Responsible Research and Innovation: from Science in Society to Science for Society, with Society

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Abstract

The term responsible (research and) innovation has gained increasing EU policy relevance in the last two years, in particular within the European Commission's Science in Society programme, in the context of the Horizon 2020 strategy. We provide a brief historical overview of the concept, and identify three distinct features that are emerging from associated discourses. The first is an emphasis on the democratic governance of the *purposes* of research and innovation and their orientation towards the 'right impacts'. The second is *responsiveness,* emphasising the integration and institutionalisation of established approaches of anticipation, reflection and deliberation in and around research and innovation, influencing the direction of these and associated policy. The third concerns the *framing of responsibility* itself in the context of research and innovation as collective activities with uncertain and unpredictable consequences. We conclude by reflecting on possible motivations for responsible innovation itself, asserting that it must be conducted for substantive and normative reasons, rather than to instrumentally expedite progress towards pre-defined policy goals.

Introduction: the emergence of responsible innovation in EU policy discourse

The terms 'responsible innovation' and 'responsible research and innovation' have a history stretching back a decade (e.g. Hellstrom, 2003; Guston, 2006; Owen et al 2009a; Owen and Goldberg, 2010, von Schomberg, 2011 a;b; Lee, 2012; Armstrong et al, 2012), and even further if cognate terms such as 'responsible development' are included (e.g. the NNI 2004 and National Research Council 2006[1] in the U.S.: see Fisher and Rip, in press for further discussion). Indeed, these terms are heirs to even earlier discussions about research integrity and the ethical, legal and social implications of research in areas such as genomics. They also have roots in visions for collaborations between social, natural and physical scientists that address the wider dimensions of science and innovation early on (evident for example within the 5th and 6th European Union (EU) Framework programme and its calls for socio-technical integration (Rodriguez et al, in press)) and calls for greater public engagement with science and technology (variations in which are analysed at an EU wide level by Mejlgaard et al, (this issue)). Further roots include, but are not limited to, integrated approaches such as technology assessment in its various forms (e.g. Schot and Rip, 1996; Guston and Sarewitz, 2002) and anticipatory governance (e.g. Karinen and Guston, 2010), some of which have been formalized within decision making processes, (of which the so-called 'Danish model' for technology assessment based on public participation and deliberation (e.g. through consensus conferences) is one notable European example (Mejlgaard et al, (this issue)).

It is over the last two years that the concept of responsible research and innovation (hereafter, RRI) has gained particular visibility and traction in an EU, and specifically European Commission (EC) policy context. Evolving from discourses of socio-technical integration within and beyond the EC Science in Society programme, RRI may also reflect recognition of the limitations of extant policy approaches to managing ethically-problematic areas of science and innovation such as Genetically Modified Organisms (Grove-White et al, 2000), synthetic biology (TNS-BRMB,2000), geoengineering (Royal Society, 2009) and ICT (von Schomberg, 2011a), coupled with an increasing awareness of the sometimes profound, global (and intergenerational) impacts of innovations in contemporary society (Jonas, 1984, Adam and Groves, 2011), of which those in the financial sector are one notable recent example (Mackenzie, 2010, Armstrong et al, 2011l Muniesa and Lenglet, in press[2]). These have catalysed an increasing willingness at a policy level to discuss, challenge and rethink linear models of science and innovation policy and the social contract for science (in which scientific freedom is exchanged for the promise or expectation of socially – beneficial impacts) and risk-based regulation as a predominant innovation governance paradigm (Owen et al, 2009b; Owen et al, in press).

Angst over the dilemma of control for emerging technologies (Collingridge, 1980; RCEP, 2008) (and how to proceed under conditions of uncertainty and ignorance), has also been accompanied by growing concerns about the public value of science, the need to demonstrate research 'impact' (Kearnes and Weinroth, 2011) and the place of public participation in both setting research agendas and modulating research trajectories towards socially-desirable ends (e.g. Fisher et al, 2006; Jones, 2008). Questions of purpose, values-sensitive design (van den Hoven et al, 2012), ethics (von Schomberg, 2007), social desirability, social acceptability and governance (Karinen and Guston, 2010) have all coalesced around an emerging zeitgeist for 'responsible innovation' that may

[1] Which states 'Responsible development of nanotechnology can be characterized as the balancing of efforts to maximize the technology's positive contributions and minimize its negative consequences… It implies a commitment to develop and use technology to help meet the most pressing human and societal needs…while making every reasonable effort to anticipate and mitigate adverse implications or unintended consequences.'

[2] For example asset-backed securities – collateralised debt obligations.

intuitively feel right, but which exhibits a lack of clarity in terms of definition, practice and, at a policy level, motivation.

The emergence of RRI in EU policy discourse is a recent phenomenon. It was in May 2011 that the first public statements indicated its significance within emerging EU policy. The first of these was at a workshop held 16-17 May, 2011 at DG Research in Brussels and attended by a number of experts drawn from academia and policy (EC, 2011). Opening the meeting, Octavi Quintana, Director of the European Research Area, stated:

> 'We need your help to define responsible research and innovation. After several years of research on the relation between science and society, we evidenced that we need to involve civil society very upstream to avoid misunderstanding and difficulties afterwards…. We cannot guarantee the social acceptability for anything but the more we have dialogue the easier it is to understand the potential obstacles and to work on them… Your advice is important to help us build a policy for the years to come, notably for the Common Strategic Framework that will begin its life in 2014 and for the European Research Area'' (ERA).

The purpose of the event, to reflect on and develop a shared understanding of the meaning of RRI, was clear, as was its significance: to formulate policy recommendations that would support the development and implementation of a policy underpinned by the concept across the ERA. Although the motivations at an EU policy level were unclear, it was evident that responsible innovation was important to the Commission, at least in sentiment, and that we were being asked to reflect and advise on what it meant, and how it might be defined (Sutcliffe, 2011).

A week later, on the 23-34 May 2011, an international workshop on the theme 'Responsible Innovation' was also held at the French Embassy, London[3]. This too brought experts and policy makers together to discuss the concept, building on emerging work in a number of countries including the UK, Holland and the US. Building on decades of complimentary study in fields of technology assessment (Rip et al,1995; Schott and Rip, 1996; Guston and Sarewitz, 2002), anticipatory governance (Karinen and Guston, 2010), socio-technical integration and 'midstream modulation' (Fisher et al, 2006; Fisher, 2007; Schuurbiers and Fisher, 2009; McGregor and Wetmore, 2009) and public and stakeholder engagement (Stirling, 2005; Wilsdon et al, 2005; Sykes and Macnaghten, in press) the purpose of the workshop was to come to a common understanding and definition of responsible innovation, discuss how it might differ from what has come before, and what it might involve in practice. Would this emerge as a genuinely transformative and even novel approach to governing science and innovation or would it merely be a repackaging of existing concepts to smooth the pathway for pre-defined policy goals?

It was at this meeting that the EC signalled more concrete intentions. First, Gilles Laroche (Head of the Science in Society Programme) announced that the EC would fund a programme of research and co-ordination within the remaining period of the 7th Framework Programme on RRI, to include projects aimed at developing governance frameworks; that an expert group with the same title would be established to advise the EC; that the EC would seek an Opinion from the European Group of Ethics; and that it would seek to develop a recommendation on RRI for the ERA, including a possible 'soft law' initiative (Laroche, 2011). Reflecting on the fact that 'the societal perception and impacts of technology are difficult (impossible) to predict' he stated that 'early societal intervention may enable anticipation of positive and negative impacts'. The goals, to develop a European model of RRI, would need to be based on the principle of inclusiveness, involving all actors at an early

[3] http://www.ambafrance-uk.org/Franco-British-workshop-on,18791

stage (researchers, civil society organisations, industry and policy makers), allowing innovation to be developed in a co-building mode that 'ensures co-responsibility'. It would help meet the EU's 2020 Vision for an ERA firmly rooted in society and responsive to its needs and ambitions, heralding a transformation from science in society to '*science for society, with society'* (Laroche, 2011).

It was also at this meeting that a paper was circulated by Rene von Schomberg from the European Commission, outlining his emerging philosophical thinking (von Schomberg, 2011b). This included a thoughtful discussion concerning the normative targeting of research and innovation towards the 'right impacts', anchored within the values articulated within the EU Treaty, more of which we will consider presently. It also included a proposal for a working definition:

> ''Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on 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, 2011b).

There have been at least seven international workshops of varying sizes over the last 18 months on the topic of responsible innovation (Fisher and Rip, in press), reflecting growing momentum in both academic and EU policy contexts. One of the more notable of these was held under the auspices of the Danish presidency of the EU: a conference on Science and Society in Europe, with the subtitle, 'Responsible Research and Innovation'. Opening the conference, Morten Østergaard, the Danish Minister for Science and Education, re-emphasised the evolving ambition at a policy level to support "the best science *for* the world" and not just "the best science *in* the world". Presenting via video-link, EU Commissioner Máire Geoghegan-Quinn provided the first tangible evidence of high level EC policy support for the concept (Geoghegan-Quinn, 2012). Framing the RRI concept as one supporting the European Commission's Horizon 2020 Strategy[4] for the Framework Programme (which itself implements the EU 2020 flagship 'Innovation Union' initiative aimed at securing Europe's global competiveness) she stated:

> ' to overcome the current economic crisis we need to create a smarter, greener economy where prosperity will come from research and innovation… In the search for prosperity, jobs and a better life for everyone, research, innovation and new technologies present us with many different choices and many possible paths to follow… 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, bolded text as in original statement)

The more instrumental EU policy framing of RRI within the Horizon 2020 Strategy[5] was re-enforced by EC Deputy Head of Cabinet Waldemar Kutt at a panel presentation at the Euroscience Open

[4] http://ec.europa.eu/research/horizon2020/index_en.cfm

[5] www.europarl.europa.eu/document/activities/cont/201206/20120620ATT47284/20120620ATT47284EN.pdf (page 5: 'introduction of new specific objective: 'Responsible research and innovation'.)

Forum meeting, July 2012 in Dublin, Eire entitled 'Can Responsible Research and Innovation expedite Europe's economic renewal?' At face value, this presentation, which emphasised goals of economic growth, jobs and strengthened economic governance, may appear to frame RRI as being narrowly, and instrumentally, motivated to support the delivery of a pre-committed policy, with economic growth as its main priority. Quite apart from the fact that the EC' Horizon 2020 Strategy has other important targets for innovation beyond economic growth (e.g. under its 'Better Society' theme), the language of RRI at this meeting and others before it involving the EC (often convened under the Science in Society programme) has in fact been more nuanced, and more ambiguous. This ambiguity may reflect a range of motivations in different parts and at different levels of the EC.

Instrumental motivations include a desire to reposition the Science in Society programme within the Horizon 2020 initiative in the face of budgetary pressures. This repositioning explicitly brings innovation within the remit of the Science in Society programme, to underpin the meeting of the Horizon 2020 strategic goals, extending the success the programme has had in facilitating the involvement of civil society with research to include innovation, and to include industry and business (where involvement has historically been limited). This however disguises the motivations of at least some at the Commission, particularly within the Science in Society programme itself, who envisage a more normative and substantive process that builds on decades of research in Science and Technology Studies, philosophy and beyond.

But what is this process? RRI has, at least in sentiment, positive, constructive overtones. As the definition provided by von Schomberg suggests, science and innovation are envisaged as being directed at, and undertaken towards, socially desirable and socially acceptable ends, through a deliberate, inclusive process. This offers both opportunities for innovation as well as for flexible management and, where appropriate, control before technological 'lock-in' (Collingridge, 1980). As a term, RRI seems hard to argue against – few would argue for irresponsible research and innovation. But, beyond this sentiment, what features can we distil from the emerging discourse of RRI in both academic and policy circles? What might it actually involve? And can it ever be of practical value (and indeed implementable) given that innovation is in reality complex, messy and collective in nature: 'knowledge spaghetti' that is often intertwined across cultures and continents (Bessant, in press). If what Beck (1995) described as 'organised irresponsibility' emerges as a consequence of this complex innovation ecosystem, rather than the sole actions of an individual scientist or innovator (von Schomberg, 2007), then it is in such an ecosystem that RRI must be located.

Our brief overview suggests that RRI is a rapidly evolving concept, with confusion as to motivation, theoretical conceptualisation and translation into practice. In this regard it exhibits traits common to many innovations in their early stages in that its purposes, processes and products are still shrouded in uncertainty. But even so, we can identify some distinct features, locating these in the context of earlier concepts, some of which we have already highlighted above. We now identify three features of RRI that we suggest are emerging from the evolving discourse. One of these calls for reflection and deliberation not only on the uncertain products of science and innovation – their intended and unintended impacts, consequences and implications – but on their very purposes and motivations: why do it, who might benefit and who might not? In this regard, it is perhaps timely that we collectively reflect on what we feel should be the purposes and motivations for RRI as an innovation itself: we end with our own conclusions in this regard.

Three emerging features of Responsible Research and Innovation

a) Science for society: democratising the governance of intent

The first emerging feature of contemporary RRI discourse we suggest is one that is concerned with the purposes of science and innovation, and the underlying motivations and intentions for these. It seeks to go beyond what we do not want science and innovation to do – the well-known and well-documented pre-occupation with characterising and managing unintended risks (the latter often through regulation) – but what we *do* want it to do. This is an important departure point for RRI. It asks how the targets for innovation can be identified in an ethical, inclusive, democratic and equitable manner. RRI moves beyond the 'closing down' framing of conventional ethical review and approval, limited in scope as it is to research conduct involving people, animals and genetic material. It has a primary purpose to democratically define, open up and realise new areas of public value for science and innovation (Wilsdon et al, 2005). It asks for inclusive deliberation concerning the direction of travel for science and innovation - from the outset - opening up opportunities for these to be directed towards socially-desirable ends. This exacerbates the tension between the principle of participation and that of scientific freedom, one that is hardly new but is of particular relevance to RRI.

For innovation this tension may be less keenly felt. Indeed, the involvement of users and other stakeholders in innovation, whether this is described as market-driven or open innovation (Chesborough, 2003), and the acknowledged value of this in new product development and beyond is hardly new. And in the domain of science, one can already witness experiments involving participatory agenda setting and values-sensitive design within research programmes across the EU (e.g. in The Netherlands[6] (van den Hoven et al, 2012) and the UK (Jones, 2008). The Alzheimer's Society in the UK for example has a research network of some 200 carers and people with dementia who help set research priorities, prioritise grant applications and sit on grant selection panels[7] (Wilsdon et al, 2005).

More broadly, the realisation of economic and social value has long been a considered responsibility of scientific institutions (Guston, 2006), morphing recently into the concept of science to meet societal challenges (Lund Declaration, 2009, Kearnes and Wienroth, 2011). Consideration of societal and economic 'impact' has become a funding condition of even 'blue skies' research in many countries. This feature of RRI – science for society- is perhaps then a development of a more general trend towards challenge-led science and innovation, with a framing that is broader than generating commercial value. What one senses is a desire for a more institutionalised and consistently-applied approach that is inclusive and values-based (or at least values-sensitive), in which the principle of participatory agenda setting, for example through the involvement of publics and stakeholders in the formulation of grand challenges, is embedded in science and innovation policy and its delivery as part of a more generalised governance framework, at a pan-European scale.

The RRI definition proposed above, and the statements made at an EU policy level, place a premium on inclusive participation that allows the setting of research and innovation goals, defined in terms of the 'right impacts', which are themselves anchored in societal values. The obvious question then becomes, what are the 'right impacts' of research and innovation, and what values should these be anchored in? Von Schomberg (2011a,b) suggests that we cannot aspire to the abstract ideals of the Aristotelian 'good life' (contested as these are) and takes a more pragmatic view that, at least in a European context, the 'right impacts' are those enshrined in the European Constitution, such as a competitive social market economy, sustainable development and quality of life. Meeting these, he asserts, should be achieved in a way that is ethically acceptable, socially desirable, safe and

[6] Maatschappelijk Verantwoord Innoveren (Responsible Innovation) programme run by the Netherlands Organisation for Scientific Research (NWO) www.nwo.nl/nwohome.nsf/pages/nwoa_7e2ezg_eng

[7] (http://alzheimers.org.uk/site/scripts/document_pdf.php?documentID=1109)

sustainable (von Schomberg, in press). In combination such targets for innovation clearly embed complex dilemmas and areas of contestation. Some will be in direct opposition to one another. The Horizon 2020 strategy features a number of high level EU – wide 'societal challenges', to be tackled through science and innovation. These include more efficient use of resources, smarter, greener transport, a safe and secure food supply and reliable, clean and efficient energy. Which should be given more emphasis?

The World Wildlife Fund (WWF, 2012) for example considers the right impacts for innovation as being *dematerialisation* (i.e. products, services or processes that dramatically cut the use of natural resources), *restorative* (i.e. innovations that contribute to net positive environmental impacts and the restoration of biodiversity and the environment, *open loop* (where waste from products is turned back into resource) and *renewable energy and low carbon*. Here there is an explicit prioritisation of innovations towards those that decouple growth from environmental impacts, protect and restore ecosystems and lead to 100% renewable energy future by 2050 (WWF, 2011). One might extend this argument further: could any process of responsible innovation that simply serves to target innovation at those 'right impacts' which support and compound an increasingly dysfunctional, and unsustainable Capitalist socio-economic world order be viewed as an irresponsible innovation in itself?

This provocative question is posed simply to illustrate the fact that negotiation of the 'right impacts' of science and innovation is inherently a political discussion, involving considerations of power, democracy and equity. RRI cannot be decoupled from its political context, and will itself always embed a strongly political dimension, particularly if it concerns itself with the governance of purpose and intent. Negotiating and prioritising the constellation of 'right impacts' will have difficult ethical dimensions and include significant political and social dilemmas. This suggests a need for substantive processes of inclusive reflection and deliberative democracy, supported by mechanisms of anticipation that describe the uncertain translation of values through to visions of impact. It is the aspiration to institutionally-embed such integrated processes in such a way that deliberation and reflection can be coupled to action (i.e. responsiveness) that is a second emerging feature of RRI.

b) Science with society: institutionalising responsiveness

As with the first feature of the emerging RRI discourse, the second may also, arguably, be considered as being evolutionary in nature. It emphasises the integration and institutionalisation of established mechanisms of reflection, anticipation, and inclusive deliberation in and around the processes of research and innovation (Owen et al, in press; Stilgoe et al, submitted).We describe these dimensions in terms of a need to a) *anticipate*: describing and analysing intended and potentially unintended impacts that might arise, be these economic, social, environmental or otherwise, supported by methodologies that include those of foresight, technology assessment and scenario development. These do not set out to predict, but serve to both open up and explore promissory narratives of expectation as well as other plausible pathways that may lead to other impacts: to prompt 'what if...' questions (Guston, in press); b) *reflect* on underlying purposes, motivations and potential impacts, what is known (including those areas of regulation or other forms of governance that currently exist) and what is not known, associated uncertainties, risks, areas of ignorance, assumptions, questions and (ethical) dilemmas and c) inclusively *open up* such reflection to broad, collective *deliberation* through processes of dialogue, engagement and debate, inviting and listening to wider perspectives from publics and diverse stakeholders.

We have brought these three dimensions together to construct a framework for responsible innovation, stressing the need for this to be an iterative, continuous and flexible process of adaptive

learning. But individually these dimensions are hardly new, building on concepts of anticipatory governance, technology assessment in its various forms and public engagement. It might be argued that their integration represents a degree of novelty, but socio-technical integration also has a history in EU policy discourse (see Mejlgaard et al, this issue), including the structuring and delivery of the EU Framework Programme (to varying degrees); (Rodriguez et al, in press). It is also evident in other programmes, such as the US National Nanotechnology Initiative (Fisher, 2007). And integration is a key feature of concepts of real-time and constructive technology assessment (which aims to broaden technological design, development and embedding in society by including more actors, and to use insights from such actors to modulate technological dynamics).

It is the *institutionalised coupling* of such integrated processes of anticipation, reflection and inclusive deliberation to policy and decision-making processes – i.e. the dimension of *responsiveness* - that is an important, if evolutionary, contribution that RRI makes, and one to which the EC aspires to embed more systematically across the ERA. Over the past several decades there has been a proliferation of public engagement activities concerning science and new technologies, from citizens' juries to consensus conferences. There is considerable heterogeneity in both the nature and extent of such activities across Europe (Mejlgaard et al, this issue). These processes have also too often been detached from policymaking, which has not been responsive (see Macnaghten and Chilvers, 2012). Social scientists and public engagement practitioners have frequently been drawn into a pre-occupation with the processes of public engagement, at the expense of a questioning of its purposes (Stirling, 2005; Marris and Rose, 2010; Stilgoe, 2007) and how science and innovation can change as a consequence – how they might look different in response (Stilgoe et al, forthcoming).

Responsiveness is a dimension that is evident in recent academic experiments involving the 'midstream modulation' of scientific trajectories described by Fisher and others within the field of nanosciences. In these experiments the introduction of social scientists and humanists has catalysed reflection, modulating research trajectories in response (Fisher and Rip, in press). There are numerous ways to enact the dimension of responsiveness, from Fisher's 'governance from within' to more formalised processes of innovation stage gating that we have recently explored in the controversial area of geoengineering. Here the application of the responsible innovation framework directly impacted on research – in this case the decision to undertake the first publicly funded field trial of a controversial solar radiation management engineering system (Macnaghten and Owen, 2011), with material influence on decisions regarding the progression and direction of this field of research, at least in the UK. These experiences have also illustrated the need for any RRI approach to be instigated from the initial definition and inception of a research programme, which must be then be multidisciplinary in its construction, resourcing and delivery.

c) Reframing responsibility

Scientists already have responsibilities, including those associated with concepts of research integrity which make explicit such morally unacceptable behaviours as data falsification and plagiarisation. The emerging concept of RRI however confers new responsibilities: and not only on scientists but universities, innovators, businesses, policy makers and research funders. How are grand challenges to be defined? How can they be responsive in their delivery? When should such an approach be used? And at what level (for example with every project, or at a thematic programme level)? How can emerging 'reflexive capital' be communicated to national and international policy making at a governmental level and beyond, particularly in contentious and controversial areas of science and technology? These are responsibilities that require reflection, *including at the European Commission itself,* on the constitution, funding and delivery of science and innovation programmes. Awareness of such responsibilities is developing. Responding to a public dialogue in the UK concerning synthetic

biology, David Delpy (the Chief Executive of the UK Engineering and Physical Sciences Research Council) stated:

> ''Research Councils have a responsibility to scrutinize the potential impacts and risks of emerging technologies, and encourage the researchers we fund to do likewise.... The challenge will be to define an approach that promotes creativity and innovation in research underpinned by a commitment to its responsible development''. (Delpy,2011)

Funders have a leadership role to play in establishing a framework for responsible innovation and its associated expectations, including processes of governance and oversight. They must lead by example. They also have a role to play in catalysing the development of capacity for responsible innovation to meet such expectations, through programmes of education and training. But while those with the gift to distribute research funds clearly have a leadership role to play (see for example EC, 2008 for a controversial example of this in the field of nanosciences), it is also clear that innovation is a collective process that requires a *collective* approach to responsibility (Mitcham, 2003; von Schomberg, 2007, Grinbaum and Groves, in press), extending beyond the early stages of research and involving other actors and users who collectively translate ideas into application and value. Von Schomberg (2007) considers that collective responsibility is supported by public debate (i.e. that 'upon everyone's shoulders rests a particular moral obligation to engage in the collective debate that shapes the context for collective decision making'), technology assessment, foresight/ knowledge assessment and constitutional change, dimensions which have strong synergies with the dimensions of anticipation, reflection, deliberation and responsiveness we have highlighted above.

The framing of responsibility itself is perhaps one of the greater intellectual challenges for those wrestling with the concept of responsible innovation. Consequentialist models of responsibility which are grounded in the status of various forms of knowledge and in which the consequences of one's actions are judged in hindsight (e.g. through legal constructs of liability or reasonable foreseeability) are deeply problematic for innovation as a future-oriented, highly uncertain activity (Ginbaum and Groves, in press). Traditionally, crippled by the limits of foresight, the only alternative has been to subscribe to moral luck, to take one's chances that we can be excused from moral blame in the fullness of time. Reframing responsibility in the context of innovation as a collective, uncertain and unpredictable activity is focussing attention on dimensions of responsibility such as care and responsiveness which are values and not rules-based, allowing for discussion concerning purposes and accommodating uncertainty (Jonas, 1984; Richardson, 1999). It is perhaps in this regard that research around the concept of RRI might make a truly novel contribution to intellectual thought.

Conclusions: the politics of responsible innovation

The EC Science in Society Stand at the European Science Open Forum conference in Dublin, July 2012 had the title ''Responsible Research and Innovation: Europe's ability to respond to societal challenges'' (Fig 1 below). We have described three emergent features of RRI discourse at an EU policy level, all of which are encapsulated in that title. The first is an emphasis on science for society – a focus on purposes, where research and innovation are targeted at Europe's societal challenges and the 'right impacts', underpinned by a deliberative democracy. The second, linked to the first, is an emphasis on science with society – a focus on the need for research and innovation to be responsive to society in terms of setting its direction, and in modulating its trajectory in the face of the uncertain ways innovation invariably unfolds as part of its naturalisation in the world. RRI calls for institutionalised responsiveness. A third is encapsulated in the explicit linking of research and innovation to responsibility, the 'responsible' in responsible innovation (Grinbaum and Groves, in

press). This is prompting a re-evaluation of the concept of responsibility as a social ascription in the context of innovation as a future-oriented, uncertain, complex and collective endeavour. This in turn is challenging scientists, innovators, business partners, research funders and policy makers to reflect on their own roles and responsibilities, acknowledging that the irresponsibility in innovation is a manifestation of the ecosystem of innovation and requires a collective, institutionalised response, if this is indeed possible.

Any process that asks for reflection on the purposes of innovation should also reflect on the purpose of RRI as an innovation itself. In the field of public engagement, the distinction between instrumental, normative and substantive motivations (Fiorino, 1989; Stirling 2005, Sykes and Macnaghten, in press) has been one useful way to consider and evaluate motivations. Is RRI a process that has normative motivations (e.g. that it is the right thing to do for reasons of democracy, equity and justice), substantive motivations (e.g. that policy choices can be co-produced with publics in ways that authentically embody diverse social knowledge, values and meanings) or instrumental motivations (e.g. that it provides social intelligence to deliver pre-committed policy objectives), (see Sykes and Macnaghten, in press)? Policy statements from the European Commission suggest that RRI has underlying motivations that are not only instrumental (i.e. in supporting the delivery of policy commitments in the Horizon 2020 Strategy and Innovation Union) but also normative and substantive (von Schomberg 2011a,b; Laroche, 2011). In these position papers and statements one can discern both grand ambition and shorter term policy goals. If RRI risks becoming a new label for business-as-usual, it also risks being used instrumentally, to smooth the path of innovation in society, and/ or to achieve pre-committed policies This, we argue, should be a primary point of discussion and clarification, acknowledging we are at a stage before the term itself becomes locked-in. The purposes and motivations for RRI at a policy level must be clear.

Responsible innovation evokes a collective duty of care, first to rethink what we want from innovation and then how we can make its pathways responsive in the face of uncertainty. Acknowledging the power of innovation to shape our collective future, RRI challenges us first and foremost to ask what kind of future we want innovation to bring into the world. Ultimately this has to be a project that is far grander in ambition than the delivery of short-term policies. But it must also be practicable and feasible, going beyond aspiration as a mechanism for genuine and transformative change. Responsible innovation must be a process in which innovation looks different in response. There are many in academia and policy who subscribe to this grand ambition, but whether RRI lives up to this challenge remains to be seen.

Acknowledgements

The authors were funded by the UK Economic Social Research Council and Engineering and Physical Sciences Research Council (RES-077-026-0001) to develop a Responsible Innovation Framework, on which this paper is partly based.

References

Adam, B and Groves, G, 2011 ‘Futures Tended: Care and Future-Oriented Responsibility’, Bulletin of Science, Technology & Society, 31(1) 17-27.

Armstrong, M., G. Cornut, S. Delacôte, M. Lenglet, Y. Millo, F. Muniesa, A. Pointier and Y. Tadjeddine (2012), “Towards a Practical Approach to Responsible Innovation in Finance: New Product Committees Revisited” Journal of Financial Regulation and Compliance, 20(2), 147-168.

Beck, U. (1995) Ecological Politics in an Age of Risk. Polity Press. pp224

Bessant J. (in press) Innovation in the 21st Century. In (eds R.Owen, M.Heintz and J.Bessant) Responsible Innovation. John Wiley.

Chesborough, H.(2003) Open innovation: The new imperative for creating and profiting from technology. Harvard Business School Publishing Corporation.

Collingridge D. (1980) The Social Control of Technology. Francis Pinter Ltd, London.

Delpy D. (2011) Synthetic Biology Public Dialogue. Science in Parliament 68 (1) 41-42.

European Commission (2008). European Commissions Code of Conduct for Responsible Nanotechnologies Research. Available at: http://.ec.europa.eu/nanotechnology/pdf/ nanocode-rec pe0894c-en.pdf, Accessed September 27, 2010

EC (2011) DG Research workshop on Responsible Research & Innovation in Europe http://ec.europa.eu/research/science-society/document_library/pdf_06/responsible-research-and-innovation-workshop-newsletter_en.pdf

Fiorino D. (1989) Environmental risk and democratic process: a critical review, Columbia Journal of Environmental Law, 14: 501-547

Fisher, E., 2007. Ethnographic Invention: Probing the Capacity of Laboratory Decisions. NanoEthics 1(2): 155-165

Fisher E.,Rip A (in press) Responsible innovation: multi-level dynamics and soft intervention practices. In (eds R. Owen, M. Heintz and J. Bessant) Responsible Innovation. John Wiley

Fisher, E., Mahajan, R. & Mitcham, C. (2006). Midstream Modulation of Technology: Governance from Within. Bulletin of Science, Technology & Society 26(6), 485-496

Geoghegan-Quinn M. (2012) http://ec.europa.eu/commission_2010-2014/geoghegan-quinn/headlines/speeches/2012/documents/20120423-dialogue-conference-speech_en.pdf

Grinbaum A.Groves C. (in press) What is the 'responsible' in responsable innovation? In (eds R.Owen, M.Heintz, J.Bessant) Responsible Innovation. John Wiley

Grove-White, R., Macnaghten, P. and Wynne, B. (2000) *Wising Up: The public and new technology.* Lancaster: CSEC, Lancaster University

Guston D.H. (2006a) Responsible Innovation in the Commercialised Uninversity. In (ed D.G. Stein) Buying in or Selling Out: The Commercialisation of the American Research University.

Guston D.H. (in press) In (eds R.Owen, M.Heintz, J.Bessant) Responsible Innovation. John Wiley.

Guston, D. H. and Sarewitz, D., 2002. Real-time technology assessment. Technology in Society 24 (1), 93–109

Hellstrom T. (2003) Systemic innovation and risk: technology assessment and the challenge of responsible innovation, Technology in Society 25 369–384

Jonas H. (1984). The Imperative of Responsibility. University of Chicago Press, Chicago pp 255.

Jones R. (2008).When it pays to ask the public Nature Nanotechnology 3, 578 – 579.

Karinen R., Guston D.H. (2010). "Towards Anticipatory Governance. The Experience with Nanotechnology". In: Governing Future Technologies. Nanotechnology and the Rise of an Assessment Regime". Mario Kaiser (eds). Springer: Dordrecht, Heidelberg, London, New York

Kearnes, M and Wienroth, M, 2011, A New Mandate? Research policy in a technological society, Research report, Durham University, Durham.

Laroches G. (2011) Presentation at the Resposnsible Innovation Workshop, French Embassy, London. Available at www.ambafrance-uk.org/IMG/pdf/Gilles_LAROCHE.pdf.Accessed 26th July 2012.

Lee, R.G. (2012) Look at Mother Nature on the Run in the 21st Century: Responsibility, Research and Innovation. Transnational Environmental Law, 1:1 (2012), pp. 105–117

Lund Declaration, 2009. Conference: New Worlds – New Solutions. Research and Innovation as a Basis for Developing Europe in a Global Context. Lund, Sweden, 7-8 July 2009. Online available at: http://www.se2009.eu/polopoly_fs/1.8460!menu/standard/file/lund_declaration_final_version_9_july.pdf|http://www.se2009.eu/polopoly_fs/1.8460!menu/standard/file/lund_declaration_final_version_9_july.pdf

Mackenzie D. (2010) Unlocking the language of structured securities. Financial Times August 19, 2010. Available at: www.sps.ed.ac.uk/__data/assets/pdf_file/0007/53998/ftaug10.pdf Accessed July 26th 2012

Macnaghten, P., Owen, R., 2011. Good governance for geoengineering. Nature 479, 293.

Macnaghten, P., Chilvers, J. 2012. 'Governing risky technology', in S. Lane, F. Klauser and M. Kearnes (eds.). *Critical Risk Research: Practices, Politics and Ethics*. Oxford: Wiley-Blackwell

Marris, C. and Rose, N. (2010). Open Engagement: Exploring Public Participation in the Biosciences. PLoS Biology, 8(11): e1000549.

McGregor J, Wetmore JM. Researching and teaching the ethics and social implications of emerging technologies in the laboratory. Nanoethics, 2009; 3: 17–30

Mejlgaard N., Bloch C., Degn L., Nielsen M.W., Ravn T. (in press) Locating Science in Society across Europe: Clusters and Consequences. Science and Public Policy.

Mitcham, C., 2003. Co-Responsibility for Research Integrity. Science and Engineering Ethics 9, 273-290

Muniesa F., Lenglet M. (in press) Responsible Innovation in Finance: Directions and Implications In (eds R.Owen, M.Heintz, J.Bessant) Responsible Innovation. John Wiley

NNI :The National Nanotechnology Initiative Strategic Plan, December 2004.

National Research Council (2006), A Matter of Size. Triennial Review of the National Nanotechnology Initiative, p. 73.

Owen, R. and Goldberg, N., 2010., Responsible Innovation: A Pilot Study with the U.K. Engineering and Physical Sciences Research Council. Risk Analysis, 30: 1699–1707.

Owen R, Baxter D, Maynard T, Depledge MH. (2009a) Beyond regulation: Risk pricing and responsible innovation. Environmental Science and Technology, 2009; 43(14):5171– 5175.

Owen R., Crane M., Deanne K., Handy R.D., Linkov .I, Depledge M.H. (2009b) Strategic Approaches for the Management of Environmental Risk Uncertainties Posed by Nanomaterials. In Nanotechnologies: Risks and Benefits (Ed I. Linkov) Springer.

Owen R., Macnaghten P.M., Stilgoe J., Fisher E., Guston D.H. (in press) A Framework for Responsible Innovation. In (eds R. Owen, M. Heintz., J. Bessant) Responsible Innovation. John Wiley.

Pellizzoni, L., 2004. Responsibility and Environmental Governance. Environmental Politics, 13(3), 541-565

RCEP (Royal Commission on Environmental Pollution (2008) Novel Materials in the Environment : The case of nanotechnology Available at www.official-documents.gov.uk/document/cm74/7468/7468.pdf
Accessed July 26th 2012

Richardson, H. S., 1999. Institutionally Divided Moral Responsibility, in Paul, E. F., Miller, F. D., Paul, J., (eds.) Responsibility. Cambridge University Press, Cambridge, pp 218-249.

Rip, A., Misa, T. and Schot, J. (eds), 1995. Managing Technology in Society: the approach of constructive technology assessment. Thomson, London

Rodriguez, Fisher E., Schuurbiers D. (in press) Integrating science and society in European Framework Programmes: Trends in project-level solicitations.

Royal Society (2009) Geoengineering the Climate: Science, Governance and Uncertainty Available at: http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/8693.pdf. Accessed 26th July 2012.

Schot J, Rip A. The past and future of constructive technology assessment. Technological Forecasting and Social Change, 1996; 54:251–268

Schuurbiers D., and Fisher E., 2009. Lab-scale intervention. Science and society series on convergence research. EMBO Reports, 10(5), 424–427.

Stilgoe, J (2007) Nanodialogues: Experiments in public engagement with science, London: Demos.

Stilgoe. J, Owen R., Macnaghten P.M. (submitted) Towards a framework of responsible innovation: from concept to practice through an experiment at the UK research councils

Stirling A., (2005) 'Opening up or closing down? Analysis, participation and power in the social appraisal of technology', in (eds M. Leach, I. Scoones, and B. Wynne) Science, Citizenship and Globalisation. London: Zed

Sutcliffe, H. (2011) A report on Responsible Research and Innovation for the European Commission, http://ec.europa.eu/research/sciencesociety/document_library/pdf_06/rri-report-hilary-sutcliffe_en.pdf

Sykes K, Macnaghten P.M. (in press) Responsible Innovation - Opening up dialogue and debate. In (eds R. Owen, M.Heintz and J.Bessant) Responsible Innovation. John Wiley

TNS-BMRB (2010) Synthetic Biology Dialogue. London: Sciencewise

van den Hoven, M. J. , Lokhorst, G.J.C. and van de Poel, I., 2012. Engineering and the problem of moral overload. Science and Engineering Ethics 18(1), 1-13

von Schomberg, R.(2007) From the ethics of technology towards and ethics of knowledge policy and knowledge assessment. Available at http://ec.europa.eu/research/science-society/pdf/ethicsofknowledgepolicy_en.pdf Accessed July 26th 2012

von Schomberg, R.(2011a). Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields, European Commission, Brussels. http://ec.europa.eu/research/sciencesociety/document_library/pdf_06/mep-rapport-2011_en.pdf

von Schomberg (2011b) The quest for the "right" impacts of science and technology. An outlook towards a framework for responsible research and innovation. in: (eds M.Dusseldorp, R. Beecroft) "Technikfolgen abschätzen lehren. Bildungspotenziale transdisziplinärer Methoden". Springer Verlag pp394.

Williams B., 1981. Moral Luck. Cambridge University Press, Cambridge

Wilsdon, J., Wynne, B. and Stilgoe, J., 2005. The Public Value of Science. Demos, London

WWF (World Wildlife Fund) 2011 Green game-changers: 50 innovations to inspire business transformation. http://assets.wwf.org.uk/downloads/green_game_changersx50.pdf . Accessed July 26th 2012

Figure 1.EC Science in Society Stand at the ESOF meeting, Dublin, July 2012