Responsiveness in practice: aligning nanotechnology research and innovation with societal needs

Enhancing the responsiveness of scientists and engineers to societal needs and values - opportunities and challenges for co-creation

White Paper 1

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Executive summary

Responsiveness is one of the major concepts defining outcomes of Responsible Research and Innovation (RRI), but the concept has, remained relatively vague. As the field of nanotechnology has served as a test field for various approaches to societal engagement, it can be considered a stronghold of strategies enhancing responsiveness with regard to research and development. While the European Commission understands responsiveness as an umbrella term for aligning research and innovation (R&I) with societal needs and values by different means (among them technology assessment), GoNano aims at taking responsiveness a step further. GoNano's understanding of responsiveness is oriented towards action, namely as the capacity of R&I actors (researchers, engineers, innovators and producers) to act on societal input at a time when technological trajectories are still malleable. Thus it understands co-creation as a way of introducing more responsiveness into R&I, even though a number of difficulties still need to be overcome.

In order to enhance responsiveness throughout the research process, GoNano has formulated five rules of thumb that emerge from co-creation experiences within the project:

1. Enhance the potential for the recognition of opportunities
Opportunities to enhance responsiveness donot present themselves on a silver platter. Often it takes special attention to identify such opportunities, and one needs to be open and willing to recognise and act on them.

2. Integration of 'interactional expertise'
Train what we call "interactional skills, literacy and expertise", meaning the potential not only to recognise opportunities for responsiveness but also to identify potential scopes within research design settings and relevant questions that could be meaningfully addressed by doing so. However, this also requires decisions, such as positioning the processes somewhere within the trade-off between the claims for enhanced inclusion (democratisation) and addedvalue in term of concrete business optimisation.

3. Select appropriate engagement measures
It is important not only to select the appropriate stage and point in time for engagement, but also to pay attention to the suitability of the format to address specific questions in specific settings with regard to R&I activities.

4. Ensure benefits for researchers
Generally speaking, saying that one is seeking to enhance responsiveness between research and broader values with regard to a perceived democratic deficit is widely appreciated. Nevertheless, in practice implementation often has to be imposed in the face of individual researchers' preferences, as the structures of the research system hardly offer rewards here. Policy therefore needs to ensure benefits for individual researchers who are willing to invest in mechanisms and structures to foster responsiveness.

5. Building trust
While hard to tackle, the building of trust between actors involved in engagement procedures to enhance responsiveness is key. It requires openness and a willingness to engage with different perspectives, as well as continuity with regard to engagement.

Highlights from the GonaNo white paper series

The GoNano White Paper series highlights the conclusions derived from the co-creation activities carried out in the project. On the basis of our GoNano experience, we recommend that the following factors should be considered when planning co-creation activities:

Knowing and reaching the target audience

- Find ways to improve the conditions to enable responsiveness on the levels of institutions, opportunities and organisational culture
- Be cognisant of what it is possible to change within the affected system
- Identify and assess issues and actors along the whole value chain for concrete scoping
- Address salient dilemmas or societal challenges to attract the attention of potential participants, using solution/opportunity-oriented framing.

Changing perspective as a precondition or outcome of co-creation

- Foster R&I actors' appreciation of the opening up of the research process and involve perspectives not usually involved in R&I
- Challenge the ways in which (the views of) others are anticipated, simplified or ignored in relation to science/scientists, industry/industry representatives and society/citizen-consumers.

Adopting tangible methods for co-creation

- Identify ways to empower actors to express diverse issues (enabling responsiveness)
- Balancing actors' involvement: be aware of the trade-off between specific expertise and societal inclusiveness
- Be aware of potential power differences among the participants: academics, industry representatives – and the general public.

Increase your gain

- Share your knowledge across sectors and activities
- Improve R&I strategies and innovation trajectories
- Find new and original design and product suggestions.

Foreword

What are the gonano white papers?

The present publication is part of a series of three white papers developed by the GoNano project covering different aspects of co-creation in research and innovation (R&I) with a focus on nanotechnology.
The white papers are intended as a knowledge repository for further GoNano communication activities. As such, they provide relevant background information with condensed GoNano findings. They also form the basis for six industry and policy briefs outlining the topics with greatest industry and policy relevance.
The GoNano White Papers are a core part of the GoNano project[1].

The three GoNano White Papers provide insights into different aspects of co-creation and responsiveness in the field of nanotechnology. Each paper addresses the question of conditions for Responsible Research and Innovation (RRI) in nanotechnology R&I from a different angle.[2]

- **White Paper 1** sets out why co-creation responsiveness makes sense in nanotechnology and describes conceptual and empirical aspects of *responsiveness of researchers and engineers* in co-creation processes with a focus on nanotechnology. It mainly addresses researchers, engineers and other stakeholders involved in the research system (e.g. research funding or research institutions), including the organisational structures they are engaged with.
- **White Paper 2** provides a strategic focus regarding *how to implement co-creation*, considering research as well as the innovation eco-system. It addresses industrial and business partners, research institutions, and policy makers who are active in and are influencing R&I processes.
- **White Paper 3** provides guidance on how to realise co-creation in the light of a *gender and diversity perspective*, in order to better integrate these perspectives into nano-related R&I. The main addressees of the paper are process organisers and/or researchers in a position to put co-creation into practice.

GoNano project and goals

This white paper explores opportunities for and constraints on implementing co-creation in nanotechnology R&I practice , It builds on the findings of the GoNano project, which is built on the assumption that several types of knowledge and expertise are needed to support co-creation towards sustainable, acceptable, and desirable applications of nanotechnologies. GoNano explored approaches that could be put into practice in different application areas of nanotechnologies (Health, Food and Energy), combining face-to-face citizen consultations, stakeholder workshops and online consultations (see Figure 1).

There has been growing interest in co-creation in recent years. Generally speaking, co-creation is defined as the practice of collaborative product or service development as developers and stakeholders work together; or the joint creation of value by the company and the customer; or as allowing the customer to co-construct the service experience to suit their context.[3]

Co-creation as a method has been applied to research and innovation to achieve very different aims and objectives. Companies have used co-creation to encourage user-led innovation. Their aim is to put the needs of users at the heart of innovation. The Creator Space initiative by BASF for example aims to foster open innovation within the company.

1. For more information on the overall structure of the project and our further understanding of co-creation see http://gonano-project.eu/.
2. For more information on the RRI framework as set out by the EC, see the website (https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation). For the aspect of responsiveness, see GoNano White Paper 1.
3. For further information see GoNano D2.1: http://gonano-project.eu/deliverable-2-1/ [20-02-2020] or, for an illustrative example, see the experiences of the Fonteer project: https://www.youtube.com/watch?v=VlD2EyW5W_k

Others have used co-creation to enable more democratic decision-making in research and innovation. The EU project Making Sense EU for example helped citizens to use academic technologies to make sense of their own environments.[4]

Within the GoNano project, co-creation is applied to strengthen the ability of R&I processes to respond and adapt according to changing demands. The underlying assumption is that R&I will be more socially robust if societal needs and values are taken into account in the early stages of innovation.[5]

> GoNano defines co-creation as *"activities [that] enable productive collaborations between researchers and societal stakeholders over longer timeframes, focusing on specific nanotechnology research lines, leading to tangible outcomes such as a new research avenue, proposal, product or prototype."*[6] (Bechtold et al. 2019[7])

Through the involvement of citizens and stakeholders from early stages of the innovation process, GoNano aims at anticipating contributions that can serve to make R&I more socially relevant.
To do so, co-creation approaches require new forms of collaboration that extend across different disciplines and sectors. (Figure 1)

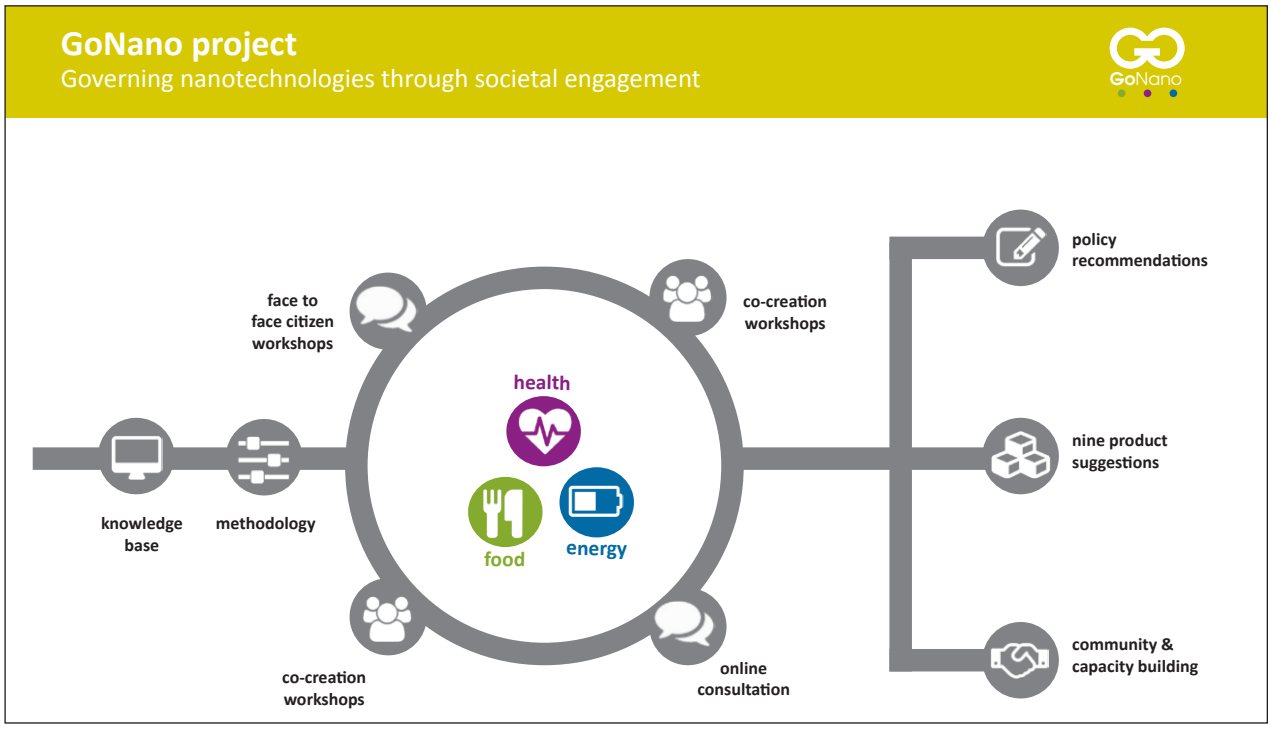

Figure 1. GoNano co-creation process

4. The Creator Space initiative brings together stakeholders with varying experience from within and outside of the company to develop concrete, challenge-based business outcomes. Originally developed as a one-time initiative to celebrate the 150th anniversary of BASF, the Creator Space now forms an integral part of the company's approach to innovation (in this Youtube video, Elise Kissling, Director of the Creator Space frontend innovation program at BASF, reports on Creator Space: https://www.youtube.com/watch?v=Y0JuOWO0hB8).
5. Using low-cost, open source technologies, Making Sense EU empowered citizens to discuss methodologies, devise data collection strategies for measuring air pollution, water quality or sound pollution, and interpret the results. It's a win-win project: scientists can use the datasets for their research, and citizens acquire tools to understand their environment and take appropriate action. In this YouTube video Frank Kresin, Managing Director of the Design Lab at the University of Twente, highlights the EU project Making Sense EU: https://www.youtube.com/watch?v=au3uVptWJbU.
6. For further information, see this earlier report on the co-creation methodology for GoNano: http://gonano-project.eu/deliverable-2-1/.
7. GoNano D2.1: http://gonano-project.eu/deliverable-2-1/ [20-02-2020]

The process in detail

GoNano has established an iterative and interactive process through which societal considerations in the area of nanotechnologies[8] can be integrated into R&I. In a series of citizen workshops, citizens expressed their wishes and concerns with respect to each of the application areas. In a series of stakeholder workshops, stakeholders subsequently explored ways to take these wishes and concerns into account in nanotechnology R&I.

At the start of the iterative and interactive process, the three pilot partners (the University of Twente in the Netherlands, the Technology Centre of the Czech Academy of Sciences in the Czech Republic, and the European Office of the Royal Melbourne Institute of Technology in Spain) organised a series of face-to-face citizen workshops in the Netherlands, the Czech Republic and Spain in October/November 2018.[9] The aim of the first round of stakeholder workshops was to come up with concrete responsive design suggestions that could be fed back into ongoing R&I activities, building on the outcomes of the citizen workshops. The design suggestions were to feed into a next round of citizen consultations, which would again feed into a second round of stakeholder workshops serving to evaluate the uptake of the responsive design suggestions of the previous round. The primary aim was to identify product suggestions which are better aligned with societal needs and values. Taken together, these iterative tasks explore the potential of co-creation in integrating societal values into R&I and provide more insight into the more actively-oriented responsiveness of business and industry.

Thus, the main findings of the GoNano process in the four steps of co-creation were:

• Citizen workshop

Citizens appreciate the promise of nanotechnologies and connect the applications to current global issues concerning sustainable development, the environment, and health and wellbeing, but they also realise that the benefits might not follow automatically: In all pilot countries, citizens seem to put a strong emphasis on the role of scientists in the process of development and implementation of nanotechnologies, expecting that they will ensure that especially food and health related applications are safe to use – that they do not harm the environment or the human body. Citizens can provide a fresh and somehow 'untainted' picture of what the technology might look like.

… for more details, see Hebáková et al (2019)[10]

• Stakeholder workshop 1

As it is far from self-evident how broader societal consideration can be applied meaningfully to R&I practice, the workshops succeeded in raising and fostering awareness with stakeholders that an early consideration of the needs and values of citizens and societal stakeholders can add value to innovation in nanotechnologies; however, it proved difficult to connect the general input from citizens to the research agenda and concerns of the professional stakeholders. So, connecting the ideas of citizens to the stakeholders and their agenda was the main challenge of all the activities.

… for more details, see Schuubiers et al. (2019)[11]

8. See GoNano Del. 1.1 (online: http://gonano-project.eu/wp-content/uploads/2018/08/1.1.pdf [2020-03-23] and 2.1 (online: http://gonano-project.eu/wp-content/uploads/2018/08/2.1.pdf [2020-03-23]) for knowledge base and the methodology developed in earlier stages of the project.
9. See the briefing report for further information on the outcomes of the citizen workshops.
10. GoNano D3.2. Online: http://gonano-project.eu/wp-content/uploads/2019/06/D3.2-Briefing-report-from-the-citizen-workshops.pdf [2020-01-21]
11. GoNano D4.2. Online: http://gonano-project.eu/wp-content/uploads/2019/07/GoNano_D4.2_Working_paper_on_the_designs_and_outcomes_of_round_1.pdf [2020-01-21]

• Online Consultation

Results of the online consultation showed that product suggestions beneficial for the whole society gain most popularity. These products would be mostly related to health application area – specifically to diagnosis of cancer and diabetes. The online consultation again proved that for health and food, the safety is the most important main need and value for the future nanotechnology applications. However, results also show that citizens can have concerns also about the solutions for the issues they raise - preferences of the wide audiences can be easily malleable and therefore unpredictable.

… for more details, see Pour et al. (2019)[12]

• Stakeholder Workshop 2

The second stakeholder workshop – as the final step of the co-creation process – resulted in the most sophisticated exchange of ideas and feedback on the co-creation process so far. In comparison to the first stakeholder workshop, the second workshop provided important insights into the requirements for co-creation in nanotechnologies, highlighting both opportunities for and constraints on co-creation.

… for more details, see Schuubiers et al. (forthcoming)[13]

12. GoNano D3.3. Online: http://gonano-project.eu/d3-3-briefing-report-on-the-outcomes-of-the-online-consultation/ [20-02-2020]
13. GoNano D4.2b (forthcoming).

Why responsiveness?

Working more closely with society to better align research processes and outcomes with the expectations, needs, and values of society continues to grow in importance in the European R&I policy context, and particularly in the H2020 programme under the concept of Responsible Research and Innovation (RRI).[14] This ethos has been emphasised in the realm of nanotechnologies. As a recent policy document notes[15]: *"The early and continuous engagement of all stakeholders is key to sustainable, desirable and acceptable innovation in nanotechnologies, in which R&I is aligned with the values, needs and expectations of society." Indeed, Jean-Eric Paquet, European Commission Director General for Research and Innovation, recently stated: "Europe's future can only be built in a completely inclusive way."*[16]

But what does all this mean in practice?

- How does an R&I system become more responsive to societal needs and values?
- Who and what should it respond to?
- What changes to research practices does increased responsiveness require/presuppose?

The answers to these questions differ depending on one's interpretation of the term 'responsiveness'. Following the European Commission's interpretation, the call for responsiveness can be understood as referring to an umbrella term encompassing the movement towards alignment of R&I with societal needs and values. Responsiveness can be understood as including technology assessment, research agenda-setting, etc. – all of which lead to alignment in the broad sense. This opening up of the R&I agenda in terms of stakeholder engagement, mutual learning and the co-development of research agendas has manifested itself in numerous approaches, ranging from participatory agenda-setting to public engagement to citizen science.

However, responsiveness can also be interpreted as a more targeted concept with an action orientation, namely as the capacity of R&I actors (researchers, engineers, innovators and producers) to act on societal input at a time when technological trajectories are still malleable.

While there has been progress towards enabling responsiveness in the broader sense, e.g. with respect to stakeholder engagement and other mutual learning initiatives, there has thus far been less emphasis on responsiveness in the more action-oriented sense. Making genuine steps from reflection to action is necessary in order to sustain trust in the R&I system. Thus it is important to ensure responsiveness as both a main, continuous aim and as a key outcome that is enabled by reflection throughout the whole development and innovation process.

We zoom in on the active interpretation of responsiveness here. We will consider the opportunities and obstacles that came to light in the findings of the GoNano project, which investigated the conditions for enabling responsiveness in the action-oriented sense. GoNano aims to facilitate responsiveness through co-creation, enabling citizens and professional stakeholders to become responsive to each other's needs and concerns; in other words, co-creation is seen as one possible route to enhancing responsiveness in R&I. While the GoNano findings as presented in this paper focus specifically on nanotechnologies, the lessons may also apply to R&I more broadly.

Data from the GoNano co-creation initiatives and from the literature will be mobilised in order to identify opportunities and obstacles and propose realistic paths forward for researchers required to demonstrate a responsive approach to their research. On the basis of this analysis, we will present some rules of thumb as action points through which to pursue and engender responsiveness.

14. European Commission. (2019) Implementing RRI in Horizon 2020. Available from: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation. (Accessed December 2019).
15. NMBP-34-2017 call description see for: https://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-leit-nmp_en.pdf , page 97
16. Joanna Roberts (2019) The future of European research must be inclusive - Jean-Eric Paquet. The EU research & innovation Magazine. Available at: https://horizon-magazine.eu/article/future-european-research-must-be-inclusive-jean-eric-paquet.html-0. (Accessed December 2019)

Nanotechnologies and responsiveness

The drive to work closely with society has been particularly visible in the area of nanotechnologies. The fear of a social backlash against nanotechnology similar to the case of genetically modified crops in Europe has been an important driver here, with the promotion of R&I coupled with calls for societal engagement ever since nanotechnology started drawing attention as a field of research and economic development. The landmark UK Royal Society and Royal Academy of Engineering nanotechnology report of 2004 noted: *"As recent debates in the UK and elsewhere demonstrate, developments in science and technology do not take place in a social and ethical vacuum. Widespread discussions of issues such as nuclear energy, agricultural biotechnology and embryonic stem cells illustrate this point only too clearly.[...] Given this backdrop, it seems highly likely that some nanotechnologies will raise significant social and ethical concerns."*(p.51).[17] The European Commission's Strategy for Nanotechnology of 2004 stated that: "An effective two-way dialogue is indispensable, whereby the general public's views are taken into account and may be seen to influence decisions concerning R&D policy. The public trust and acceptance of nanotechnology will be crucial for its long-term development and allow us to profit from its potential benefits." In the US, the twenty-first century Nanotechnology Research and Development Act similarly mandated the integration of nanotechnology R&D with research on societal, ethical and environmental concerns.[18]

The challenge as to how to integrate public voices has given rise to a steady stream of European outreach and dialogue activities over the last fifteen years or so. The European Commission's Nanotechnologies, Advanced Materials, Biotechnology, and Advanced Manufacturing and Processing (NMBP) programme has funded a range of dedicated projects including NANODIALOGUE, NANOTOTOUCH, NANOYOU, TIMEFORNANO and SEEINGNANO. The focus of these projects was mostly on outreach, i.e. education and communication, and less focused on actually implementing approaches to integrating societal concerns into R&I.

The question concerns how to enable new models of innovation that integrate societal considerations earlier and more effectively in the R&I process. Nanotechnology governance, including the associated public engagement landscape, is about finding the right level of public oversight needed to maximise the chances of creating maximum public benefit with acceptable levels of risk. This gives rise to some important questions: When should we actively seek to direct or control – govern –R&I, and when should we let the market drive innovation, and who should decide?

Nanotechnology engagement has focused on broader notions of responsiveness – and not so much the ability of innovation actors to act. This has led to calls for responsiveness in the more action-oriented sense. The Re-finding Industry report from the High-Level Strategy Group on Industrial Technologies calls for more social dialogue and participation in Europe, noting that: *"Civil society has a central role in identifying the main challenges, and must be actively involved in the development of missions and projects. The role of society in the missions and projects is not only in the execution phase, but also in most phases of the public policy cycle. Civil society must also take part in the identification of the problem itself, in setting the agenda for solutions, in the policy making and evaluation."*[19]

More recently, projects like the NANODIODE project have begun to explore how to strengthen the responsiveness of the R&I system. The GoNano project is a recent initiative within that broader legacy. It attempts to enhance responsiveness through co-creation and thus provide a concrete way to integrate societal concerns and values into R&D. The following section will present the aims and activities of the project in further detail, and will reflect on the preliminary findings of the project activities, noting both opportunities and obstacles.

17. Royal Society & The Royal Academy of Engineering. (2004). Nanoscience and nanotechnologies: Opportunities and uncertainties. London: Royal Society.
18. Fisher, E., & Mahajan, R. L. (2006). Contradictory intent? US federal legislation on integrating societal concerns into nanotechnology research and development. Science and Public Policy. 33(1):5–16.
19. Re-Finding Industry. Report from the High-Level Strategy Group on Industrial Technologies. European Commission, 2018.

Findings from GoNano: opportunities and challenges of co-creation exercises

How can co-creation contribute to enhanced responsiveness of researchers and innovators to input from citizens and stakeholders? Taking the learning objectives for the GoNano stakeholder workshops as an entrance point, the results suggest that – at least in some cases – the workshops succeeded in raising awareness with stakeholders that the early consideration of the needs and values of citizens and societal stakeholders can add value to innovation in nanotechnologies. For instance, one of the researchers who was involved in the workshop on sensor technologies, as part of the co-creation process for nanotechnologies for health, adjusted her research line based on expertise from societal actors (CSO and policymaker) and researchers from other technical disciplines. She explained that the co-creation process was a game-changer for her own research trajectory.

However, the workshop findings also point to obstacles to co-creation. It proved difficult to link the input from the citizens to the research agendas and concerns of the professional stakeholders. For example, during the first stakeholder workshop in the Czech Republic experts acknowledged some of the needs and values expressed by citizens but seemed to remain mostly sceptical about a substantial number of these. Therefore, what seemed to be beneficial for the acknowledgment of the needs and values by the experts was to have citizens involved directly in the discussions during the stakeholder workshop where they could restate these needs and values themselves.

Another apparent issue was that the citizen input provided by facilitators or the citizens to the discussion during the stakeholder workshops was often perceived as challenging to integrate, as these inputs may provide varying contents and ideas. This resulted in discussions where stakeholders found themselves in the position of having to weigh seemingly contradictory needs and values.

The findings also suggest that there is a trade-off between inclusiveness and specificity: the decision to treat all stakeholder perspectives on an equal footing for reasons of inclusiveness may come at the cost of a clear action perspective. Conversely, the choice of one particular action perspective to enable specificity is – by definition – partial and exclusive. In the first workshop on diabetes, the focus was on providing suggestions for products developed by the businesses present at the workshop. This discussion was less relevant for some of the researchers present because they were working on research that was at an early Technology Readiness Level (TRL) and so could not be mobilised for product development.[20]

In the first stakeholder workshop held in Spain, stakeholders were asked to ideate new research lines that were aligned with a single societal need or value (e.g. use more energy from renewable sources; better quality of life), which they themselves considered as essential for future nanotechnology research lines or products. The challenge with completing this task did not arise during the initial ideation, as many ideas that aligned with the needs and values were shared. Rather, stakeholders found it difficult toagree on a specific idea that they could all contribute to. The more diplomatic approach to including all stakeholders led to fewer concrete research lines and goals; however, the alternative would have required a shift in the balance of contributions between the stakeholders, possibly to the point of exclusion for some.

Despite these challenges, some of the workshops succeeded in generating possibilities to open up current nanotechnology developments. For example, while during both stakeholder workshops in the Czech Republic stakeholders remained largely critical of citizens' ideas, there were some clear benefits from the citizen input. The

20. For further information, see this earlier report on the design and outcomes of the workshop round: http://gonano-project.eu/wp-content/uploads/2019/07/GoNano_D4.2_Working_paper_on_the_designs_and_outcomes _of_round_1.pdf

creativity and variety of these ideas were unattached to any specific expertise on or knowledge of how the respective technology worked (in both a positive and a negative sense).

This suggests that enhancing responsiveness will depend on the function assigned to the opportunities of engagement, e.g. out of the box thinking, as well as re-orienting and potentially challenging aspects previously not considered by actors in R&I.

In the nanotechnology and health stakeholder workshop in Enschede (NL), one of the entrepreneurs observed that the workshop was a 'reality-check' of whether they were going in the right direction with their data management plan for artificial pancreas. The post-doc researcher mentioned that the co-creation workshop gave them the possibility to explore the societal context in which their product would be implemented.

Nevertheless, integration may not go as smoothly as intended even when there is a willingness to consider the suggestions that have been made. In the Dutch and Spanish workshops, researchers were willing to look into the concerns raised (by citizens or other researchers) about data protection relating to the products they were developing. However, concrete action resulting from these good intentions will only be visible after the R&I path related to these particular projects and researchers has developed further. This suggests that outcomes (e.g. how societal values are integrated) will depend on how the research and development process goes in practice, which means it might not always be predictable or even easy to trace. This embraces the fact that specific systemic conditions limit (or enhance) opportunities for responsiveness, e.g. whether or not to allow for considering wider societal values while the current system is running.

In the following section, these findings will be synthesised in the form of rules of thumb designed to serve as guidance in establishing and facilitating co-creation exercises.

RULE OF THUMB

1

Enhance the potential for the recognition of opportunities

WHY?

In order to induce systemic change, it is important that actors recognise opportunities for change. However, the emergence of opportunities to establish collaborative work and actors' ability to recognise and act on these is not always apparent to researchers.

HOW?

The modulation of ongoing technological trajectories has a significant influence on the overall shift towards an alignment of R&Iwith societal needs and values. This argument may also need to be made more explicit with reference to significant changes that can only be made in the research arena, e.g. reduced toxicity/ successful substitution of harmful chemicals, enhanced user performance, more ergonomic/economic design, more resource-efficient production, etc, and by understanding the role of various actors and distinguishing the various stages of the innovation process in order to align realistic objectives with each stage and actor engagement.
Our experience from previous projects (NanoDiode, RRI-Practice, and others) and the findings of the academic literature (Fisher and Rip, 2013; Owen et al., 2012; Stilgoe et al., 2012) show that a system's ability to respond and adapt to changing conditions depends on several factors. A key factor for change is the emergence of opportunity, coupled with actors' ability to recognise and act on an emerging opportunity.

The GoNano pilots involved multiple stakeholders with potential to act as change agents in the nanotechnology R&I system. They included nanotechnology researchers, industry and innovation network representatives, civil society organisation representatives, citizens and policy makers. Where one stakeholder group sees a challenge, another may see an opportunity; however, simply throwing these diverse groups together does not guarantee a positive outcome – much work must be done in advance to ensure smooth interactions and support the stakeholders' abilities to recognise the opportunities provided through collaborative work modes such as interdisciplinary work and cross-sectoral approaches. By designing the GoNano co-creation process to include multiple steps with structured and unstructured interactions between stakeholders, the potential for identifying opportunities in nanotechnology research increased. And by including the same stakeholders across the different steps of the co-creation process the prospects of forming the stronger ties needed to act upon these opportunities were also improved.

RULE OF THUMB

2

Integration of ‘interactional expertise’

WHY?

The GoNano co-creation workshops suggest that enhancing the ability of R&I actors to act on societal input when technological trajectories are still malleable can present significant – and often overlooked - opportunities to align R&I with societal needs and values. However, this comes at a price. Responsiveness is at odds with inclusiveness: enabling R&I actors to revise research decisions due to societal considerations is necessarily exclusive. In the following, we home in on two specific aspects of this challenge which those designing and implementing co-creation processes should be aware of.

HOW

Detailed understanding of the research choices that are available (hence of the research at hand) is necessary. This means that only those who, at the very least, have interactional expertise can meaningfully participate in these particular collaborations (which is not to say that they cannot meaningfully participate in other collaborations, for instance in the policy or public arena). Only certain considerations can be operationalised, i.e. those that can be operationalised at the level of research decisions. In other words, certain things need to be taken for granted (e.g. it does not make sense at this level to conclude that the type of research at hand should not be carried out at all - while this could be a legitimate conclusion, it moves the debate into the policy arena) and thus away from an action-oriented notion of responsiveness.

RULE OF THUMB

3

Select appropriate engagement measure

WHY

Enhancing responsiveness will depend on different forms of societal engagement at different stages of the R&I process.

HOW

By understanding the potential and limitations of distinct forms of engagement; targeting them to the appropriate stage in the innovation process; and adjusting the nature of the engagement measures to the specific actors, while being aware of the opportunities and challenges of each form of engagement.

For instance, citizen and multi-actor consultations could help to determine the sorts of research that we – as a society – do or do not want to pursue, and the ways in which we do or do not want nanotechnology to shape our society. Focused, in-depth co-creation approaches can be used to integrate specific societal considerations into concrete research trajectories. In order to achieve such in-depth approaches, it is important to consider the different roles of various stakeholders at every step of the value chain. Creating a stakeholder map can contribute to the *ex ante* definition of the kind of interaction required from the specific actor group (e.g. listen, decide, provide knowledge, and so on) and at which step of the value chain this interaction should take place (see White Paper 2). Moreover, the relevance of the respective topic for actor groups involved should be clarified at the beginning (e.g. patient, doctor or problem owners in a wider sense).

RULE OF THUMB

4

Ensure benefits for researchers

WHY

The question of 'What's in it for me?' is particularly challenging for researchers. Researchers do not see stakeholder involvement as core business. It will only become core business for them if enactors see the added value of these interactions in relation to their own goals and objectives. This requires compelling examples that demonstrate how the research improved or how resistance was overcome. The FoTRRIS project[21] found that a positive correlation can be seen between the relevance of cooperation for a particular research field and the willingness of R&I actors to engage in collaboration. Thus, drivers for involvement in a co-creation project should be carefully considered. For example, academics may seek to move closer to industrial contexts by improving the industrial relevance of their training programmes and ensuring the societal relevance of their research programmes.

Moreover, close collaboration with non-research actors should not put the R&I community's autonomy and independence at risk. If we want to engage researchers, it is our responsibility to demonstrate that it does make sense to look at the broader dimensions: this can be achieved by highlighting that such reflection can help researchers to achieve their own goals (this is first-order learning).

In order to achieve this, social sciences and humanities communities need to strengthen their consultancy skills and their ability to understand the context and 'DNA' of the actors involved:

- from product-driven ('Here's my theory, what do you think?') to demand-driven: 'How can I help you?'
- clear and compelling examples, presented in a way that non-experts can understand

HOW

Seeking a shared goal that drives collaboration between stakeholders is key. This might involve mobilisation around a specific problem that requires a need for consensus, e.g. how can we move forward in tackling this problem? Researchers will need to know why, to what end, and when they need input from stakeholders. Defining what is at stake is crucial. In other words, it is necessary to have a clear problem diagnosis, e.g. exploring norms and values related to the technology at stake, the potential contributions of citizens to the research process and, especially in the case of nanotechnology, the degree of urgency and openness with regard to research activities. In short, expectation management on different levels is key.

In order to motivate scientists to participate in and engage with co-creation exercises, it may be helpful to find individuals within the scientific community who want to do something that may not be immediately useful to their own research, i.e. those scientists who are not continuously concerned about 'What's in it?' for them. Ideally, co-creation projects like GoNano would work with scientists and researchers who are interested in collaboration whether it serves their own purposes or not and who find during the collaboration that it is actually relevant to their work.

21. http://fotrris-h2020.eu/

RULE OF THUMB

5

Building trust

WHY

Close collaboration as required by co-creation is far from being a mainstream procedure; this means it is crucial to establish trust in both people and organisations as well as in the co-creation process itself.

People have to be open and willing to see the 'win-win' of co-creation and to trust each other and their respective roles in the process. A partnership has to be allowed to develop; this might be related to normative (claim to more and broader inclusion) or economic added value (claim to improve specific products). Co-creation work will take on varying degrees of importance and meaning according to the type of stakeholder involved.

HOW

Establish a culture of thorough argumentation: whoever participates and shares their knowledge (regardless of expert knowledge or lay knowledge) needs to know that they are being listened to, that they have a say, and how their input will be further processed (communication and transparency).

This, however, should not stop at the level of individual co-creation or engagement processes, but extend to the policy arena: Why and how are inputs, thoughts and reflections there included or excluded?

References

European Commission. (2007). Work programme 2007, Capacities, Part 5, Science in Society. C(2007)563.

European Commission. (2019) Implementing RRI in Horizon 2020. Available from: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation. (Accessed December 2019).

Fisher, E., and Mahajan, R. L. (2006). Contradictory intent? US federal legislation on integrating societal concerns into nanotechnology research and development. Science and Public Policy. 33(1):5–16

Fisher, E., and Rip, A. (2013). Responsible innovation: Multi-level dynamics and soft intervention practices. In R. Owen, J. Bessant, & M. Heintz (Eds.), Responsible innovation: Managing the responsible emergence of science and innovation in society (pp. 51–74). London: Wiley.

Joanna Roberts (2019) The future of European research must be inclusive - Jean-Eric Paquet. The EU research & innovation Magazine. Available at: https://horizon-magazine.eu/article/future-european-research-must-be-inclusive-jean-eric-paquet.html-0. (Accessed December 2019)

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, 751–760

Schuurbiers, D. and Fisher, E., 2009. Lab-scale intervention. EMBO reports, 10(5), pp.424-427.

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

Strand, R. S., Spaapen, J., Bauer, Martin W., Hogan, E., Revuelta, G. and Stagl, S. (2015). Indicators for promoting and monitoring Responsible Research and Innovation. Report from the Expert Gorup on Policy Indicators for Responsible Research and Innovation. E. Commission. Brussels., p. 10. Online: http://ec.europa.eu/research/swafs/pdf/pub_rri/rri_indicators_final_version.pdf [2020-03-18]

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