7) and into Horizon 2020 and the establishment of an expert group on RRI. In 2012, the then EU Commissioner for Research, Innovation and Science Maire Geoghegan-Quinn formally stated high-level EC policy support for RRI:

> Researchers, policy makers, business people, innovators and most of all, the general public, have difficult choices to make as regards how science and technology can help tackle our different societal challenges . . . we can only find the right answers by involving as many stakeholders as possible in the research and innovation process. Research and innovation must respond to the needs and ambitions of society, reflect its values and be responsible . . . our duty as policy makers [is] to shape a governance framework that encourages responsible research and innovation. (Geoghegan-Quinn, 2012)

As the EC transitioned from the Framework Programme into Horizon 2020, RRI formally became a cross-cutting issue (Article 14, EC (2013))[12] and funding for RRI projects from the Science in Society programme (now rebranded as the 'Science with and for Society Programme') began in earnest. The ambition to 'mainstream RRI' across the European Research Area was reflected in the 'Rome Declaration on RRI' in 2014. Building on the Lund Declaration (2009) it called on 'European Institutions, EU

Member States and their R&I funding and performing organisations, business and civil society to make Responsible Research and Innovation a central objective across all relevant policies and activities, including in shaping the European Research Area and the Innovation Union'. In its call for action, building capacity for RRI (including resources for RRI and its integration into research and innovation programmes), the development of RRI performance evaluation metrics and the implementation of institutional changes that foster RRI (e.g. through creating spaces to engage civil society actors, adapting curricula, developing training and including RRI criteria in the evaluation and assessment of research staff) were highlighted. As we will shortly discuss, these have met considerable challenges in practice.

From the outset, framings of (and motivations for) RRI at the EC were ambiguous and plural. However, as time went on it became increasingly clear that von Schomberg's original, more holistic vision would succumb to RRI as a policy artefact crystallised specifically around five 'keys' (Table 2.2).

These keys reflected action lines and budget categories of the EC's Science in Society programme and had, it is important to note, been a feature of the EC RRI discourse from the outset. But now they became a dominant frame, gathering momentum during the phase of transition into Horizon 2020 and being formalised in the Rome Declaration (2014; para. 3). RRI was a useful umbrella term to help reposition the action lines of the Science in Society programme within the Horizon 2020 initiative. This had a strong focus on innovation and grand societal challenges, an area where involvement of the Science in Society programme had historically been limited but now became a necessity if the transition was to be a successful one. In this repositioning, these thematic keys would come to provide much of the concrete substance for RRI in EC policy and the content for many of the subsequent RRI projects that the EC funded.

In 2014 the EC appointed an expert group 'to identify and propose indicators and other effective means to monitor and assess the impacts of RRI initiatives, and evaluate their performance in relation to general and specific RRI objectives'.[13] The group viewed RRI 'from a network perspective, consisting of stakeholders jointly working on a set of principles guided by the RRI keys'. While they extended RRI to considerations of sustainability and social justice/inclusion 'as more general policy goals', the main focus, as per the brief set out to them by the EC, was on the RRI keys as described in Table 2.2. As the EC moved from concept to practice, and to evidencing impact from its investment, projects were funded that included monitoring of RRI almost exclusively in line with the EC RRI keys. The broader, original vision for RRI, which as we have mentioned

Table 2.2   EC Responsible Research and Innovation 'keys'

RRI 'key'	Description	Comparison with RI dimensions (Table 2.1)
Public engagement	Promoting a scientifically literate society able to actively participate in and support democratic processes, and development of science and technology. This includes research and innovation policy agendas, in particular the nature of societal challenges. An emphasis on co-creation, mutual understanding and iterative, inclusive and participatory 'multi-actor dialogues'.	Strong alignment with inclusive deliberation dimension.
Open access/ Open science	Making findings from publicly funded research (data, peer-reviewed publications) freely accessible without charge, to improve knowledge circulation, foster innovation and strengthen the knowledge economy.	Alignment with openness dimension but RI arguably has less instrumental motivations.
Gender	Encouraging girls to study science and female students to further embrace a career in research, fostering gender balance in research teams, removing barriers that generate discrimination against women in scientific careers, ensuring gender balance in decision making (e.g. in peer review and advisory panels) and integrating the gender dimension in research and innovation content.	RI has no specific gender dimension, but advocates a broader concept of inclusion. Issues of gender and diversity are however useful entry points to engage with RI.
Science education	Making science (including education and careers) more attractive to young people, thereby increasing society's appetite for innovation, and opening up further research and innovation activities. Strong focus on promoting science, scientific literacy and innovative pedagogies.	RI has no dimension on science education, but focuses on a multi- and trans-disciplinary approach to epistemology and pedagogy.
Ethics	Applying established ethical principles and legislation to research involving children, patients, vulnerable populations; use of human embryonic stem cells; privacy and data protection issues; research on animals and non-human primates. Also includes established principles of research integrity (data fabrication, falsification, plagiarism or other research misconduct).	RI strongly advocates reflection on ethical issues. RI includes, but goes beyond, existing ethical procedures.

shared much with the discourse of RI, has retained some visibility at the EC, which it continues to frame in headline terms as

> an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation . . . RRI implies that societal actors . . . work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society.[14]

However, *in practice* RRI has become framed by the EC 'as a package that includes multi-actor and public engagement in research and innovation, enabling easier access to scientific results, the take up of gender and ethics in the research and innovation content and process, and formal and informal science education'. There has been considerable unease amongst academics working on EC funded RRI projects concerning the reconciliation between this package of EC RRI keys and a more integrated, broader vision. This has been handled by academics involved with RRI projects in different ways: from attempts to position the keys as policy agendas within a broader schema, to those who have completely ignored the EC RRI keys, to those who have chosen to focus only on the keys and ignore the broader vision.

RRI faces an uncertain future at the EC and, if it does persist, how it is framed may well change again. It seems likely to become framed around the '3 Os' of 'open innovation, open science, open to the world', which have a strong focus on digital technologies and innovation. Open innovation is now envisaged as a quadruple helix which brings civil society into the triple helix of government, industry and universities. Open science meanwhile aims to transform science through ICT tools and networks, making research more 'open, global, collaborative, creative and closer to society'. Open to the world finally advocates international cooperation in research and innovation to remain relevant and competitive, to access the latest knowledge and talent worldwide, tackle global societal challenges more effectively and create business opportunities in new and emerging markets.

FROM POLICY TO PRACTICE

In the last few years the focus for both RI and RRI has shifted, to varying degrees, to one of 'mainstreaming' and embedding in institutional practice (e.g. across the European Research Area for RRI). Emergent policies, the funding of RRI projects by the EC and RI elements in programmes

funded by various research councils (such as the UK EPSRC and Dutch Research Council) have resulted in the emergence of initiatives in some European countries which have been formally badged as either RI or RRI. The Research Council of Norway has for example made a significant investment, notably within its Digital Life (Biotechnology) programme that is configured along (and inspired by) the RI discourse, although interestingly it is titled RRI,[15] illustrating the interchangeable use of the terms.

Some eight years after the introduction of these terms, it seems reasonable to ask to what extent have these discourses gained purchase? The EC funded RRI-Practice project,[16] which aims to understand the barriers and drivers to the successful implementation of RRI, in 2017 undertook a series of workshops across the globe involving some 200 stakeholders, which have provided useful insights in this respect. Initial findings suggest that despite being heuristically attractive, general awareness of RI and RRI in many countries remains low. The terms are interpretively flexible, with meanings sometimes based on intuition and personal experience, and often in ways that accord with stakeholders' perceived role responsibilities, spheres of agency, contexts of action and world views. However, despite this, many express a common view that RRI and RI should foster openness and support scientific research and innovation oriented towards societal needs and assessed along societal lines. Principles of inclusion, participation and continuous, open dialogue frequently surface. Stakeholders seem conscious however of the potential tensions such an inclusive and open approach poses for extant norms of scientific autonomy, which often imply a division of labour between undertaking science on the one hand and reflecting, anticipating and deliberating on societal dimensions and impacts on the other. These emergent discourses may be perceived as posing a threat to these norms and role responsibilities and adding unnecessarily to these as a burden that may hamper creativity, progress and innovation.

Stakeholders are often able to identify many existing policies and activities that they consider as being related to RRI if this is framed around the EC RRI keys, and which allow them to claim they are already 'doing RRI'. These might include formal policies on gender equality in research and higher education, codes of ethics, policies on open access or those promoting science literacy, education and communication. The discourses may already be becoming synonymous to some researchers with ad hoc public engagement, risk analysis, research integrity and existing codes of research ethics, that is, existing de facto responsibility norms. Drawing on a study undertaken in a UK university, Hartley et al. (2017) concluded that such a narrow framing (e.g. RI or RRI as science communication or public outreach) risks closing down the political dimensions of research,

ensuring this remains a site of what they describe as 'non-politics'. Such limited ranges of imagination risk becoming adopted, institutionalised and habituated, with a temptation to position RRI as 'business as usual'. Goos and Lindner (2015) in this regard describe the dynamics of RRI at the Fraunhofer-Gesellschaft, Europe's largest organisation for applied research, where the 'Changing Cultures' unit was renamed an RRI unit in 2013,[17] partly due to soft intervention measures instigated by the German Federal Ministry of Education and Research. The authors contend that in fact very little has changed in terms of the work of the unit, which focuses on methods of participatory foresight and fostering technology transfer. They assert that 'participatory processes conducted by the RRI unit . . . can be characterised as an occasional supplement to the everyday work of Fraunhofer scientists and engineers'.

These authors suggest that this in part reflects the *context of RRI institutionalisation*. The Fraunhofer-Gesellschaft is an applied science organisation with strong industry relations that is strongly conditioned by the need to acquire third-party funding. Embedded in neo-corporatist type institutional arrangements, 'societal benefit is still largely viewed as technological benefit which, in turn, is understood to be synonymous with market uptake' (Goos and Lindner, 2015). This resonates with findings from the RRI-Practice workshops where the context of institutionalisation was also often discussed, and where the external political context was highlighted as being an important macro frame for RRI or RI.[18] In China for example, stakeholders suggest that an important context is national competitiveness and innovation undertaken in the national interest, while in the UK, the imperative for economic growth and productivity is viewed as being a significant contemporary macro frame. In contrast, in Norway the Nordic model of tripartite cooperation is seen as paving the way for closer dialogue between research, society, politics and innovation: here social democratic traditions of dialogue, trust and cooperation are more firmly rooted. Likewise, in the Netherlands, a more deliberative tradition and higher-trust society are perceived as providing fertile ground for these discourses. However, these external political contexts cannot be assumed, vary geographically and are often nuanced. So, while the first responsibility for innovation in China might be promoting economic and social development, understanding of social risks and the consequences of science, technology and innovation are also seen as being increasingly important: China may in this respect be entering into reflexive modernity.

Both RI and RRI face significant institutional barriers and logics that are framed by this external context. If for example they challenge deeply engrained institutional and disciplinary cultures, norms, behaviours and governance arrangements (e.g. norms of scientific autonomy) they can

encounter deep resistance and be seen as an obstacle. However, this perception varies considerably across countries, institutions and career levels. And while there has without doubt been resistance in some universities, in others these discourses are viewed as being central to the DNA of the institution and even a source of competitive advantage. What seems clear is that, by and large, current disciplinary and institutional expectations of researchers, incentives, rewards and progression/promotion criteria pose significant barriers. The institutional challenges for inter- and trans-disciplinary research are well known (e.g. Felt et al., 2016). RI in particular challenges existing approaches to epistemology, definitions of how research excellence and quality are defined[19] and in turn how these are evaluated and rewarded. Overall, the workshops suggest competence and capacity for RI is lacking, exacerbated by a lack of education, training and resources at institutional levels. Stakeholders recognise the need for committed and effective leadership, but it is not clear who has agency, and at what level. Where RI initiatives have had some success, this has been the result of committed individuals who have been effective change agents and champions; conversely, when such individuals quit or move to different roles these initiatives can quite quickly collapse.

THE CHALLENGES OF INSTITUTIONALISATION AND TRANSFORMATIVE CHANGE

In this chapter we have discussed Responsible Innovation and Responsible Research and Innovation as two significant discourses emerging in science and public policy over the last decade. Both are fragile and contested discourses. Both advocate the notion of shared responsibilities for the development and consequences of techno-visionary science and innovation, fostering collective responsibility, for example through continuous embedding of public and stakeholder engagement (Ribeiro et al., 2017). RI in particular builds on a history of STS and shares with it a critical stance regarding the relationships and dynamics between science, innovation, politics and society. It is RI's second order reflections on not just science and technology but innovation and innovation systems that prompt and invite a more critical discussion on the notion of innovation itself in the 21st century and, associated with this, interrogation as to how innovation systems are configured and for what purpose. This we suggest is the first of three major research gaps, all of which are deeply linked and each of which cannot be viewed in isolation. To date, there has been very little research or scholarship at the *intersection of RI and innovation systems* (whether this is national, regional, technological or sectoral innovation systems). How

RI intersects with and challenges such concepts as the triple helix and its central construct of the entrepreneurial university, or aligns with concepts such as the quadruple helix and its desire to embed civil society as a fourth strand remains little explored.[20] How RI aligns with such institutional constructs as the civic university (Goddard et al., 2016), grounded as this is in active stakeholder and community engagement and having a sense of purpose ('not just what a university is good at but good for' (ibid.)) is unclear. How the structures and functions of innovation systems (Hekkert and Negro, 2009) could (and should) be reconfigured and to what normative ends likewise remains unexamined. The concept of the responsible innovation system is we suggest an important avenue for future research.

Such reconfiguration we suggest is critically important. As Genus and Stirling (2018) note, 'innovation is whatever happens to emerge from incumbent structures of interest, privilege and power in prevailing innovation systems'. And innovation systems continue to be, by and large, configured to provide an ever-increasing supply of innovative products, services and business models for the market, to stimulate markets, to create new markets and to protect and increase market share. That is not to say that innovation (and in particular social innovation) does not produce benefits for society. But, we suggest, innovation overwhelmingly remains intimately and unreflexively tied to the idea of gaining competitive advantage within the construct of the market society, while being insufficiently directed at the deepening problems facing society and our planet, which include a rapidly escalating crisis of climate change and ecological sustainability, demographic change, inequality, geopolitical conflict and resource sustainability and insecurity. Indeed, innovation can exacerbate such problems. This we argue is the banality of innovation. Discourses of RRI and RI, particularly with their focus on innovation aimed at societal grand challenges, strongly suggest an ambition to collectively direct innovation towards a future that is sustainable, equitable, just, flourishing and good. Not only that, but they make this a responsibility imperative. But in doing so they need to confront the banality of innovation, reframing innovation and reconfiguring innovation systems (Schot and Steinmueller, 2018).

This leads us to the second research gap, which relates to RI's (and RRI's) political and ideological imaginary, which as we have already discussed requires far greater interrogation and articulation. We have discussed this earlier in the chapter, and we need only note here that any consideration of the transition to a responsible innovation system cannot be divorced from a consideration of its political and ideological imaginaries, visions and assumptions: these need to be opened up for scrutiny and explored in far greater detail. The third research gap, which also connects to innovation systems, relates to how RI can become institutionalised in

practice: what Randles (2017) describes as the challenge of 'deep institutionalisation'. In describing the nature and phases of deep institutionalisation, Randles (arguably for the first time in the context of RI/RRI) draws attention to the literature on legitimacy construction (and its importance for the formation of new institutions) and the dynamics of organisational change. This is a literature which emphasises the importance of '*shifting external institutional contexts* [i.e. the rules, norms and ideologies of wider society] producing both pressures and opportunities to which organisations variously contribute and respond' (ibid., italics in original). It is during moments of *crisis or instability* in this external institutional context that legitimacy questions and struggles can arise, prompting *'(de)institutionalisation processes* where the status quo and its attendant logics . . . are called into question' (ibid., italics in original) (see also Oliver, 1992).[21] But, as Randles goes on to explain, such challenge in itself does not necessarily lead to institutional change, that is, whereby a value system is not only articulated through visions but becomes routinely performed in practice. She notes that incumbents can buttress their position and that challengers need to be effective institutional entrepreneurs and change agents in order to build and sustain an alternative vision and narrative, supported by a culture of pluralism that enables and encourages such entrepreneurs. The challenges and barriers to RI /RRI described in the preceding section suggest both a buttressing of positions by incumbents and a need for effective institutional entrepreneurs to build and sustain a RI narrative.

Randles further explains that in order for a discourse such as RI to become institutionalised there also needs to be a process of de-institutionalisation of the incumbent tradition (or prior-institutionalised form), through processes of assimilation, dilution, disembedding, competition and erasure (Dacin and Dacin, 2007). Arguably, we have witnessed some institutional assimilation (i.e. absorption of RI elements into existing traditions such as those found in universities) and some dilution (i.e. enlarging and adding complexity to existing institutional practices). In a number of cases we have witnessed, as a result, both 'responsibility-overload' ('as new imperatives of responsibility are loaded onto organisations by external pressures whilst the original logics and corresponding obligations remain' (ibid.)) and tactical responses that have presented as 'responsibility-washing' (e.g. de-coupled 'RRI units' which leave 'the rest of the organisation intact and performing according to earlier institutional logics' (see our earlier observations concerning Fraunhofer)). Overall it is hard to conclude that, with only some exceptions, there has been substantive disembedding (i.e. the compromising and dismantling of incumbent institutional logics), competition or transformational change (noting Dacin and Dacin's observation that erasure rarely occurs; rather, there

is a phenomenon of 'sedimenting over' of new narratives over old ones, elements of which persist).

What these three research challenges have in common is a desire to maintain a level of transformative ambition and systemic focus. A vision based around RRI framed as a package of individual EC keys might foster more scientifically literate and engaged citizens, in part helped by better access to scientific results, better gender balance in science and a more systematic institutional embedding of codes of conduct for ethics and research integrity. These are important. However, we contend that this basket of policy agendas risks a narrow interpretation of what, in the context of innovation, being responsible is and how we critically engage with innovation in a way that allows us to take responsibility for our future. Not only that, but this may, unwittingly or through conscious choice, in fact support and reinforce the status quo. The discourses of Responsible Innovation and Responsible Research and Innovation cannot shirk these questions of deep institutionalisation, transformation and systemic change. Maintaining this ambition is, we suggest, imperative.

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NOTES

1. Randles (2017) describes '*de-facto rri*' as 'what actors already do, in collective fora, in order to embed institutionalised interpretations of what it means to be responsible into the practices, processes, organisational structures and outcomes of research and innovation'.
2. http://www.vr.se/download/18.7dac901212646d84fd38000336/ – accessed 5 Jan 2018.
3. https://ec.europa.eu/research/swafs/pdf/rome_declaration_RRI_final_21_November.pdf – accessed 5 Jan 2018.
4. https://ec.europa.eu/digital-single-market/en/news/open-innovation-open-science-open-world-vision-europe – accessed 22 Jan 2019.
5. See also Schot and Steinmueller (2018) who describe two macro frames for innovation since the Second World War, with a transition from linear models of innovation to innovation systems.
6. In its second order formulation, reflexivity considers how 'society, and modern rationality in particular, work, . . . not only a reflection on our own actions . . . but a reflection on how the presupposition, the governance principles and the values determine our way of acting' (GREAT, 2014, pp. 73–76).
7. With, as Kuhlmann and Rip (2014) suggest, a 'focus on system-oriented strategic interventions, tentative and experimental in design.'

8. At the earlier stages of an innovation there is most opportunity to adapt and control innovation, with fewer costs and less resistance from vested interests, but at these early stages there is often little or no evidence of wider (undesirable) impacts to make the case for doing so; conversely, by the time we have procured knowledge that leads to a better understanding of the impacts of an innovation, it may be 'locked in' to society and both costs and vested interests may be so significant we may have little ability to do much about it. Genus and Stirling (2018) provide a more detailed account of this and other contributions relevant to RI/RRI originally made by David Collingridge.
9. https://epsrc.ukri.org/index.cfm/research/framework/ – accessed 22 Jan 2019.
10. We need to note here that there are many unaccountable individuals who have a powerful say in this regard, from influential scientists ('Grey Gods') to philanthropists directly funding research and innovation with little to no democratic accountability (Fejerskov, 2017).
11. See also an interesting discussion on the concept of 'knowledge parliaments' in Kuhlmann and Rip (2014, p. 8).
12. COM(2013)0624 20.12.2013 Official Journal of the European Union L 347/121 (1).
13. http://ec.europa.eu/research/swafs/pdf/pub_rri/rri_indicators_final_version.pdf – accessed 22 Jan 2019.
14. https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation – accessed 5 Jan 2018.
15. www.forskningsradet.no/prognett-biotek2021/Ansvarlig_forskning_og_innovasjon_RRI/1254026368408 – accessed 5 Jan 2018.
16. www.rri-practice.eu – accessed 5 Jan 2018.
17. www.cerri.iao.fraunhofer.de/en.html – accessed in January 2018.
18. Randles (2017) discusses the issue of 'vertical alignment' in more detail.
19. Interestingly, a key observation made in a 2015 report to the UK Higher Education and Funding Council for England by King's College London was that 'Staff within high-performing research units display a distinct ethos of social and ethical values', suggesting in fact a strong link between excellence and social and ethical values. http://www.hefce.ac.uk/media/HEFCE,2014/Content/Pubs/Independentresearch/2015/Characteristics,of,high-performing,research,units/2015_highperform.pdf (Observation D) – accessed 3 May 2018.
20. See the EU FoTRRIS project for an example of an initiative that draws inspiration from the quadruple helix in its work on RRI (http://fotrris-h2020.eu/).
21. The SPICE project (Stilgoe et al., 2013) was the location for one such moment, but one can think of others in which technologies have been implicated, from GM to complex financial instruments and their role in the 2007–2008 financial crash to the data scandal involving Facebook and Cambridge Analytica. Likewise, it is interesting to speculate whether the emergence of RRI within the EU Science and Society programme at least in part resulted from a similar moment of external uncertainty prompted by the transition from FP7 into Horizon 2020.

REFERENCES

Barben, D., Fisher, E., Selin, C. and Guston, D.H. (2008). Anticipatory governance of nano-technology: foresight, engagement, and integration. In E.J. Hackett, O. Amsterdamska, M. Lynch and J. Wajcman (eds), *The Handbook of Science and Technology Studies* (pp. 979–1000). Cambridge, MA: MIT Press.
Bessant, J. (2013). Innovation in the 21st century. In R. Owen, J. Bessant and M. Heintz (eds), *Responsible Innovation* (pp. 1–25). Chichester: John Wiley & Sons.
Blok, V. and Lemmens, P. (2015). The emerging concept of responsible innovation. Three reasons why it is questionable and calls for a radical transformation of the concept

of innovation. In B.-J. Koops, I. Oosterlaken, H. Romin, T. Swierstra and J. van den Hoven (eds), *Responsible Innovation 2* (3rd edn, pp. 19–35). Cham, Switzerland: Springer International Publishing.

Dacin, T.M and Dacin, P.A. (2007). Traditions as institutionalised practice: implications for de-institutionalisation. In R. Greenwood, C. Oliver, R. Suddaby and K. Sahlin-Andersson (eds), *The Sage Handbook of Organisational Insitutionalism* (pp. 326–351). Singapore: Sage Publications.

Douglas, H.E. (2003). The moral responsibilities of scientists (Tensions between autonomy and responsibility). *American Philosophical Quarterly*, *40*(1), 59–68.

Fejerskov, A.M. (2017). The new technopolitics of development and the global south as a laboratory of technological experimentation. *Science, Technology, and Human Values*, *42*(5), 947–968.

Felt, U., Igelsböck, J., Schikowitz, A. and Völker, T. (2016). Transdisciplinary sustainability research in practice. *Science, Technology, and Human Values*, *41*(4), 732–761.

Fisher, E. and Rip, A. (2013). Responsible innovation: multi-level dynamics and soft intervention practices. In R. Owen, R., J. Bessant and M. Heintz (eds), *Responsible Innovation* (pp. 165–183). Chichester: John Wiley & Sons.

Genus, A. and Stirling, A. (2018). Collingridge and the dilemma of control: towards responsible and accountable innovation. *Research Policy*, *47*(1), 61–69.

Geoghegan-Quinn, M. (2012). Commissioner Geoghegan-Quinn keynote speech at the 'Science in Dialogue' Conference Odense, 23–25 April 2012. Available from http://ec.europa.eu/archives/commission_2010-2014/geoghegan-quinn/headlines/speeches/2012/documents/20120423-dialogue-conference-speech_en.pdf – accessed 29 January 2019.

Glerup, C. and Horst, M. (2014). Mapping 'social responsibility' in science. *Journal of Responsible Innovation*, *1*(1), 31–50.

Goddard, J., Hazelkorn, E., Kempton, L. and Vallance, P. (2016). Introduction: why the civic university. In J. Goddard, E. Hazelkorn, L. Kempton and P. Vallance (eds), *The Civic University: Policy and Leadership Challenges* (pp. 3–15). Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Goos, K. and Lindner, R. (2015). *Institutionalising RRI – The Case of a Large Research Organisation.* RES-AGorA case study by Fraunhofer ISI. Available from https://www.res-agora.eu/assets/Institutionalising-RRI_FhG_20150325-formatiert.pdf – accessed 22 January 2019.

GREAT (2014). Project Deliverable 2.3. Available from www.great-project.eu/deliverables_files/deliverables02 – accessed 16 October 2016.

Grinbaum, A. and Groves, C. (2013). What is 'responsible' about responsible innovation? Understanding the ethical issues. In R. Owen, J. Bessant and M. Heintz (eds), *Responsible Innovation* (pp. 119–142). Chichester: John Wiley & Sons.

Hartley, S., Pearce, W. and Taylor, A. (2017). Against the tide of depoliticisation: the politics of research governance. *Policy and Politics*, 45(3), 361–377.

Hekkert, M.P. and Negro, S. (2009). Functions of innovation systems as a framework to understand sustainable technological change: empirical evidence for earlier claims. *Technological Forecasting and Social Change*, *76*(4), 584–594.

Jasanoff, S. (2003). Technologies of humility: citizen participation in governing science. *Minerva*, *41*(3), 223–244.

Jonas, H. (1984). *The Imperative of Responsibility*. Chicago: University of Chicago Press.

Kuhlmann, S. and Rip, A. (2014). *The Challenge of Addressing Grand Challenges: A Think Piece on How Innovation Can Be Driven towards the 'Grand Challenges' as Defined under the Prospective European Union Framework Programme Horizon 2020*. European Research and Innovation Area Board (ERIAB). Available from https://research.utwente.nl/en/publications/the-challenge-of-addressing-grand-challenges-a-think-piece-on-how – accessed 22 January 2019.

Lubberink, R., Blok, V., van Ophem, J. and Omta, O. (2017). A framework for responsible innovation in the business context: lessons from responsible-, social- and sustainable innovation. In L. Asveld, R. van Dam-Mieras, T. Swierstra, S. Lavrijssen, K. Linse and J.

van den Hoven (eds), *Responsible Innovation 3* (pp. 181–207). Cham, Switzerland: Springer International Publishing.

Macnaghten, P.M. and Owen, R. (2011). Good governance for geoengineering. *Nature*, *479*, 293.

Oliver, C. (1992). The antecedents of deinstitutionalisation. *Organisation Studies*, *13*(4) 563–588.

van Oudheusden, M. (2014). Where are the politics in responsible innovation? European governance, technology assessments, and beyond. *Journal of Responsible Innovation*, *1*(1), 67–86.

Owen, R. (2014). The UK Engineering and Physical Sciences Research Council's commitment to a framework for responsible innovation. *Journal of Responsible Innovation*, *1*(1), 113–117.

Owen, R., Macnaghten, P. and Stilgoe, J. (2012). Responsible research and innovation: from science in society to science for society, with society. *Science and Public Policy*, *39*(6), 751–760.

Owen, R., Stilgoe, J. Macnaghten, P.M., Gorman, M., Fisher, E. and Guston, D. (2013). A framework for responsible innovation. In R. Owen, J. Bessant and M. Heintz (eds), *Responsible Innovation* (pp. 27–50). Chichester: John Wiley & Sons.

Pellizzoni, L. (2004). Responsibility and environmental governance. *Environmental Politics*, *13*(3), 541–565.

Randles, S. (2017). *Deepening 'Deep Institutionalisation'*. JERRI Deliverable 2.1. Available from www.jerri-project.eu/jerri-wAssets/docs/deliverables/wp-1/JERRI_Deliverable_D1_2_ Deepening-Deep-Institutionalisation.pdf – accessed 22 January 2019.

Ribeiro, B.E., Smith, R.D.J. and Millar, K. (2017). A mobilising concept? Unpacking academic representations of responsible research and innovation. *Science and Engineering Ethics*, *23*(1), 81–103.

Richardson, H.S. (1999). Institutionally divided moral responsibility. In E. Paul, F. Miller and J. Paul (eds), *Responsibility* (pp. 218–249). Cambridge: Cambridge University Press.

Rip, A. and Voß, J.-P. (2013). Umbrella Terms as mediators in the governance of emerging science and technology. *Science, Technology and Innovation Studies*, *9*(2), 39–59.

Schot, J. and Steinmueller, W.E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy, 47*(9), 1554–1567.

Stilgoe, J., Owen, R. and Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, *42*(9), 1568–1580.

Stirling, A. (2008). 'Opening up' and 'closing down': power, participation, and pluralism in the social appraisal of technology. *Science, Technology, and Human Values*, *33*(2), 262–294.

Sykes, K. and Macnaghten, P. (2013). Responsible innovation – opening up dialogue and debate. In R. Owen, J. Bessant and M. Heintz (eds), *Responsible Innovation* (pp. 85–107). Chichester: John Wiley & Sons.

van Oudheusden, M. (2014). Where are the politics in responsible innovation? European governance, technology assessments, and beyond. *Journal of Responsible Innovation*, *1*(1) 67–86.

von Schomberg, R. (2012). Prospects for technology assessment in a framework of responsible research and innovation. In R. Dusseldorp and M. Beecroft (eds), *Technikfolgen Abschätzen Lehren: Bildungspotenziale Transdisziplinärer* (pp. 39–61)*.* Wiesbaden: VS Verlag für Sozialwissenschaften.

von Schomberg, R. (2013). A vision of responsible research and innovation. In R. Owen, J. Bessant and M. Heintz (eds), *Responsible Innovation* (pp. 51–74.). Chichester: John Wiley & Sons.

Zwart, H., Landeweerd, L. and van Rooij, A. (2014). Adapt or perish? Assessing the recent shift in the European research funding arena from 'ELSA' to 'RRI'. *Life Sciences, Society and Policy*, *10*(1), 11.