Arch. Immunol. Ther. Exp., 2008, **56**, 147–152
PL ISSN 0004-069X
DOI 10.1007/s00005-008-0020-7

Dual use and the ethical responsibility of scientists

Hans-Jörg Ehni

Institute of Ethics and History of Medicine, University of Tübingen, Germany

Received: 2008.02.19, **Accepted:** 2008.05.08, **Published online first:** 2008.05.30

Abstract

The main normative problem in the context of dual use is to determine the ethical responsibility of scientists especially in the case of unintended, harmful, and criminal dual use of new technological applications of scientific results. This article starts from an analysis of the concepts of responsibility and complicity, examining alternative options regarding the responsibility of scientists. Within the context of the basic conflict between the freedom of science and the duty to avoid causing harm, two positions are discussed: moral skepticism and the ethics of responsibility by Hans Jonas. According to these reflections, four duties are suggested and evaluated: stopping research, systematically carrying out research for dual-use applications, informing public authorities, and not publishing results. In the conclusion it is argued that these duties should be considered as imperfect duties in a Kantian sense and that the individual scientist should be discharged as much as possible from obligations which follow from them by the scientific community and institutions created for this purpose.

Key words: research ethics, dual use, responsibility, complicity.

Corresponding author: Hans-Jörg Ehni, Institut für Ethik und Geschichte der Medizin, Universität Tübingen, Germany, e-mail: hans-joerg.ehni@uni-tuebingen.de

INTRODUCTION

"Dual use" is a concept which is basically related to the possibility to use goods or technologies for either civilian or military purposes. This is especially relevant in the context of export, where an international agreement, "The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies" of May 12, 1996, has now been signed by 40 nations. The European Union issued directive EC 1334/2000, which contains a list of dual-use goods and technologies which should not be exported. Very often it is just the intention of an actor which determines whether something could be considered a weapon or not. The phenomenon is obviously not new, also in the context of science and technology, as such legends as the use of mirrors invented by Archimedes to burn ships show. But the existence of weapons of mass destruction and the increase in international terrorism contribute to a very critical situation.

The results of scientific research, especially if it concerns fundamental natural processes, can have a wide range of desirable and undesirable technological applications. It might be difficult, and only possible in the long run, to decide which are desirable and which are not. The "classical" dual-use case from the beginning of the 20th century is the discovery of chain reactions and the like in physics and its dual use for atomic bombs and nuclear energy. In the beginning of the 21th century, the technology which raises the most concern is the genetic construction and reconstruction of pathogenic organisms and viruses by biotechnological means. The most discussed recent cases have been the description of a procedure to increase the pathogenic character of mousepox, which could be used for smallpox as well, the synthesis of a polio genome, and the reconstruction of the virus which caused the fatal Spanish flu in 1918 [9, 10]. What raises special concern is that bioweapons are much cheaper to construct with these technologies and that, once the necessary procedures are published, they are available via the internet. While the dual use of technologies, scientific results, and goods which are well known requires juridical regulation on the national and international level, the possible dual use of new technologies and new scientific results creates ethical problems for the scientist and the scientific community, especially with regard to how to define the responsibility to prevent such dual use. As a first step towards such a definition, the concept of dual use has to be further analyzed to show where these problems are most acute.

In principle, the concept of dual use can be related to several different pairs of oppositions. The following are relevant in this context: intended or unintended, beneficial or harmful, and legal or criminal. Basic

research can of course be carried out without having any application in mind. A researcher may also try to develop a certain application for a technology, discover a second possibility for a future use, and also follow up on this possibility. From this point it would be considered "intended dual use". Even if the research was dedicated to achieve a certain purpose and to develop a certain technology, this technology may be used by others for purposes other than those originally intended. Depending on the technology and on the newly intended purpose, this can be beneficial or harmful, in some cases extremely harmful, as for instance in the case of the use of nuclear energy and the construction of nuclear weapons. However, even harmful technologies might be used by states for legal purposes, such as wars justified by international law, which at least for some scientists may not create specific ethical problems. Therefore, the further distinction of legal or criminal has to be introduced. Applications can be legal or criminal, such as doping in sports or possible terrorist attacks with modified pathogenic organisms. The latter is the kind of dual use that calls for strict juridical regulation. From the perspective of the scientist and the scientific community, all these types of dual use generate different normative problems, but also the last case is the most difficult to solve.

However, it is not the normative evaluation of dual use in such acts and their contexts (actors, victims, ideologies, etc.) which creates any specific problems in itself. A terrorist attack in which people are killed will be considered murder, and if a new technology was abused to carry out this action, this adds nothing to this basic qualification. Of course, the sophisticated application of a technology in a crime or the high degree of cruelty which is needed to apply a certain technology for such a purpose will qualify a crime as especially malicious and detestable, but this is related to the kind of technology which is used and precisely how it is used. The simple fact that a new technology or scientific knowledge is applied for a criminal purpose for which it was not originally conceived is not an ethical problem in itself. Also, national and international regulation in reaction to potentially harmful and dangerous research results, their application, or dissemination does not create an ethical problem in itself, as it is a legitimate aim to protect citizens from harmful technologies in an international context.

The ethical problem is the specific responsibility of the scientist who created these results and of science as a social institution. Here the freedom of science conflicts with other values. There is no basic difference between direct involvement of research dedicated to the development of a dual-use application and direct involvement in any other action. Consequently, this kind of responsibility will not be the main concern in this context. Analyzing the responsibility of the individual scientist and of the scientific community becomes more difficult if dual use is unintended, harmful, and criminal.

RESPONSIBILITY IN DUAL USE

Responsibility is often analyzed as a predicate with four variables: *Who* is responsible for *what* to *whom* and *why*? Or more formally: "X is responsible for Y to W because of Z", where X is the actor, Y the object of that action, W the person or institution which has a claim on that responsibility, and Z is defined by the relevant moral duties in the respective context. Additionally, prospective responsibility is distinguished from retrospective responsibility. Prospective responsibility can be illustrated by the responsibility to care for somebody founded on a duty resulting from the role the responsible person has, e.g. the responsibility parents have for their children. In the case of harmful unintended dual use it is crucial to define the duties of the scientist and of the scientific community from which the prospective responsibility of both result. Retrospective responsibility is that which is related to imputation, e.g. for the result of an action which is imputed to the actor who contributed actively to this action or who could have prevented it. Both forms of responsibility are interconnected: because somebody has had a certain prospective responsibility, he can be held responsible for a certain action. The question here is not how far a scientist is responsible for the intended effects of his action, but how far he is responsible for the foreseen effects of his research, for their prevention and also for the effort to predict certain effects. The answer will depend on how the prospective responsibility related to the duties corresponding to the role of the scientist and the scientific community will be defined in the given case [3].

THE FREEDOM OF SCIENCE, MORAL SKEPTICISM, AND RESPONSIBILITY

But is a scientist really responsible in this case? Does not the freedom of science allow someone to carry out research however undesirable its results may be, and is it not the task of legislation and the executive powers of the state to control its application? In unintended, harmful, and criminal dual use, the scientist could be considered not to have any responsibility regarding the application of the results of his research. As the freedom of science and research are considered important values in our societies, an unclear, indirect responsibility might not provide sufficient arguments for a limitation of this freedom. On the other hand, a scientist could still believe himself to have far-reaching prospective and retrospective responsibility for such an application, even if he only provided the necessary basic knowledge. A scientist could very well feel guilty because of foreseeable effects of dual-use applications and for his omission to prevent harmful effects. There is a basic conflict between the freedom of the researcher and the duty to prevent harm which is difficult to solve because it is unclear what the contribution to the relevant action

is and to what degree this is controllable. As we are only responsible for something we can control, the point is to what degree the scientific community and the individual scientist can be considered to be able to control such effects. For both options, i.e. a high degree of responsibility and no responsibility, further arguments can be provided.

The scientist could be considered to have no responsibility at all for the application of the results of his research work in dual use. A possible foundation for this position could be general skepticism directed against the relevance of ethical principles to science. For instance, the German sociologist Niklas Luhmann considered science to be a self-organizing social system which follows a binary code, with the options true or false. Moral reflections can have no influence in the quest for truth. Luhmann believes that the autopoiesis of knowledge, as he calls the generation of knowledge in the self-organizing social system of science, cannot be controlled by research ethics and by the interdiction of certain types of research. The social system of science will produce any truth in the long run, no matter how undesirable knowing this truth might be. Of course, other social systems, such as the juridical system, could apply their own binary codes, such as legal or illegal, to science and research. But Luhmann thinks that the effectiveness of prohibiting research and the publication of results is very low. Distinctions like beneficence or maleficence run across to the basic code of science, i.e. true or false. Even if there is agreement that in some cases ignorance would be better, this can hardly be achieved by prohibitions, because they are too easy to break and can be too easily avoided in an international context. For Luhmann, science is confronted with two impositions: to consider the quest for truth as risky and to assume responsibility if the true knowledge generated by scientific research triggers causal chains. Both impositions are inconsistent with truth as the positive ideal of science [6]. While at least the sociologist might accept that there is a problem, as there are important risks, he offers no solution and also confirms that there can be none. A social institution would be needed to decide what would be right or wrong in the quest for scientific truth. But such an institution, in his opinion, is impossible because there cannot be an institution representing the whole society within society itself. This raises important questions in the context of dual use: Can the production of knowledge which is considered dangerous because of dual-use applications be controlled? Can the dissemination of this knowledge be controlled? And how can an institution which controls dual use be conceived and what can the role of science in such an institution be? Skeptics like Luhmann provide no positive answers to these questions, but they show that there will be no easy solution.

Surprisingly, Hans Jonas, one of the most widely read philosophers in the ethics of science in Germany and still influential in the international bioethics community, shares some of the basic assumptions of Luhmann's moral skepticism: It will be extremely difficult or even impossible to ban a certain type of research completely because of the global dimension of scientific research. And it is also hardly possible to keep scientific results secret [5]. But Jonas offers a different analysis of the basic situation of science. Scientific freedom which includes the claim to be free of restrictions can only be justified by the contemplative character of science, without any involvement in the sphere of actions. However, Jonas shows that this contemplative character is lost in most scientific disciplines apart from mathematics and cosmology. The reason for this is the inseparable unity which links modern science with technology. Technological demands, interests, and input in the form of results of applications direct scientific endeavor in which technological instruments are themselves indispensable tools for further progress, for example in measurement. Science is no longer pure theory and therefore scientists and the scientific community are accountable for the consequences of their research. From these possible consequences of potentially apocalyptical, global dimension results a very high degree of responsibility for scientists. In the long run it is also extremely difficult to distinguish legitimate use from misuse of technologies and scientific results, which is directly relevant in the case of dual use. In his main work, "The Imperative of Responsibility", Jonas therefore, as a reaction to this situation, formulates an ethics of responsibility. The internal dynamics and immense power of modern science require an increased awareness of individual and social responsibility, which is expressed by Jonas in a modification of Kant's categorical imperative: "Act so that the effects of your action are compatible with the permanence of genuine human life" [4]. This imperative demands foresight and precaution from each scientist and the scientific community. It is clear from his above skepticism that this responsibility cannot be borne alone by individual scientists, and that it also cannot be guaranteed by political or social institutions alone, which according to Jonas are difficult to conceive and are only in their early beginnings. Part of this responsibility certainly has to be assumed by institutions created by the scientific community itself and by their recommendations, as in the case of the ethics of research involving human subjects. Jonas also offers an example of concrete measures: a moratorium on a certain type of research. While these are all general recommendations based on his conception of responsibility, he offers no detailed analysis of the responsibility of the scientist or the scientific community which could provide a model for prospective responsibility and the related duties in the case of unintended, harmful, and criminal dual use.

DUTIES AND COMPLICITY

The general duty of the scientist and the scientific community in this case is not to contribute to this type of dual use, as far as this is controllable, and to help to

prevent it. This results not only from the duty to prevent harm, but also from the scientific competence to support or foresee such dual-use applications with scientific knowledge. Without the contribution of scientists it will not be possible to predict and regulate dual use. Some more concrete and possible duties which might fall under this general duty and which need further discussion have already been mentioned above, and others can be easily added. The first two duties are related to limitations of research, while 3 and 4 require a certain handling of results:

1) do not carry out a certain type of research;
2) systematically anticipate dual-use applications in order to warn of dangers generated by them;
3) inform public authorities about such dangers;
4) do not disseminate results publicly, but keep dangerous scientific knowledge secret.

The scope of these duties and the degree of the related prospective responsibility is difficult to determine from a general point of view. However, an analysis of the retrospective responsibility in a concrete case will contribute to further clarification. A helpful instrument in such an analysis is the concept of complicity, which is used in other bioethical debates [2].

The concept of complicity is used to distinguish different degrees of contribution to the success of an action. These degrees correspond to decreasing involvement in the action: "direct causality", "indirect causality", "causality by normative evaluation", and "expressive dissonance". In particular, this means that an actor, K, contributes to an action in the following ways:

1) K contributes consciously to the success of an immoral action h (direct causality);
2) K causes or encourages another actor to h (indirect causality);
3) K encourages third parties to a more tolerant attitude to h (causality by normative evaluation);
4) K disagrees with the moral condemnation of h (expressive dissonance).

All types of complicity generate a corresponding degree of retrospective responsibility. How could they be applied in a concrete case of unintended, harmful, and criminal dual use? As an example, let us assume a scientist has carried out basic research on the modification of cells. As a possible application of his new discoveries, he postulates a technology to increase the pathogenic character of a certain kind of bacteria. He publishes a scientific article about his research, including a detailed description of the technological application, and some months later there is an assault, obviously based on his findings. This might be an unrealistic scenario as the awareness of such possible dangers is already increased, but this does not necessarily have to be the case in the future, so even if the example is unrealistic at the moment, it is not impossible that something comparable might happen.

In such a case, the scientist might possibly feel responsible, and even guilty. Is this justified in relation to the different degrees of complicity? Expressive dissonance (4) and causality by normative evaluation (3) can be excluded in this case, although they might be relevant in other dual-use contexts, for instance if a medical doctor generally describes the advantages of a certain therapy and possible other uses in a way that encourages doping in sports. Direct causality (1) can also be excluded, as by definition the scientist did not contribute consciously to the unintended dual use. What remains is indirect causality (2). Did the scientist in our case cause or encourage another actor to carry out an assault? Clearly this was not the case, as the scientist was not involved in the planning or in the proceedings of the action. But there might be a lower degree of indirect causality in the present case to which the scientist has contributed. He did not cause another actor to act, but he created one of the necessary preconditions to this action. The scientist did not give a stone to somebody and tell him: "If you throw this stone in that window, I will make you a rich man", but he may have left a pile of stones somewhere or described how stones could be made. He did not encourage the actor to act, but he described how such an action could be carried out. The scientist not tell anyone, "It would be a good thing to throw a stone through this window", but he stated: "This is a stone which can be found in this place and it could be thrown through windows". How should we evaluate the degree of responsibility which would result from comparable statements? In certain contexts it would be morally neutral, but if people are around who are searching for stones to throw through windows and the scientist should have known that, it may be considered negligent behavior with a low degree of indirect causality and, therefore, a certain corresponding moral responsibility, probably without legal consequences, but perhaps not in the juridical system of the U.S., which tends to generous compensation for damages of all sorts. Whether the scientist feels guilty or not in the present case may be a question of character and moral sensibility, but it could hardly be said that it is totally unjustified.

PERFECT AND IMPERFECT DUTIES

According to these reflections it is possible to assume a low degree of responsibility of the scientist involved in the present case of dual use resulting from a variant of indirect causality. However, to have a low degree of responsibility for a fatal outcome could still be the foundation for strict duties. Which of the duties mentioned above does the scientist have in the present case? Should he have stopped his research before the results which were used in the assault could be produced? Or did he even have the duty to systematically continue his research in the new direction in order to discover possible dangers and counter-measures? A principle or maxim in the Kantian sense would be, for instance, "Stop research if there is a danger of unintended, harmful, criminal dual use", on which such

duties could be considered imperfect duties. The contrary "Never stop research..." would not be universally applicable, as rational beings would not want the possibility that they might be harmed by the respective research, and this cannot be excluded. But the maxim still corresponds to an imperfect duty. This means that it is possible to think of it as a universal law, but it is not desirable for rational beings. It is not a perfect duty because a universal law according to which research should never be stopped does not lead to a contradiction which makes it unthinkable, and it is also not a perfect duty because it depends on contexts and further practical judgments, like other imperfect duties according to Kantian examples, for instance the duty to help. On the other hand, continuing the respective research to explore dangers and counter-measures, together with informing public authorities, could contribute to the prevention of fatal incidents of dual use. The same arguments could be provided for the duty not to publish results.

CONCLUSION

I have tried to show that the involvement of a scientist in a fatal case of unintended, harmful, and criminal dual use can be considered complicity in the sense of a weak indirect causality. From this results a retrospective responsibility and, possibly, the feeling of guilt, which cannot be easily refuted. Furthermore, four basic duties can be formulated to define the prospective responsibility of scientists: 1) stopping research in some cases, 2) systematically exploring dangers of dual use in some cases, 3) informing public authorities about possible dangers resulting from research and the application of its result, and 4) not publishing results and descriptions of research results and possible dual-use applications.

All these duties can be considered imperfect duties, and the precise obligations which result from them in the context of concrete cases can be very difficult to determine. Also, moral skepticism and the ethics of responsibility share doubts on the effectiveness of measures taken by the individual researcher or scientist. These doubts refer to both possible measures: banning research and the publication of results. This difficult situation for the individual researcher can only be solved by the scientific community and their institutions. A heated debate has especially resulted from the mousepox and polio studies around the problem whether in that case the benefits of publication outweighed the risks. But who will be able to determine the long-term risk of a fatal bioterrorist attack? In February 2003 a "Statement on Scientific Publication and Security" was published by the "Journal Editors and Authors Group" [1]. Concerned by a possible limitation of the integrity of the scientific process, including adequate publication of results, the statement acknowledges that "on occasion an editor may conclude that the potential harm of publication outweighs the potential societal benefits" [1]. Of course the argument of public security to limit civil freedom may be easily abused and the censorship of scientific results is a severe problem for academic freedom and freedom in our societies in general. But Jonas' imperative of responsibility, the difficulty to predict long-term effects, and the difficulty to know the context of a publication can render the weight of responsibility far too great for a single editor and a single scientist. It is no solution to the "dual-use" problem to transfer total responsibility to individuals in these cases. Miller and Selgelid [7] discuss different options of how to organize this responsibility in a long recommendation on how to handle the dual-use dilemma. These options range from the autonomy of the single scientist to complete governmental control. According to the moral requirements formulated above, only a mixed authority which is constituted by the scientific community together with governmental bodies, but with the participation of scientists meeting their responsibility so far as possible, can solve the problem. Scientists should identify with the purposes of such institutions because these assume the greatest part of their personal responsibility. Scientific knowledge and the awareness of individual scientists are indispensable, but not sufficient. As it would be ineffective if only applied by individuals, it can only be the scientific community which should arrange committees to fulfill the necessary tasks resulting from the four duties above. Authorities like the US National Research Council can and should formulate lists of "experiments of concern", as has been done in the NRC "Report on Biotechnology in an Age of Terrorism" [8]. Public authorities alone will not be sufficiently competent and individual scientists will need colleagues who are familiar with dual-use problems to consult in cases where their responsibilities are hard to define. But the wider context of the relevant research and the necessary knowledge to meet the "imperfect duties", for instance possible security threats, can only be provided by public authorities. As the reflections of Miller and Selgelid [7] show, the task of organizing such an authority is complex and difficult and cannot be discussed in the context of the present article. However, the analysis of the possible retrospective responsibility of the individual scientist and the corresponding duties shows that it is necessary to create such authorities, not at least to discharge scientists from a responsibility which might be of low degree, but have far too heavy a weight for individuals.

REFERENCES

1. Atlas R., Campbell P., Cozzarelli N. R., Curfman G., Engquist L., Fink G., Flanagin A., Fletcher J., George E., Hammes G., Heyman D., Inglesby T., Kaplan S., Kennedy D., Krug J., Levinson R. E., Marcus E.,.Metzger H., Morse S. S., O'Brien A., Onderdonk A., Poste G., Renault B., Rich R., Rosengard A., Salzburg S., Scanlan M., Shenk T., Tabor H., Varmus H., Wimmer E., Ymamoto K. and Journal Editors and Authors Group (2003): Uncensored

exchange of scientific results. Proc. Nat. Acad. Sci. USA, **100**, 1464.
2. Birnbacher D. (2006): Bioethik zwischen Natur und Interesse. Suhrkamp, Frankfurt am Main, 357–360.
3. Duff R. A. (1998): Responsibility. In: Routledge Encyclopedia of Philosophy. Routledge, London-New York, **8**, 290–294.
4. Jonas H. (1984): The imperative of responsibility. The University of Chicago Press, Chicago, pp. 11.
5. Jonas H. (1987): Technik, Medizin und Ethik. Suhrkamp, Frankfurt am Main, pp.78.
6. Luhmann N. (1990): Die Wissenschaft der Gesellschaft. Suhrkamp, Frankfurt am Main, pp. 663–664.
7. Miller S. and Selgelid M. J. (2007): Ethical and philosophical consideration of the dual-use dilemma in the biological sciences. Sci. Eng. Ethics, **13**, 563–580.
8. National Research Council (2004): Biotechnology research in an age of terrorism. National Academies of Science, Washington, D.C.
9. Selgelid M. J. (2007): A tale of two studies. ethics, bioterrorism, and the censorship of science. Hastings Cent. Rep., **37**, 35–43.
10. Van Aken J. (2007): Ethics of reconstructing Spanish flu: is it wise to resurrect a deadly virus? Heredity, **98**, 1–2.