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Actors, Practices and Processes

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Chapter 11

The governance of dual-use research in the EU

The case of neuroscience

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Introduction

An important element of the European governance of emerging technologies is the European Union (EU) Framework Programme (FP) rules on dual-use research. This chapter analyses the challenges that might arise in implementing them at the project level and the ways to tackle these challenges. To do that, it draws on the work of one of the largest projects ever funded by the FP, namely, the Human Brain Project (HBP), which is also one of the large-scale international neuroscience initiatives.

Neuroscience is seen as one of the most promising technologies of the twenty-first century that is expected to provide cures for mental disorders and contribute to the development of other technologies such as Information and Communication Technologies (ICT) and Artificial Intelligence (AI). At the same time, advances in neuroscience raise major concerns about potential misuse of sensitive research results. Neuroscience is seen as inherently a dual-use technology, which can be used for beneficial as well as harmful purposes (Ienca, Jotterand and Elger 2018).

Against this background, this chapter focuses on the governance of dual-use research in neuroscience in the EU. At a time when many countries are making unprecedented investments in the field of neuroscience, which sometimes are described as the 'gold rush' or 'golden age' of neuroscience, the European Commission has been supporting neuroscience – or brain research as it is sometimes called – via its research and innovation FP. In the FP7 that lasted from 2007–2013, the Commission invested €3.1 billion in neuroscience. In the first five years (until November 2018) of the following Horizon 2020 programme, a similar sum of €3.2 billion was invested (European Commission 2019a). This funding supports a number of neuroscience research projects included within the Future and Emerging Technologies (FET) programme.

The biggest EU project in this area is one of the FET Flagships projects – the HBP. The HBP is a ten-year, large-scale, multidisciplinary project (2013–2023), with an EU funding of approximately €400 million, bringing together more than 500 scientists and engineers at more than 100 universities and research institutes in some 20 countries (Human Brain Project 2020; Stahl *et al.* 2019). It is one of

the large-scale neuroscience research projects in the world. Other major brain research initiatives have been launched or are about to be launched by the United States, Canada, Japan, South Korea, China and Australia (Savage 2019). These seven major neuroscience projects have established an International Brain Initiative, which is supported by the Kavli Foundation (International Brain Initiative 2020). While the International Brain Initiative aims to help these diverse projects to work together, it is also clear that they operate under very different governance, regulatory and ethical frameworks.

What is specific about the governance of neuroscience in the EU? At the moment, the EU has not adopted either a binding legislation or voluntary code of conduct or guidelines specifically dedicated to neuroscience, as has been the case in other technological areas (e.g. nano, AI; see Csernatoni and Lavallée, Chapter 13 in this book). However, all neuroscience research that is funded by the EU FPs is governed by specific regulations and rules, which notably specify that selected projects should have an exclusive focus on civil applications. This requirement distinguishes the EU's HBP from some of the other major brain initiatives around the world, in particular from the US Brain Initiative, which has been partly funded by the Defence Advanced Research Projects Agency (DARPA) with an explicit focus on developing neurotechnology for military use (DARPA 2020).

Thus, in the context when there is a clear military interest in the advancements of neuroscience that can be used for military purposes, it is necessary to better understand how the EU FP's commitment to fund only research that has an exclusive focus on civil applications can be implemented and what challenges might emerge in this process. Accordingly, the main research questions addressed in this chapter are – how is dual-use research in neuroscience governed in the EU and what challenges does it face?

To address these questions, this chapter first introduces the main EU initiative in neuroscience research – the HBP and the way dual-use research is tackled in the HBP, which goes beyond the compulsory EU framework and additionally applies the Responsible Research and Innovation (RRI) approach to deal with the dual-use issues. Second, the chapter reviews the main concepts of dual-use and RRI. Third, the chapter looks at the main actors involved in the governance of dual-use research in the HBP. Fourth, the chapter discusses challenges of governing dual-use research at the project level. Thus, this chapter aims to contribute to the studies of the European governance of emerging technologies by focusing on the governance of dual-use research in the fast-developing field of neuroscience at the project level by analysing one of the biggest research projects ever funded by the EU – the HBP.

The chapter draws on the review of academic literature and policy documents, as well as on the author's critical reflection on her two-year experience (December 2017–November 2019) of contributing to the development of the governance of dual-use research in the HBP, where she participated in the development of Opinion on Responsible Dual-Use and is co-chairing the HBP Dual Use Working Group.

The governance of dual-use research in neuroscience in the EU: the case of the Human Brain Project

The HBP was launched in 2013 as one of the two initial FET Flagship initiatives (with Graphene being the other one). Building on its well-regarded FET funding programme, the European Commission developed the FET Flagship model for large-scale multidisciplinary projects. This new funding model was established during a time of austerity with an aim to move the ICT research frontiers and establish the global EU leadership in FET research. According to the European Commission, the FET Flagships are 'visionary, science-driven, large-scale initiatives addressing grand scientific and technological (S&T) challenges' (2014). While the FET Flagships are often presented as 'one billion projects', in reality, the FPs fund only part of that amount (e.g. for the HBP, approximately 40 per cent) and the projects are expected to raise additional funding from other sources such as industry and national governments.

Thus, the HBP is supported by the EU funding for multidisciplinary ICT research and it aims to integrate research from neuroscience, computing and other research fields and scientific disciplines. According to the Commission, the HBP was launched with a promise that it:

> will create the world's largest experimental facility for developing the most detailed model of the brain, for studying how the human brain works and ultimately to develop personalised treatment of neurological and related diseases. This research lays the scientific and technical foundations for medical progress that has the potential to will dramatically improve the quality of life for millions of Europeans.
>
> (European Commission 2013)

While the original FP funding for this project is planned until 2023, it is envisaged to be turned into sustainable research infrastructure that helps to advance neuroscience, medicine and computing (Amunts *et al.* 2019). This research infrastructure aims to provide access to a wide range of brain data and computing services. The work in the HBP is organised according to a number of divisions such as Neuroinformatics, Brain Simulation, High Performance Analytics and Computing, Medical Informatics, Neuromorphic Computing and Neurorobotics. The HBP also has a dedicated Ethics and Society division that includes work on foresight, public engagement, compliance and researchers' awareness. Dual-use is one of the key ethical issues that the HBP has addressed.

As the project is funded by the FPs (initially by the FP7 and afterwards by the Horizon 2020), the HBP has to comply with the relevant regulations. Ethical principles set out in Article 19 of the Horizon 2020 regulation stipulate that 'research and innovation activities carried out under Horizon 2020 shall have an exclusive focus on civil applications' (European Parliament and the Council of the EU 2013). Issues of dual-use, exclusive focus on civil applications and

potential misuse of research results is part of the Horizon 2020 ethics issues checklist and ethics self-assessment, which form part of the grant proposal, later becoming part of the grant agreement and can give rise to binding obligations that may be controlled through ethics checks, reviews and audits (European Commission 2019b).

The Commission's guidance document for completing the ethics self-assessment for Horizon 2020 draws on the EU Export Control Regulation in defining dual-use (European Commission 2019b; see Vila Seoane, Chapter 5 in this book). Accordingly, it focuses on research involving dual-use items that 'are normally used for civilian purposes but might have military applications, or may contribute to the proliferation of weapons of mass destruction' (European Commission 2019b: 33). Furthermore, this guidance document specifies that exclusive focus on civil applications:

> does not rule out the participation of military partners or the development of generic technologies, products or knowledge that may meet the needs of both civil and military end-users (known as 'dual-use' goods or technologies), provided that the research itself has a clear focus on civil applications.
>
> (European Commission 2019b: 35)

Additionally, the ethics issues checklist includes a question about a potential for misuse of research results that concerns 'research involving or generating materials, methods, technologies or knowledge that could be misused for unethical purposes' (European Commission 2019b: 37).

In practice, a number of challenges emerge in answering and dealing with these important questions. To address these challenges, the HBP Ethics and Society division has undertaken a broad research and practice agenda that focuses on applying the Responsible Research and Innovation (RRI) approach. The RRI will be introduced in the following section dedicated to explaining the key concepts, while the application of RRI in the HBP will be addressed in the later sections on actors and challenges.

What are dual-use research and Responsible Research and Innovation?

This section will review the literature on the key concepts used in this chapter: dual-use research and RRI.

Dual-use research

The concept of dual-use research and technology is rather imprecise and contested (see Martins and Ahmad, Chapter 3 in this book). Traditionally, research and technology have been considered to be dual-use when they have current or potential military and civilian applications, recognising that distinction between military and civilian technologies is not sharp and clear-cut (see, e.g., Molas-Gallart 1997).

It can include both turning civilian/benevolent technology into military/hostile uses as well as turning military technology into civilian (e.g. Vogel *et al.* 2017). The dual-use concept has been questioned analytically because it simplifies the link between scientific knowledge and technological innovation (Vogel *et al.* 2017: 977).

While historically, the meaning of dual-use had a military–civilian connotation, today it is used more generally to distinguish research that has the potential to have benevolent/beneficial as well as malevolent/harmful applications (Oltmann 2015). Tara Mahfoud and her colleagues (2018) highlight the problem that distinguishing between military and civilian applications of scientific research and technology has become increasingly difficult. They call for a more nuanced framework that would go beyond the binary world implied by the term 'dual-use'. According to them, policy makers and regulators need to identify and focus on undesirable uses in the political, security, intelligence and military domains (Mahfoud *et al.* 2018).

To clarify some of the questions involved, new terms such as 'intentional misuse' and 'dual-use research of concern' (DURC) have been introduced (Ienca *et al.* 2018: 269). The DURC label was introduced by the United States government to prevent the malicious application of life science research. While historically most attention to dual-use technology emerged in fields of molecular and cell biology, recently the focus has expanded to other fields such as neurotechnology (Ienca *et al.* 2018) and ICT (Langley and Parkinson 2017).

Attitudes towards dual-use research and technology have varied considerably across times, areas of activity and political beliefs. Haico Te Kulve and Wim Smit (2003) explained how the meaning of dual-use technology historically has shifted from a problematic to a desirable feature. According to Te Kulve and Smit, during the Cold War,

> dual-use was viewed as a negative feature that complicated export controls: countries might try to obtain military sensitive technology under the guise of buying civilian technology. The presumed dual nature of some products and technologies also created tensions between the economic and defence perspective on technology exports.
>
> (Te Kulve and Smit 2003: 955–956)

Te Kulve and Smit noticed a profound change in the discourse on dual-use products by the time the Cold War had ended, highlighting that then:

> rather than a negative feature, the dual-use aspect of technology was viewed as something that should be promoted and pursued, as it might solve the twin problem of maintaining a high tech defence technology base restrained by limited budgets, and improving a country's economic competitiveness by a more efficient allocation of R&D funds.
>
> (Te Kulve and Smit 2003: 956)

Similarly, Jordi Molas-Gallart (1997) demonstrates different understandings of dual-use technology from an arms control and industrial perspectives. According to him, 'from an arms control outlook, dual-use technology has been seen as a problem for the control of the international diffusion of advanced weaponry', while from industrial perspective, it is perceived 'as providing an opportunity for the wider exploitation of research and manufacturing efforts beyond their initial (military or civilian) use' (Molas-Gallart 1997: 370). Major differences in attitudes towards dual-use research and technology can also be seen when comparing the approach in research and innovation policy to promote dual-use research and technology (e.g. Molas-Gallart 1997) with the calls in bio- and neuro-ethics to regulate dual-use technology (e.g. Ienca *et al.* 2018).

Diverging attitudes become even more pronounced in the area of military research and technology that is related but not identical to dual-use research. Economists often emphasise many benefits for civilian technologies such as computers, electronics and commercial airspace technology that have originated from military research. A well-known example is the iPhone. Many technologies behind the iPhone have originated from defence research funded by DARPA, Department of Defence, US military and Army Research Office (Mazzucato 2013). However, the opposite argument emphasises the problem that military research leads to 'the diversion of funding from better understanding of root causes of insecurity' and therefore should be reduced (Langley and Parkinson 2017: 205).

Moreover, there are diverse views on the interaction and relationship between civilian, military and dual-use research and technology. In their case study of the development of an advanced battery in the Netherlands, Te Kulve and Smit investigate the cooperation between civilian and military actors and conclude that 'in view of the difficulties of realising civilian–military integrated joint development projects, the establishment of "dual capacity networks" is suggested as part of possible strategy towards an integrated civilian–military technology and industrial base' (2003: 955). In other contexts, interactions between civilian and military research are more restricted, either due to the secrecy of military research or because of funding rules such as the EU FP that require exclusive focus on civilian applications (but does not prohibit the participation of military partners).

The implementation of the EU FP rule about an exclusive focus on civil applications faces old and new challenges. Jakob Edler and Andrew James (2015) pointed out that already in the mid-1990s the European Commission itself recognised that, although the FP is civilian in focus, half of all FP-funded projects have had a strong dual-use dimension in particular in areas such as aeronautics, information technology and materials. Furthermore, since the FP7, a programme dedicated to security research has been introduced within the FPs (see Martins and Ahmad, Chapter 3 in this book). Recently, new defence-related EU research funding mechanisms have emerged outside the FPs (see Fiott, Chapter 2 in this book). These include explicit funding for dual-use research from the European Structural and Investment Funds as well as dedicated defence

research funding from the European Defence Fund (EDF). The 2017 Communication from the European Commission on launching the EDF envisages that the planned funding for the EDF 'would make the EU one of the biggest defence R&T investors in Europe and the first investor in collaborative defence research' (European Commission 2017). It also stipulates that the EDF research proposals 'will be reviewed in relation to ethical, legal, or societal aspects by a group of experts on defence ethical and legal issues' and that the precise relationship between the EDF and the future FPs will be determined (European Commission 2017). These developments increase the complexity of dual-use research in EU countries and can raise new practical challenges, for example, if a research group receives funding from both – the FP with its exclusive focus on civil applications and the EDF – how does it practically separate in its lab its research with exclusive focus on civil applications from its defence research.

In the literature on dual-use research, a number of approaches have been suggested for addressing some of the challenges. These include regulation, self-regulation and education (Engel-Glatter and Ienca 2018) as well as participatory governance with a broader public input (Vogel *et al.* 2017). Putting these measures in place could intensify the tension between scientific freedom and public interest.

In recent years, many of these issues related to dual-use and the relationship between military and civilian research have been discussed in the context of neuroscience research (Ienca *et al.* 2018; Mahfoud *et al.* 2018; Royal Society 2012; Tennison and Moreno 2012). Concerns about dual-use and misuse of neuroscience are particularly relevant due to military funding for neurotechnologies in countries such as the USA and its applications including warfighter enhancement or neuroscientific deception detection and interrogation. For these reasons, Ienca and his colleagues (2018) suggest a 'neurosecurity framework' involving calibrated regulation, (neuro)ethical guidelines and awareness-raising activities within the scientific community.

Responsible Research and Innovation (RRI)

In the past ten years, the RRI approach has been promoted by researchers and funding agencies across Europe as a way to shape research and innovation towards social goods (De Saille 2015). According to a well-known definition by Jack Stilgoe, Richard Owen and Phil Macnaghton, 'responsible innovation means taking care of the future through collective stewardship of science and innovation in the present' (Stilgoe, Owen and Macnaghton 2013:1570). They operationalise responsible innovation along four dimensions of anticipation, reflexivity, inclusion and responsiveness.

The European Commission has been one of the major supporters of the RRI approach. The Horizon 2020 regulation recognises RRI as a cross-cutting issue that has to be promoted to improve societal engagement in research and innovation (European Parliament and the Council of the EU 2013). RRI is implemented in the Horizon 2020 via supporting thematic elements of RRI such as public

engagement, open access, gender, ethics and science education as well as via integrated actions that foster uptake of the RRI approach by institutions and stakeholders (European Commission 2019c). One of the main political documents on RRI is the Rome Declaration on Responsible Research and Innovation in Europe, which defines RRI as an 'on-going process of aligning research and innovation to the values, needs and expectations of society' (Italian Presidency of the Council of the EU 2014). While the European Commission has extensively supported the implementation of RRI during the Horizon 2020, due to shifting political priorities (e.g. towards mission-oriented research), it is unlikely that RRI will receive the same amount of support in the following Horizon Europe programme.

Furthermore, a number of national research funding councils are also implementing the RRI approach. One of the first funders that started to implement this approach was the Engineering and Physical Sciences Research Council (EPSRC) in the UK. The EPSRC approach to responsible innovation highlights the need to continuously seek to anticipate, reflect, engage and act and is therefore known as the AREA framework (EPSRC 2019). According to this approach, anticipation implies describing and analysing intended and unintended economic, social, environmental and other possible impacts of innovation, while reflection focuses on purposes, motivations and potential implications of research and associated uncertainties. Engagement allows the opening up future visions to broader deliberation and dialogue, but action aims to influence the direction and trajectory of the research and innovation process itself.

While the RRI approach has an important aim of aligning research and innovation with societal values and needs, its practical implementation experiences a number of well-known research governance challenges, for example, how to deal with the diversity of societal values, what is the right balance between academic freedom and steering and how to address uncertainty inherent in research and innovation. The RRI approach still encounters the so-called 'Collingridge dilemma' according to which, during the early stages of research, too little is known to regulate emerging technology, while later when technology is more extensively developed and used, it is difficult to modify it via regulation (Stilgoe *et al.* 2013).

Actors involved in the governance of dual-use neuroscience research in the HBP

To address the complex issues described above, a wide range of actors, internal and external to the HBP, have been involved in developing and implementing the governance of dual-use research. Internal actors are the project's governing bodies, researchers and administrators from diverse disciplines and teams within the project. External actors are the European Commission as a funder as well as diverse stakeholders from citizens and patients to experts, other brain initiatives and international bodies such as the Organisation for Economic Co-operation and Development (OECD), which developed guidelines for governance of neuroscience and neurotechnology.

The HBP's Ethics and Society division has undertaken a leading role in the development of the governance of dual-use research in the HBP. The Ethics and Society division brings together research from social sciences and humanities, ethicists and public engagement practitioners from a number of universities and research entities across Europe. As a major EU initiative in a highly sensitive research area, the HBP implements a broad RRI agenda to identify and address major ethical and societal concerns (Stahl *et al.* 2019). In particular, the HBP implements the AREA framework of the EPSRC, which was one of the first frameworks available for a practical implementation of the HBP. According to the AREA framework, anticipation activities implemented by the HBP's Ethics and Society division include foresight analysis of future development of neuroscience and ICT developed by the HBP, while reflection activities focus on philosophical and neuroethical research. Engagement involves citizen workshops and online consultations to understand public views on neuroscience, while action focuses on developing and implementing processes, procedures and good practices to support RRI in the HBP. Thus, the HBP Ethics and Society division implements a wide-ranging research and practice agenda that goes well beyond complying with the FP regulatory requirements and includes anticipation, reflection, engagement and action on the conceptual and practical underpinnings of the regulatory requirements, their limitations and the ways of overcoming them.

These principles of going beyond the legal FP requirements, critically reflecting on them and suggesting broader ethical and social agendas are also present in the HBP Ethics and Society team's work on dual-use. The key element of this work is the 'Opinion on "Responsible Dual-Use": Political, Security, Intelligence and Military Research of Concern in Neuroscience and Neurotechnology' (Ethics and Society 2018). This is the second opinion of the HBP Ethics and Society team, following the first one on Data Protection and Privacy published in the previous year. The Dual-Use Opinion starts with the recognition that 'current and newly emerging insights and technologies arising from research in brain sciences increase capabilities to access, assess and affect thought, emotion and behaviour' (Ethics and Society 2018). These capabilities can be used in socially beneficial as well as harmful ways. Examples mentioned in the Opinion include:

> brain inspired neuro- and ICT technologies that are already in use or in advanced stages of development, for example, in warfighter 'enhancement', intelligence gathering, image analysis, threat detection, manipulation of emotional states, incapacitation of adversaries, and the development of autonomous or semi-autonomous weapons, or weaponized robots using artificial intelligence technologies and machine learning algorithms for target detection an elimination.
>
> (Ethics and Society 2018: 5–6)

Thus, the Opinion discusses important social and ethical questions these developments raise and develops a set of recommendations for the HBP, the EU and social actors.

The preparation of the Dual-Use Opinion took several years and was done according to the RRI principles and the AREA framework of anticipation, reflection, engagement and action. The anticipation activities included a number of scoping reports to identify current and potential applications of brain research and brain-inspired technologies and their social and ethical implications. The reflection part focused on the conceptual clarification of dual-use terminology and identification of ambiguities in existing regulations and guidelines. The engagement part consisted of a broad range of activities involving experts on dual-use and neuroscience and research policy makers as well as citizens in webinars, workshops and online consultations. The results of the engagement activities have been made public to researchers and stakeholders within and beyond the HBP and some of these activities have been positively evaluated by neuroscience and dual-use experts as 'a first promising step in the direction of awareness-enhancing strategies' (Ienca *et al.* 2018: 273). The anticipation, reflection and engagement activities resulted in preparing recommendations for action.

One of the key insights from the preparatory work was the need to go beyond the binary civilian–military distinction of the dual-use definition used in the Horizon 2020 approach to ethics and to broaden it. To do that, the Dual-Use Opinion develops a broader set of terminology, building on terms such as dual-use research of concern, RRI and political, security, intelligence and military research of concern. The Opinion suggests that applying the principles of RRI to the concept of dual-use could increase the ability to identify which programmes and projects of research, development and innovation are 'of concern' and distinguish between 'responsible' and 'irresponsible' systems of research and technological development. Accordingly, the Opinion uses the term 'dual-use research of concern' to refer to:

> neuroscience research and technological innovations, and brain inspired developments in information and communication technologies, for use in the political, security, intelligence and military domains, which are either directly of concern because of their potential for use in ways that threaten the peace, health, safety, security and well-being of citizens, or are undertaken without responsible regard to such potential uses.
>
> (Ethics and Society 2018: 5)

Thus, the identification of research 'of concern' is not straightforward but rather is a matter of debate. The RRI principles should enable such a debate, capacity building to reflect and engagement of researchers and stakeholders. In the Opinion, responsibility does not simply refer to responsible conduct of individuals but also

> to processes and practices within research and development systems, and the extent to which they encourage or constrain the capacity of all those involved in the management and operations of research to reflect upon,

> anticipate and consider the potential social and ethical implications of their research, to encourage open discussion of these, with a view to ensuring that their research and development does indeed contribute to the health and well-being of citizens, and to peace and security.
>
> (Ethics and Society 2018: 9)

Thus, responsibility here means developing institutions and cultures that support socially beneficial research.

To implement these principles of responsibility, the Opinion recommends that the HBP evaluates the potential implications for dual-use research of concern, ensures a responsible use of its data and services, considers conditions for partnering with institutions that receive military funding and develops educational activities and materials on dual-use. Furthermore, the Opinion includes a number of recommendations for the EU. These include suggestions to extend its policies on dual-use research beyond the focus on aims, objectives and intentions of the researchers, to support research on dual-use research of concern and to establish an advisory body to have an oversight of all EU funded research with political, security, intelligence and military potentials. The recommendations to other social actors include a strong focus on the education of neuroscientists on social and ethical issues including questions of dual-use as well as on self-regulation of research institutions and industry.

The HBP governing bodies have approved the Opinion and established the HBP Dual-Use Working Group to implement its recommendations. This working group includes researchers, engineers and administrators from all HBP divisions.

Challenges for developing and implementing governance structures for dual-use research at the project level

Addressing issues related to dual-use research at the project level presents a number of challenges related to the complexity and sensitivity of the topic as well as uncertainties about potential uses and impacts of research results. On the basis of the ongoing work in the HBP discussed above, three challenges can be highlighted: first, limitations of the dual-use definition used in the EU FP; second, issues of education and awareness raising; and third, questions of global collaboration. These challenges can be relevant for research in other scientific disciplines and fields as well.

First, the FPs use a definition of dual-use from the EU export control regulation (see Vila Seoane, Chapter 5 in this book). According to that definition, the dual-use items are goods, software and technologies, which ‘are normally used for civilian purposes but may have military applications, or may contribute to the proliferation of weapons of mass destruction’ (European Commission 2019b: 13). Two limitations of this definition in particular can be highlighted. First, for basic research at the early stages of development, the definition’s focus

on goods, items and software often is not relevant. Second, this definition still defines dual-use in binary terms of military versus civilian, while practitioners and scholars in this field have recognised that a broader understanding of beneficial and harmful uses is needed (Ienca *et al.* 2018; Oltmann 2015). Thus, rather than inviting anticipation and reflection on the potential future uses of research that is at early stages, for many scientists doing basic research, this definition suggests that dual-use questions are not relevant for them. To address this challenge, the Ethics and Society division of the HBP suggested broadening the understanding of dual-use by bringing in concepts of dual-use research of concern, RRI and political, security, intelligence and military research of concern. In a similar manner, future EU research funding programmes could benefit by broadening their approach to dual-use and developing definitions that are dedicated to specificity of research by adjusting and going beyond dual-use definitions in export controls.

Second, building governance structures for dual-use research at the project level requires the involvement and support from the researchers. One limitation that such an approach faces is a lack of awareness about dual-use issues among researchers. Ethical and social issues of science and technology are not always included in science education nor are they required, supported or built into research career structures. The HBP has started to address these issues within the project's dedicated Education programme that includes workshops, online lectures and webinars on ethical and social issues including dual-use. To make such education and awareness-raising activities relevant, a particular challenge is to adjust them to the specificities of each scientific discipline and research field. That is not a straightforward task in a multidisciplinary project bringing together scientists and researchers with very diverse scientific backgrounds. At the institutional and policy levels, the importance of education and awareness of dual-use issues among scientists cannot be underestimated and novel ways to engage and support scientists in these endeavours need to be sought.

The third challenge focuses on global collaboration for addressing dual-use research issues. As research is global and scientific knowledge flows freely across national and regional borders, it is of paramount importance that dual-use issues are recognised at the global level. In the neuroscience field, the need to address issues of misuse has been recently recognised by the representatives of International Brain Initiative (Rommelfanger *et al.* 2018) that brings together the main large-scale neuroscience projects from the EU, USA, China, Japan, Australia, Canada and South Korea (see information in the Introduction) as well as by the OECD in its Recommendation of the Council on Responsible Innovation in Neurotechnology (OECD 2019). At the moment, the HBP is the only one among the main neuroscience projects that is developing and implementing dedicated governance structures to address issues of dual-use and potential misuse. To facilitate responsible neuroscience research globally, similar activities in other brain projects and global coordination efforts are needed.

Conclusions

This chapter demonstrates that the fast-developing field of neuroscience research not only promises major health, economic and technological benefits, but also raises important concerns about the potential misuse or harmful uses of research results. To address these concerns, appropriate governance structures should be built at the global, regional, national, institutional and project levels. The chapter shows that the research project level plays a key role in the governance of dual-use research. At the same time, the project-level governance is closely intertwined with governance at other levels.

The chapter reveals how one of the main neuroscience research projects worldwide – the EU-funded HBP – addresses a number of challenges such as the limitations of the EU FP's definition of dual-use based on the export control regulation and focusing on binary distinction between civilian and military applications by developing a novel approach that incorporates concepts of dual-use research of concern, RRI and political, security, intelligence and military research of concern. The development and implementation of such an approach benefits from engaging a broad range of researchers, stakeholders, experts and citizens. The lessons learned so far suggest the need for education and awareness-raising activities, global collaboration and reconsideration of policy definitions of dual-use and their suitability for research activities. The HBP, as a large-scale project, benefits from having dedicated Ethics and Society as well as Education teams for the development and implementation of its project-level governance of dual-use research. Nevertheless, lessons learned and practices developed in this project could be relevant for other brain initiatives as well as research projects in other disciplines.

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