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RRI requires doing the best science for the world, not only the best science in the world.

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Responsible Research and Innovation in the Digital Age

AT A TIME when increasingly potent technologies are being developed with the potential to transform society, researchers in all technological fields, including information and communications technology (ICT), are under growing pressure to consider and reflect on the motivations, purposes, and possible consequences associated with their research. This pressure comes from the general public, civil society, and government institutions. In parallel is a growing recognition that current ethics review procedures within ICT may not address broader concerns (such as the potential societal consequences of innovation).

Instances of ICT raising concerns abound. For example, along with attention-grabbing headlines that artificial intelligence (AI) could ultimately pose an existential threat to humankind, there are more prosaic, yet strongly felt, social transformations already associated with AI technologies. For example, AI is an increasingly powerful protagonist in the story of how digital technologies are transforming the nature of work, as more types of work are mediated digitally, including how it is allocated, assessed, and rewarded. With these new forms of digital agency driving important aspects of labor markets, questions arise as to whose interests are being served and how accountability and transparency can be assured.

This is but one example of many debates around technology-, product-, and process-based innovation. Potential conflicts are wide-ranging and, most important, often emerge only after technologies have been embedded into the mainstream.

ICT scholars and professionals have long tried to understand and address these issues, though there are still numerous areas of concern. A novel concept—"responsible research and innovation," or RRI —has emerged recently in response to the challenge of designing innovations in a socially desirable and acceptable way. It may be useful for framing the discussion about how to manage the introduction of future innovations in ICT. In this article, we discuss the origins of RRI, consider relevant research from computer ethics and human-computer interaction (HCI), and illustrate the need for a new approach for the governance of ICT research. Finally, we suggest ways researchers might draw upon a framework for RRI in ICT based on the findings of an interview study conducted

» key insights

- **Responsible research and innovation aims to ensure that the processes and outcomes of research are aligned with societal values.**
- **Our qualitative interview study found that ICT raises particular challenges for RRI; ICT researchers are best positioned to be able to identify them.**
- **We propose a context-specific and flexible framework for RRI in ICT to help researchers use it as a source of inspiration and creativity.**

IMAGE BY SUAT GURSOZLU

with the ICT community by investigators at the University of Oxford and De Montfort University, both in the U.K., from 2011 to 2013.

Ethics and Social Responsibility

ICT has traditionally been associated with the development of tools with discrete and transparent functionality aimed at supporting specific tasks. However, its diversity, scope, and complexity have extended far beyond this view to become situated within the very fabric of our daily lives.[17] Rather than being merely tools, the technologies now being designed are arguably transforming and augmenting the world around us, where computer-generated information, objects, and infrastructures "coexist in the same space as the real world," as outlined by Azuma et al.[1]

Debates about ethical issues in ICT are not new; researchers have been concerned with ethics in computing since at least the 1950s.[23] With the emergence of HCI in the 1980s, these debates have focused on the design of usable interactions between people and computers, where the broader ethical and societal aspects of application design and use have also been considered.[4] ICT researchers have tried to address ethical questions in many ways, as in, say, participatory design[13] and ICT for development.[10]

In addition to the approaches to ethics that come from within the ICT research and development community, there is a rich array of complementary thought that likewise tries to address particular ethical issues. The field of computer ethics, which draws on philosophy and social sciences, as well as computer science and information systems, has a history of reflecting on the ethics of ICT.[6,11]

Professional bodies like ACM (https://ethics.acm.org/), IEEE (http://www.ieee.org/about/ethics.html), and BCS (http://www.bcs.org/category/6030) have developed codes and standards for professionals to follow when considering ethical issues. While guidelines and standards are in place, there is an ongoing debate in regards to the limits of these approaches. A key question is whether or not future ethical and societal challenges are likely to be amenable to being addressed this way.

Though these approaches to identifying and debating ethical conflicts and questions are valuable, what is lacking today is a way to combine them in a manner that will allow a broad range of stakeholders to systematically engage with the goals, purposes, challenges, problems, and solutions encountered in research and innovation processes. This means individual researchers, research institutions, professional bodies, research funders, industry, and civil society all need to collaborate more. In practice, it means incorporating different kinds of knowledge, including from citizens, to inform the goals, directions, and trajectories of innovation in an inclusive way. This has been the case in some areas, as in, say, privacy and data protection, where longstanding debates have led to regulation and legislation, and to innovation in methods for design. However, such processes of collective reflection and deliberation have not yet happened in many areas of ICT. In light of the societal importance of ICT, broader engagement may now be necessary. Other areas of research and innovation that have been more socially contested have a longer history of engagement. We thus propose to look at RRI as a discourse that has evolved from these more contested fields, including whether and how it may be applied to ICT.

Scope of RRI

RRI initiatives across policy, academic research and scholarship, and legislation emerged more than a decade ago.[5,15] It began by aiming to identify and address uncertainties and risks associated with novel areas of research, beginning with nanotechnology[5] and moving to the environmental and health sciences, including geo-engineering[18] and synthetic biology.[21] The scope of RRI has since expanded to include computer science, robotics, informatics, and ICT more generally.[8] RRI proposes a new process for the governance of research and innovation. The aim is to ensure science and innovation are undertaken in the public interest by incorporating methods for encouraging more inclusive and democratic decision making through greater inclusion of stakeholder communities that might be directly affected by the introduction of novel technologies.

That is, RRI proposes a more reflective and inclusive research and innovation process, from fundamental research through to application design. In each phase of the innovation process, certain responsibilities may be associated with activities that occur within them, particularly in relation to how decisions taken might affect society. The focus is on creating a new mode of practical research governance that would transform existing processes, ensuring greater acceptability and even desirability of novel research and innovation outcomes, while also identifying and managing potential risks and uncertainties. RRI requires widening the scope of research and development from governance of risk to governance of innovation itself.[18]

There is a broad debate over the conceptual foundations of RRI and ways to implement it in practice. The most advanced framework for RRI today is probably the one proposed by Stilgoe et al.,[18] who also provided a non-exhaustive list of possible RRI methods, tools, and techniques (such as citizen juries and moratoriums). This approach has been taken up in E.U. policy and research, as in the RRI Tools project (https://www.rri-tools.eu/). It has also been adopted and adapted by the U.K. Engineering and Physical Science Research Council (EPSRC, https://www.epsrc.ac.uk/research/framework/). The EPSRC framework uses the acronym AREA to describe four key RRI components: Anticipate possible outcomes of research and innovation, Reflect on motivations, processes and products, Engage with relevant stakeholders, and Act accordingly to address issues revealed.

The ideas behind RRI and the AREA framework may be easy enough to understand but raise significant conceptual and practical questions. Fundamental problems include the fact that research and innovation do not follow linear and predictable patterns. Bunching together research and innovation blurs important boundaries and hides significant differences. To complicate matters, pluralistic democracies usually lack consensus as to what counts as acceptable and desirable. Additionally, stakeholder engagement can be misused for specific aims. The idea of RRI itself contains specific values, and implementing it may engender power struggles.

Most participants in the RRI discourse are well aware of these issues.[14] It is thus important to understand that RRI is not an attempt to invent a new top-down way of governing research and innovation but rather a way of linking and embedding existing principles and activities with a view to broadening their reach and relevance. This means RRI encompasses existing techniques for public engagement and reflection (such as participatory design, research ethics, and professional codes) and aims to ensure they can develop synergies. It also means building on extant research into corporate ICT governance. More precisely, RRI may be understood as a demand for multilevel ethics (systemic and institutional macro ethics, in addition to individualistic micro ethics), engagement of a broader variety of stakeholders, and inclusion of social, political, and ethical issues in ICT governance.[7] It remains problematic, though, how these ideas can be put into practice.

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Embedding RRI in ICT Innovation

Embedding RRI into ICT innovation is a challenge. First, it is necessary to understand how ICT researchers and practitioners manage their professional responsibilities, as well as how they perceive the notion of RRI, in order to assess how to move forward and fit features of RRI to researchers' perceptions and expectations. One significant issue is how to develop a set of practical actions within an RRI framework that may be adopted by the ICT community and how it might be embedded and deployed within current organizational processes. In order to address these questions, we conducted investigations from 2011 to 2013 with ICT researchers in the U.K. among research funders, professional organizations, industry, and civil society organizations into the ways RRI concepts, tools, and processes might become a creative resource for innovation in ICT. Our work was part of the Framework for Responsible Research and Innovation in ICT project funded by the Engineering and Physical Sciences Research Council (EPSRC, https://www.epsrc.ac.uk/) in the U.K.

The ICT Community Landscape

We interviewed leading computer scientists, researchers, and postdoctoral and Ph.D. students, as well as EPSRC portfolio managers and representatives of professional bodies in the U.K.[3] The study was the first extensive summary of current positions regarding the boundaries of professional responsibility and identification of potential long-term societal consequences of ICT. It provides an important baseline, giving us an opportunity to describe, understand, and triangulate ICT researchers' and other stakeholders' questions and concerns across a variety of computer science domains, including mobile computing, AI, photonics, and signal processing.

Many researchers welcome enhancements to current governance processes (such as by framing questions that help reflect on research outputs). Also, some researchers embrace the further integration of social and ethical research into design and development. Apart from such perceived RRI opportunities, many interviewees in our study raised concerns. We outline five, as discussed by participants. Together, they identify typical problems involved in integrating RRI into ICT. We thus sought to relate them to concepts and approaches that would allow researchers to specify RRI in ICT.

The first is the difficulty of predicting the potential uses of research outcomes. Some researchers we interviewed said it may be inappropriate to attempt to predict future effects in the context of ICT research because the uncertainties tend to be social rather than scientific, meaning technologies are socially shaped and not fixed. Researchers in the study cited two unknown factors related to prediction. First, in fundamental research, risks and uncertainties are identifiable only within the context of their use. Second, in application-oriented research, industry and user adaptation can change the trajectory of ICT in unforeseen ways. The very open nature of ICT, its logical malleability,[12] interpretive flexibility,[2] and the social production of technology make it even more difficult to predict outcomes of research and innovation than in other areas of science and technology research. We refer to these aspects of ICT as related to the "product" of ICT research and innovation.

A second concern points to the perceived differences between ascertain-

ing risks and uncertainties in computer science to that in the physical and life sciences. For example, researchers participating in our study discussed what we refer to as the "rhythm of ICT" whereby outputs may occur at a quicker pace than in the physical sciences. Software may be developed, released, and go viral potentially on the same day with little, if any, oversight and have far-reaching effects on human activities and societal structures. These concerns relate to the "process" of research and innovation.

A further distinguishing feature typical of ICT is what Johnson[11] called "the problem of many hands," or organizational and institutional reliance on a division of labor whereby most activities are split among numerous individuals. The problem becomes more fraught beyond organizational boundaries when trying to conduct open source projects. Moreover, different disciplinary languages are significant, making interdisciplinary work that much more important but difficult to achieve in practice. Ascribing accountability for eventual consequences is therefore difficult. These aspects of ICT projects point to the importance of considering what we call the "people dimension" of RRI in ICT.

A final concern that emerged from our study is the notion of "convergence"[9] whereby the increasingly pervasive nature of technologies in the age of the Internet, Web 2.0, and pervasive computing means that demarcating clear boundaries among systems, features, and functionality is increasingly problematic. Blurring boundaries means it becomes progressively more difficult to discern the "purpose" of ICT research and innovation.

These concerns pose a significant challenge to RRI in ICT that may go beyond those in other fields. We thus developed the "4 Ps," or product, process, people, and purpose, outlined earlier, as well as other concepts and approaches to be explained next, to develop a framework for RRI specific to ICT.

Fundamental problems include the fact that research and innovation do not follow linear and predictable patterns.

Toward AREA Plus

The AREA acronym refers to general points of interest in RRI, but more detail is needed for ICT research. The discussion so far has shown that RRI in ICT cannot be realized in a prescriptive manner. The nuances of acceptability and desirability and competing interests and their embedding in social, economic, and political structures mean that many aspects of ICT are likely to remain contested for the foreseeable future. RRI cannot therefore expect to establish universal definitions of what counts as responsible but instead needs to be understood as a contextual process that facilitates development of sensitivities toward relevant issues and a willingness of stakeholders to engage with one another, making them responsive to mutual needs and interests.

We frame RRI for ICT as an ongoing cultural dialogue in which multiple voices from within the HCI community talk to RRI proponents in order to find ways of translating back and forth what forms of responsible ICT design and development might already be available, be under development, or have yet to be developed. This approach is akin to the view asserted by Strand et al.[20] who developed a set of indicators for the European Commission that could be used to monitor RRI across different disciplines, research themes, and projects. While proposing a comprehensive list of indicators, Strand et al. also suggested that any indicator set would ultimately need to be (re)developed in a given research or application context. Our framework is thus self-critical by design and meant to be continuously challenged and adjusted.

We exemplify what such a dynamic and context-sensitive framework for responsible behavior might include for ICT. Our EPSRC-funded study focused on interviewees' comments regarding the difficulty of predicting ICT trajectories. While we regard this as appropriate skepticism in the overall RRI discourse, under "anticipation" of socio-technical futures we also suggest different approaches that consider the possible futures their innovation may bring about (such as a collaborative quest for future solutions informed by current experiences). This alternative view profits from existing ICT research; that is, ICT researchers have much to add to the RRI discourse to make it more context-specific and useful. Reeves's analysis[16] of "envisioning" techniques is a case in point, making

Figure 1. The AREA Plus framework.

	Process Rhythm of ICT	**Product** Logical malleability and interpretive flexibility	**Purpose** Convergence and pervasiveness	**People** Problem of many hands
Anticipate	Is the planned research methodology acceptable?	To what extent are we able to anticipate the final product, future uses, and impacts? Will the product be socially desirable? How sustainable are the outcomes?	Why should we pursue this research?	Have the right stakeholders been included?
Reflect	What mechanisms are used to reflect on process? How might we do it differently?	How do we know what the consequences might be? What might be the potential use? What do we not know? How can we ensure social desirability? How might we do it differently?	Is the research controversial? How might we do it differently?	Who is affected? How might we do it differently?
Engage	How can we engage a wide group of stakeholders?	What are the viewpoints of a wide group of stakeholders?	Is the research agenda acceptable?	Who prioritizes research? For whom is the research being done?
Act	How can your research structure become flexible? What training is required? What infrastructure is required?	What needs to be done to ensure social desirability? What training is required? What infrastructure is required?	How might we ensure the implied future is desirable? What training is required? What infrastructure is required?	Who matters? What training is required? What infrastructure is required?

clear that the social shaping of technologies is at the heart of computer science, not external to it, as suggested by some of the interviewees in our study. Visions, utopia, predictions, promises, and hype have been produced for decades concerning how socio-technical futures may unfold, though much of it has been done rather unconsciously, thus shaping the trajectories of ICT in ways that shut down alternative paths. There are thus implicit human and technological powers at play. Narratives, teleology, and technological determinism proliferate but are not sufficiently reflected.

In practical terms, our framework draws on such existing approaches to ICT development and provides a variety of scaffolding questions. Each aspect of the framework expands into deeper questions, suggesting literature, more detailed discussion, and problematization of a particular aspect of ICT innovation. For instance, after scanning the framework as a whole (see Figure 1) a researcher might want to consider to what extent the effects of ICT development may be anticipated (see Figure 2 and Figure 3). Various links between approaches provide questions for exploring different possible pathways, a more comprehensive line of reasoning, and references.

Our framework is meant to be adapted to the context in which researchers and other stakeholders find themselves. The idea is to productively "open up" not "close down" expert discourse.[19] At the same time, we do not question "closure" per se. Any design-and-development process requires taking countless decisions and translating them into software and hardware solutions at multiple points in time. However, closures may still leave room for diversity.[19]

In sum, certain forms of practical self-reflection and self-criticism exist in ICT research and could be cultivated further under the extended AREA Plus framework. In this sense, EPSRC's original AREA principles are

Figure 2. Selecting anticipation.

	Process Rhythm of ICT	**Product** Logical malleability and interpretive flexibility
Anticipate	Is the planned research methodology acceptable?	To what extent are we able to anticipate the final product, future uses, and impacts? Will the product be socially desirable? How sustainable are the outcomes?

Figure 3. Unpacking anticipation.

To what extent are we able to anticipate the final product, future uses, and impact?
The future cannot be predicted with certainty, but there is room for exploring different possible pathways. Also, researchers and other stakeholders can build on existing formal and informal practices of anticipation in the ICT community.

Exploring different possible pathways
- Who might be the intended audience(s) of the envisioned product?
- What is the context the envisioned product is meant to address? And what is the context in which this anticipation process itself is taking place?
- What current issues does the anticipation process target or could target?
- What can we learn from earlier (historical) anticipation processes?
- In pursuing a particular vision, what pathways might we also be shutting down? And what endpoints and current issues might be excluded?

(Scaffolding questions adopted and adapted from Reeves[16])

Envisioning in ICT
As in Reeves,[16] although it is difficult to predict the trajectory of ICT innovations, including outcomes, future uses, and impacts, ICT is a domain in which vision, utopia, predictions, promises, and hype have been produced for decades. Much of it has been done rather unconsciously, thus shaping the trajectories of ICT in ways that shut down alternative paths. Implicit powers are also at play. Narratives, teleology, and technological determinism proliferate but are not sufficiently reflected.

a starting point for the reinvigoration and possible extension of a much more nuanced discourse with and within ICT research.

Future AREA Plus Framework

The framework we started to develop in 2011, as explained earlier in this article, is not a panacea and cannot perform miracles. Many questions of relevance concerning ICT projects are related to fundamentally opposing concerns and socially and politically contested interests. Such conflicts will not disappear overnight. However, the framework may allow researchers and innovators to better understand their own and others' positions and contribute to better-informed debate and higher-quality policies and decisions.

Much remains to be done to achieve this vision of responsible technology development and support its progress. The framework needs to be supported by effective tools and specific guidance on particular topics, issues, and technologies. The web-based resource we developed to provide them (http://www.orbit-rri.org/) is only a starting point. We next identify concerns that are crucial to the further development and adoption of the framework.

First, embedding RRI activities needs to be perceived by researchers as something achievable. As we explained earlier, "anticipation" becomes significantly less mysterious when realistically scoped and grounded in concrete practices, including specific envisioning techniques and questions. Implementing RRI is about finding ways to instantiate concrete achievable practices and not about unattainable ideals of "perfect" foresight or "risk-free" innovation. Also, RRI for ICT may require developing new initiatives that are likely to depend on more fine-grain case studies beyond the scope of this article.

In addition, an integrated approach to RRI is needed for the successful adoption of the framework. RRI has to be sensitive to the relationships among researchers, practitioners, and the hierarchies and organizational structures in which they are situated. Responsibilities need to be apportioned across the entire ecology of organizations that together deliver research and innovation.[8] Taking RRI seriously as a strategic concern would facilitate practices of anticipation, reflection, and engagement to occur in the formation of new research programs by funding councils and in the final stages of commercialization at the academic/commercial interfaces where academic and commercial interests most visibly overlap and sometimes collide. In between these poles a responsible research and innovation process would incorporate the roles of funding councils, professional bodies, and others in sustaining RRI practices within research teams by providing appropriate support, services, and guidance. Responsible behavior thus becomes a collective, unpredictable activity, less about accountability and liability, and more about care and responsiveness to the public.[18]

There is evidence that these developments are under way. Academia and industry are starting to be aware of RRI for many reasons. Maybe the best of them, and a good conclusion for this article, is that RRI, while largely conceived as a risk-management approach to socio-technical change, has a much more positive trajectory than simply constraining innovation to mitigate risk. By incorporating active considerations of alternate socio-technical futures into design, engaging with stakeholders, reflecting on process, product, and purpose, and putting people at the center of research and innovation, RRI may well provide inspiration and become a unique source of innovation and creativity.

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References

1. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., and MacIntyre, B. Recent advances in augmented reality. *IEEE Computer Graphics and Applications 21*, 6 (Nov. 2001), 34–47.
2. Doherty, N.F., Coombs, C.R., and Loan-Clarke, J. A re-conceptualization of the interpretive flexibility of information technologies: Redressing the balance between the social and the technical. *European Journal of Information Systems 15*, 6 (Dec. 2006), 569–582.
3. Eden, G., Jirotka, M., and Stahl, B. Responsible research and innovation: Critical reflection into the potential social consequences of ICT. In *Proceedings of the Seventh IEEE International Conference on Research Challenges in Information Science* (Paris, France, May 29–31). IEEE, 2013, 1–12.
4. Ehn, P. *Work-Oriented Design of Computer Artifacts.* Lawrence Erlbaum Associates, Mahwah, NJ, 1990.
5. Fisher, E. and Rip, A. Responsible innovation: Multi-level dynamics and soft intervention practices. In *Responsible Innovation*, R. Owen, J. Bessant, and M. Heintz, Eds. John Wiley & Sons, Inc., New York, 2013, 165–183.
6. Floridi, L., Ed. *The Cambridge Handbook of Information and Computer Ethics.* Cambridge University Press, Cambridge, U.K., 2010.
7. Gotterbarn, D. ICT governance and what to do about the toothless tiger(s): Professional organizations and codes of ethics. *Australasian Journal of Information Systems 16*, 1 (Nov. 2009), 165–184.
8. Grimpe, B., Hartswood, M., and Jirotka, M. Towards a closer dialogue between policy and practice: Responsible design in HCI. In *Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems* (Toronto, Canada, Apr. 26–May 1). ACM Press, New York, 2014, 2965–2974.
9. Grunwald, A. Converging technologies: Visions, increased contingencies of the conditio humana, and search for orientation. *Futures 39*, 4 (May 2007), 380–392.
10. Heeks, R. ICT4D 2.0: The next phase of applying ICT for international development. *Computer 41*, 6 (June 2008), 26–33.
11. Johnson, D.G. *Computer Ethics, Third Edition*. Prentice Hall, Upper Saddle River, NJ, 2012.
12. Moor, J. What is computer ethics? *Metaphilosophy 16*, 4 (Oct. 1985), 266–275.
13. Muller, M.J. and Kuhn, S. Participatory design. *Commun. ACM 36*, 6 (June 1993), 24–28.
14. Owen, R., Heintz, M., and Bessant, J., Eds. *Responsible Innovation.* John Wiley & Sons, Inc., New York, 2013.
15. Owen, R., Macnaghten, P., and Stilgoe, J. Responsible research and innovation: From science in society to science for society, with society. *Science and Public Policy 39*, 6 (Dec. 2012), 751–760.
16. Reeves, S. Envisioning ubiquitous computing. In *Proceedings of the 30th Annual ACM Conference on Human Factors in Computing Systems* (Austin, TX, May 5–10). ACM Press, New York, 2012, 1573–1582.
17. Sellen, A., Rogers, Y., Harper, R., and Rodden, T. Reflecting human values in the digital age. *Commun. ACM 52*, 3 (Mar. 2009), 58–66.
18. Stilgoe, J., Owen, R., and Macnaghten, P. Developing a framework for responsible innovation. *Research Policy 42*, 9 (Nov. 2013), 1568–1580.
19. Stirling, A. 'Opening up' and 'closing down': Power, participation, and pluralism in the social appraisal of technology. *Science, Technology & Human Values 33*, 2 (Mar. 2008), 262–294.
20. Strand, R., Spaapen, J., Bauer, M., Hogan, E., Revuelta, G., and Stagl. S. *Indicators for Promoting and Monitoring Responsible Research and Innovation.* Publications Office of the European Union, Brussels, Belgium, 2015; http://ec.europa.eu/research/swafs/pdf/pub_rri/rri_indicators_final_version.pdf
21. Tucker, J.B. and Zilinskas, R.A. The promises and perils of synthetic biology. *The New Atlantis 12* (Spring 2006), 25–45.
22. Van den Hoven, J. Value-sensitive design and responsible innovation. In *Responsible Innovation*, R. Owen, J. Bessant, and M. Heintz, Eds. John Wiley & Sons, Inc., New York, 2013, 75–83.
23. Wiener, N. *The Human Use of Human Beings.* Da Capo Press, Cambridge, MA, 1954.

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