

Responsibility as Method—A Model for Operationalizing Ethical Reflection in the Sciences

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ABSTRACT: In this article, we show why the growing significance of ethics entails that the call for ethical evaluations is no longer just a specific issue for the particular discipline of academic ethics but a challenge for all academic researchers. Therefore, complex theoretical approaches must be put into practice, and the relationship between ethics and other scientific fields must be clarified. Hence, this essay shows how these requirements can be fulfilled and how to cope with the complexity of ethical consideration on a practical level. We aim to operationalize responsibility as a method. In order to achieve this, basic criteria of practical ethical reflection are elaborated. As a result, we suggest an extended ethical matrix covering the entire research process using a step-by-step model. Our ethical matrix is designed to help researchers reflect and make judgments on moral and ethical issues, enabling them to find their own solutions to these challenges without providing a formal guideline for moral decision-making.

Keywords: Ethical matrix; Conflict of interests; Growing significance of ethics; Responsibility in the sciences



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1. Introduction: The Increasing Need for Ethical Competence

If a growing significance of ethics can be observed today, it is not only because society's moral sensitivity might have increased, but also because the science-based expansion of human power over nature as well as the extension of contexts to apply knowledge imply, almost correspondingly, the need for strengthened ethical reflection. The increase in agency needs an expansion of ethical reflection and responsible practice [1,2].

The ethical challenges in the field of climate engineering and geoengineering are examples of this. In order to limit global warming, artificial interventions in the climate system are increasingly being discussed, which are reflected in two measures. Carbon dioxide is to be removed from the atmosphere with the help of Carbon Dioxide Removal. And with the help of Solar Radiation Management (SRM), solar radiation is to be regulated [3]. Technological progress thus opened possibilities that require decisions that can no longer be decided by recourse to established morality. Situations arise in which either the moral intuition can no longer provide clear answers due to a lack of experience of the lifeworld¹, or—as an expression of the pluralism of values—there are different, sometimes conflicting, or even contradictory intuitions.²

This generates considerable expectations on the part of researchers regarding the capacity of ethics to offer problem-solving competencies or even concrete solutions for many ethical questions in science. However, it is also necessary for science as a self-organizing process to agree on ethical guard rails, which is tantamount to a call for ethical reflection in relation to the process of gaining scientific knowledge. However, this presupposes an epistemology (i.e., a

reflection on ethical judgment in the context of science—which must be developed systematically) explicitly based on an ethical reflection on conditions, goals pursued, means used to pursue goals, and potential and real consequences of science. As an example of scientific responsibility, reference can be made to the prominent call by renowned scientists for a moratorium on possible interventions in the human germ line using the CRISPR/Cas genome editing method. This molecular biological method allows simple, inexpensive, and precise insertion, removal, or elimination of gene sequences. The authors, including one of the discoverers of this method, Emmanuelle Charpentier, called for an international moratorium on germline interventions in the context of human genetics, because its application cannot currently be considered responsible because of the unforeseeable consequences for humanity [6,7]. The demand can be understood as a responsible limit to research, which ultimately protects future generations' freedom.

The overarching aim of this article is to suggest the design of an instrument intended to aid ethical reflection in the whole process of doing science in a methodologically controlled and transparent manner. One decisive category is responsibility—to be able to justifiably name the responsibility of all actors in all phases of scientific knowledge processes. Appealing to the responsibility of scientific actors is not new, but what is new is to claim ethically responsible action within a single ethical framework of thought for all actors and above all, phases of a paradigmatic scientific process. This means that ethical reflection is not only called for a series of undesirable consequences and not only for application-oriented sciences, but for all phases and all fields of sciences and humanities and all actors involved.

The model is critically open and utilizes the entire spectrum of ethical reflection and schools of ethics. Therefore, no specific ethical theories and positions are prejudiced, but rather a methodologically guided reasoning of how scientific practice can be justified. The background of this endeavor is the growing need for ethics, especially in the sciences. This calls for the development of a broad concept of ethics focused on responsibility, ultimately leading to a model of ethics in the sciences. Building on previous approaches to ethical matrices, three dimensions are distinguished: the phases of the scientific knowledge process, the actors involved and the evaluation criteria. Overall, the matrix is intended to be a tool to perceive, describe and evaluate research projects from an ethical perspective.

This may be an example of exceptional scope.³ However, comparable reflections would have to be made in all scientific projects. This raises the question of ethics in and for the sciences and humanities, i.e., of those ethical foundations that are closely intertwined with epistemic norms of knowledge generation (without which the search for intersubjectively valid and reliable knowledge in the sciences would be inconceivable) within the individual disciplines [1,8,9]. However, this also involves recognizing moral problems in research practice and then being able to address them as such problems in the context of ethical reflection. Ethics in the sciences and humanities therefore, addresses not only ethical questions but also questions about their operationalization as well as questions about concrete steps for the realization of responsible decision-making.

In this context, ethics in the sciences and humanities has a dual function. On the one hand, it must advocate for and promote the integration of all involved disciplines to enable knowledge-based decisions. On the other hand, it must also be a philosophical discipline with a specific set of methods and a variety of theoretical approaches. The consideration of different theoretical models serves as a balanced explication of normative positions and their weighing. In this sense, the discipline of ethics understands responsibility as a method, i.e., as a way (Greek “*methodos*”), procedure, and process to reach good decisions. This understanding of *methodos* follows Gadamer's concept of truth as method [10]: At its core, it is not a prior knowledge to be merely applied deductively to concrete situations, but a procedure of generating (practical) knowledge. Ethics understood as “responsibility” is about a method of decision-making in response to the challenges of the respective situation. In doing so, we presuppose a responsive model of ethics [11]. It understands knowledge of practice and its empirical-interdisciplinary development as integral to ethical theorizing. It is a partially empirical “mixed” theory and, therefore should be programmatically situated as ethics in the sciences [1,12–14]. Ethics aims to provide answers to emerging problems in an interconnected world and to encourage proactive approaches to ethical issues within the various scientific disciplines. Ethics in the disciplines has developed decision-making aids for ethically responsible science, especially in exchange with various disciplines. On this basis, a matrix for operationalizing ethical reflection in the sciences is presented below.

If ethical reflection is to be considered an essential component of scientific activity, its specific role must be explained and justified, along with how it fits within the respective scientific disciplines. First, this requires a clear delimitation of what the proprium of ethics actually is. A systematic reflection on the concept of ethics allows for a deeper, existential understanding of what ethical reflection is, which preconditions it proceeds, which goals it pursues, and conversely, which requirements would overload it. Only when this definition of the content of ethics has been made does it make sense to ask at which points within the concrete research activity ethical questions become pressing and where the often-invoked but rarely systematically carried-out ethical reflection must start. Based on this classification,

a possible sequence of steps of ethical reflection can be developed, starting from the idea of operationalizing ethics in and for the sciences.⁴

2. The Proprium of Ethics and the Limits of Ethical Reflection

2.1. Ethics and Morals

To answer the question of when a moral problem exists in scientific practice and to what extent there is a need for ethical reflection on it, it is necessary to develop an idea of what a *moral problem* is and what constitutes an *ethical problem* in contrast. For this purpose, the following definition serves: While morality is understood as those action-guiding norms that claim validity within a society,⁵ *ethics* is generally considered to be the higher level of reflection of these moral claims.⁶ The character of ethics is expressed in the term moral philosophy, which is often used synonymously: ethics is the “reflective theory of morality” ([18], p. 358), ([19], p. 17) and can thus be understood as the scientific discipline that deals with the variety of morally relevant decisions and the moral behavior of people.⁷

“The pluralistic diversity of morals in modern society does not speak against the possibility of ethics, but rather constitutes its very pragmatic precondition: without this diversity, i.e., if one morality were binding for all (as in a theocratic system), were accepted by all and not doubted, and were sufficient to answer questions at hand, there would be no need for ethical reflection in the first place” ([21], p. 18 (translated by authorship)).

2.2. Ethics Is Foundation-Based Deliberation, Not an Algorithm

Because of this diversity, but also because of the highly divergent situations and contexts in which ethical questions arise, ethics “as a theory of [...] preferable action or as a theory of ‘good’ action” ([22], p. 34 (translated by authorship)) cannot provide ready-made answers like a recipe. Rather, ethics as a scientific discipline—with its respective conditions, goals, and methods—attempts to provide the best comprehensive description of the problem field. Following a balanced process of consideration and justification, it offers approaches for prospective solutions without reducing itself solely to solving problems (i.e., solutionism) ([23], p. 471–472). Even if the need for ethical reflection often appears problem-oriented, it is also concerned with desirable moral Outcomes. Sometimes, it starts long before a problem is perceived. To counteract the impression that ethics only ever appears when moral problems must be dealt with, it is also necessary to point out the abundance of positive goals, obligations and options for action which are formulated in a rationally responsible manner within the framework of ethical reflection, and which are intended to guide action. Ethics is thus not merely the setting up of stop signs, but also of rationally justified (real) utopias that are intended to enable persons (in the sense of the positive component of the concept of freedom) to do something or to open a space of new opportunities for the respective stakeholders. Moral duties constrain, provide orientation, and enable reliable cooperation. In this view, ethics is a methodical competence for the moral assumption of responsibility, which also builds on anticipatory and preventive elements ([24], p. 55f).

Ethics would thus be misunderstood in the sense of a hasty moralization, i.e., rejecting one direction while preferring another perspective. As a scientific discipline, ethics rather offers its own set of methods to deal with moral questions in the context [23] of a transparent and grounded reflection. Consequently, ethics cannot and should not stop at the categorical exclusion of the unpopular or the conjuring up of the desirable but must comprehensively uncover and precisely evaluate conflicting goals and dilemma structures. Ethics is neither the mere optimization of consequences nor simply the deductive application of existing norms and principles. Therefore, at the core of ethics are decision-making considerations (*deliberations*), the disclosure of the underlying arguments, and the facilitation of a reason-based consideration of the questions regarding good and evil, right and wrong, and the explication of what is morally desirable. Ethics thus constitutes an attempt to think critically about what criteria guide human decisions or actions and how to shape a better world and a reconciled coexistence.⁸ Such a practice of proportionate responsibility is the starting point of concrete freedom, understood not merely as freedom of choice and arbitrariness, but as the capacity for identity-forming self-determination as a moral subject in conflict situations. As a rule, this has to do with the management of conflicts of goals, interests, and convictions, which is the task of ethics as a method-guided scientific reflection of normative reason ([23], pp. 470–472), [26].

2.3. Ethics and Responsibility

In the narrower sense, therefore, ethics means *answering* the challenges of living together in a respective situation. Still, in the broader sense it also includes the perspective of being *accountable to positive goals and options for action*. This *responsive character* is directly expressed in the concept of responsibility. The art of taking responsibility, and thus of ethical reflection, is to distinguish between primary and subordinate levels of responsibility and degrees of commitment. Ethical reflection aims at enabling justice through the subsidiary strengthening of autonomy, potential, and participation of the respective stakeholders. Responsibility cannot be simply derived from the desirable, but it depends on a sober consideration in conflict situations [27,28]. Taking responsibility in an ethical sense expresses itself in the willingness to give account to oneself and others for one's actions—based on transparent reasons that can be seen intersubjectively and rationally insightful. In this sense, the basic intention of ethics always consists of a duty to provide information without, however, being narrowed down to always having to immediately offer unambiguous *recommendations for action* ([23], p. 471).

3. Ethics in the Sciences

3.1. The Dual Function of Ethics

What does this mean now concerning science? The basis, especially for the application-oriented discourse, is to define the moral claims raised within the discourse, to examine them for preconditions and limits, and to clarify and finally evaluate (necessary or potential) implications of arguments of the questions to be negotiated. Ethics in the sciences and humanities is consequently about the attempt of a *moderated debate* to fix the status of a conflict (based on clear facts and sound theories) in a publicly accessible language. For this purpose, the respective arguments must be exchanged on an interdisciplinary level and examined for their viability to systematize and evaluate individual positions regarding moral claims to ultimately provide an advisory basis for decision-making. Accordingly, ethics in the sciences and humanities takes on a *dual function*, which manifests itself in two different movements: On the one hand, ethics enters the field as a scientific discipline, whereby ethicists enter an exchange as disciplinary experts, for example, about questions about the justification of ethics or its possible target perspectives. On the other hand, ethics integrates all other (involved, affected) disciplines and actors. In doing so, it reaches beyond the specialist perspective and contributes to the mutual exchange of individual perspectives. The prerequisite for this is not only to let mutual communication occur in respectful cooperation “at eye level”. And it is not only to get involved in the language games and perspectives of the other participants in the discussion and their disciplines. It is also about exposing the normative background assumptions of the respective positions to bring the power of the better argument to the fore in the search for what is morally desired [1,8]. In consequence, ethical considerations have no “moralizing” effect, as they are concerned with identifying the optimal solution for all stakeholders ([29], pp. 8–10).

3.2. Tasks of Ethics within Scientific Knowledge Processes

The specific tasks of ethics *within* scientific cognitive processes are multifaceted: to fathom what moral problem might occur in the course of one's research practice; but also, and far more broadly, to what extent does the research practice has moral relevance when placed in specific (social) contexts. With the help of ethical reflection, the different scientific positions will be examined regarding their moral content by showing which normative tensions can be named within the different perspectives brought into the discourse and how these can be justifiably weighed up. Ethics is, first and foremost, concerned with the *communicative and deliberative exchange* between different perspectives when problems arise in the orientation of action. In other words, ethics rationally weighs these perspectives with a sense of proportion to explain what is morally responsible. As a level of reflection on morality, ethics offers a method of clarifying conflicts within prevailing moral contexts and deliberates on appropriate actions when controversy arises—i.e., in situations of ‘normative uncertainty’ ([21], p. 17 (translated by the authors)). In specific cases, such as concrete research actions, a decision to act must be made.

3.3. What Ethics in the Sciences Is Not

Ethics in the sciences and humanities must neither be limited to adhering to epistemically founded rules of good scientific practice, nor must it be content to stand exclusively *ex post*, i.e., at the end of the research process, classifying only the consequences of the research and its results and, if necessary, intervene restrictively.⁹ Considering this is particularly important, given the growing challenges to academic freedom in Europe [31].

For example, Julian Nida-Rümelin [32] distinguishes between two dimensions of decided scientific responsibility. According to this widespread view, science as a product of the European modern era was genuinely oriented toward acquiring knowledge. Scientific responsibility of that era meant, first and foremost, to be committed to an epistemic goal, i.e., to work according to the rules of good scientific practice. However, Nida-Rümelin also emphasizes the interconnectedness of science with other social groups it interacts with, highlighting the need to supplement epistemic responsibility and rationality with an external dimension of societal responsibility.

The implied conception could, however, run the risk of making the societal responsibility of science a simple and dispensable surplus under certain conditions. Against Nida-Rümelin, therefore, the implied separation of internal and external scientific responsibility should be shown here to be artificial. Finally, it can be fundamentally asked where knowledge production is supposed to lead. What is knowledge produced for? Towards what? By what means and under what conditions? With what consequences? These are all fundamentally ethical questions that, if answered, are typically addressed with cautious references to increasing prosperity, promoting health, and similar goals, but are easily recognized as rudimentary attempts at ethical responsibility. Such an approach would not be advisable, if only for economic reasons, since there would be a great danger of investing resources unnecessarily in research that would subsequently have to be restricted again or could not even be applied in the first place. Instead, ethical considerations should be considered as early as the research orientation and the choice of research objectives. Ethics is not only restrictive but also both restrictive and constructive, insofar as ethical considerations guide the design of the target states to be aimed at. On the one hand, it is about changing morally deficient states; on the other hand, it is about preventing the occurrence of such states.

3.4. All Science Is Ethically Relevant

The identification of morally relevant content in a broad sense, or of moral problems (potential or real) in a narrower sense, always occurs within disciplinary or interdisciplinary research practices in the context of the sciences. Therefore, it is important to make a distinction between disciplines—those that are initially not in the narrow focus of ethical reflections and others that are. In this sense, there may certainly be research areas and scientific disciplines that initially, *eo ipso*, have no direct connection with normative, societal concerns but which may well do so under certain (societal) conditions. Even where the primary aim of research practice is to expand knowledge and only secondarily to expand the possibilities of human action, highly relevant ethical concerns may be negotiated so that a relevance check must occur. Here, we will argue for the relevance of ethics for all scientific disciplines, not only for the applied sciences, which serve societal transformation processes from the outset. Finally, a possible latency must be accounted for, as numerous examples from the history of science can prove where procedures and insights that initially seemed ethically unobjectionable turned out to be ethically significant after a certain latency period and under changed conditions (such as energy released from fossil fuels). It must be clarified based on which criteria this could be tested. It is also tantamount to declare normative considerations relevant only in applicable contexts and to exclude basic research *per se*. However, everything, from the selection of research topics and research methods to the justification of the research process and the process itself and the current and potential consequences of the research results, can become the subject of normative reflections. The central advantage of this *monitoring that accompanies all phases of the research process* is that it leaves a well-founded assessment of whether ethical concerns and normative starting points are present in the intuition of the individual scientist.

4. Operationalization of Ethics in the Sciences and Humanities—A Model

4.1. Relevance Criteria

If every action and decision in research practice were to be subjected to a systematic ethical analysis, this would lead to an excessive demand in several respects. This would be neither temporally nor epistemically achievable by scientists. Instead, various indicators are proposed to suggest the ethical relevance of research and thereby prompt a systematic ethical analysis. But how can we say that research is ethically relevant? And *what* about it is ethically relevant? How can a path be described, starting from an intuition, an initial suspicion, through the perception of moral relevance to realizing moral responsibility?

If the role of ethics in research practice is to capture the full picture as comprehensively as possible and examine its normative implications, a system should be provided to scientists to help them recognize the extent to which ethical questions are or could become relevant within their research activities. The following scheme is intended to assist in this regard. However, the individual criteria or indicators should be understood so that they can or must be supplemented in

view of the heterogeneous prerequisites of the individual disciplines in research practice. Therefore, there cannot be a uniform checklist that must be checked off throughout the research process, which is always designed similarly. The criteria are oriented towards the question, which is essential for ethical reflection, of the extent to which questions of consideration must be made within the research action. Here, *material* criteria are distinguished from *formal criteria*. While the former are substantive criteria that aim at a normative-contextual level and must therefore be concretized normatively, the latter are criteria that enable a gradual qualification of the material criteria and can thus contribute to a normative differentiation. While the material criteria are thus to be filled with content and normatively underpinned, the formal criteria define the material criteria in more detail and thus classify them.

Material Criterion A—Harm Avoidance: Generally speaking, research is morally relevant whenever entities deemed worthy of moral consideration are unjustifiably impacted in their existence or when their interests are affected. Depending on the ethical position, there is disagreement as to whether this includes only humans (anthropocentrism), sentient beings (pathocentrism), all living beings (biocentrism), or even inanimate nature or entire ecosystems (holism). The more directly these are affected, the more obvious is the moral relevance of research. Furthermore, research is morally controversial if there is disagreement about which consequences are to be expected or how the consequences are to be evaluated. Throughout all stages of the research process, there are inquiries regarding *real* and *potentially* damaging events, which have to be determined and evaluated against the background of non-knowledge and uncertainty. To the extent that goals and consequences are relevant to ethical reflection on scientific research, a reference to the future is always present. While goals refer to the intended states desired by actors, consequences refer to future events or states causally related to research and can be intended or unintended. Knowledge about the future, however, is always incomplete. Until the 1980s, this incompleteness focused on possible risks. In the case of risks, only a probability of occurrence can be stated, and the nature of the possible damage is known.

Other forms of incomplete knowledge—such as known unknowns and unknown unknowns—gained importance with the increasing complexity of technologies and globalized societies, becoming a focus particularly in economics, technology assessment, sociology, and the philosophy of science. In this context, non-knowledge is the starting point of all research. What is already known does not need to be researched. This is an integral part of the control paradigm of modern science. For scientific knowledge, it means gaining control over the processes that occur, which is especially true for the experimental sciences. However, every research process raises new questions and thus new (known) non-knowledge. Therefore, with the generation of new knowledge, it is not only knowledge which is expanded. At the same time, the attempt to push back ignorance also generates more ignorance. Research becomes ethically relevant for a systematic analysis that generates foreseeable unpredictable consequences.

Especially the current challenge of climate change represents such a complex system of unintended side effects and non-knowledge, where the impact assessment of individual interventions in the global climatic system is often more difficult to estimate or is latently precarious, and therefore, an ethical approach to this kind of non-knowledge is needed, which can be contained with the help of simulations, but cannot be completely replaced. The result is that scientific action must move within stabilizing guard rails to avoid irreversible, unintended side consequences of one's actions. The departure from a model of linear consequence assessment also requires openness in the decision-making process, which is why ethical reflection must accompany it at all stages ([33], pp. 224–230). This is necessary because “knowledge is actually of no use at all if we do not extend it beyond its always far too narrowly drawn boundaries and continuously support and supplement it in the awareness of guiding convictions” ([34], p. 40). This is particularly evident in the context of the Anthropocene debate, where it becomes apparent that the unethical application of scientific knowledge can have destructive consequences while at the same time remaining a crucial tool for addressing the challenges of the future ([29], pp. 73–74).

Material criterion B—Principle of Precaution: There are areas of science where the principle of harm avoidance is not clearly relevant or applicable, or where research is conducted on subjects that do not immediately present moral issues. Not only for these scientific disciplines but also for all other research areas, the question of a direct, indirect, or potential benefit is at issue, which research action has to provide simply by virtue of being state-funded. From an ethical point of view, the question of benefit categories relates both indirectly and directly to the social relevance or applicability of the respective scientific fields. From these, in turn, a different responsibility emerges—which, in addition to the side of *negative* freedom, would also like to see its *positive* component realized. Moreover, a distinction must be made between a mere quantitative plurality of freedom options and the ethical-qualitative content of such options [35]. Like the discussion about the negative and positive sides of the concept of freedom, the material criterion of the precautionary principle takes precedence over the benefit calculus. This can be justified because the principle of precaution is attributed to a more precise possibility of determinability than the benefit calculus, which is more difficult to elicit.

Formal criteria: In addition to the (primary) basic categories of (ethical) relevance testing listed above, which necessarily require normative specification for their applicability in order to be able to specify the respective standard for a harm or a benefit, several formal (secondary) criteria can also be named, which can differentiate and further spell out the basic categories. Here, we will start from open lists of criteria that can be supplemented depending on context, question, and discipline. With the *depth of intervention*, a criterion is named that aims to graduate the extent of man's power to manipulate nature and the associated risks and to stimulate reflection on the possible consequences and benefits. The criterion of *urgency* is intended to designate the degree of necessity of certain measures. It may be possible to establish a hierarchy of urgency, for instance, in terms of time, as exemplified by the search for appropriate measures against climate change. The criterion of proportionality aims at keeping the evils and damages associated with an action as low as possible, and the following applies in principle: The harm must not be greater than the good sought by the action ([36], p. 92). In legal terms, this is referred to as the *principle of proportionality*. The criterion of *reversibility or irreversibility* asks about the reversibility of potential consequences. The more irreversible the consequences appear, the greater the demands on the justifiability of corresponding actions. Finally, the criteria of *directness, immediacy, and proximity*: The more direct, immediate, and closer the desired or undesired consequences or goals, the higher the requirements for their justification. From a normative perspective, consequentialism should not be solely promoted; moral obligations—such as human dignity, human rights, forms of justice, and positive law—must also be sufficiently considered, as they follow entirely different justification structures. Nevertheless: If, in the context of scientific processes, there is an initial suspicion that there is (potential or real) harm to certain groups, possibly even a moral problem, or that there is the prospect of a benefit, possibly with a high level of intervention and urgency, then this can be taken as an indication of high ethical relevance, which calls for in-depth ethical reflection.

4.2. The Ethical Matrix for Operationalizing Normative Reflection in the Sciences

The ethical matrix is a helpful tool to reflect on ethical issues. It does not aim directly at concrete recommendations for action but wants to assist a meta-level to *recognize, order and operationalize* ethical problems. Only in a further step can practice-oriented guidelines be developed in connection with the contextual knowledge of scientific disciplines and research areas.

At this point, such a decision-making aid in the form of the ethical matrix is to be taken up and further developed. This matrix should simultaneously be universally applicable in the sciences and serve as a practice-oriented guideline for ethical investigations in science and research. In addition, the matrix must also reflect the overall societal (i.e., socio-ethical) relevance of research.

The matrix enables an *operationalization of ethical reflection*, through which the concept of responsibility is made tangible and—when linked with qualitative indicators—becomes usable for the evaluation of scientific projects. Also, withholding of judgment in science (i.e., keeping an assessment open in view of possible misjudgments, cf. the legal principle: *in dubio pro reo*) give momentum to the formation of judgments (until more detailed data/information are available). For science is obliged to provide information, but not in every case to give recommendations for action.

The bioethicist Ben Mepham developed one of the most relevant versions of an “*ethical matrix*” for the ethical assessment of research projects [25]. It is essentially based on the conception of Beauchamp and Childress developed in 1977, which, however, was even more personalized in the sense of a strong localization of the moral responsibility on the applying subject. In this process, the *prima facie* categories necessary for the ethical matrix were developed, which not only proved to be particularly intuitive but also provided an introductory summary of the multitude of ethical theories. These include the *prima facie* deontological category of autonomy, fairness corresponding to procedural justice, and teleologically apprehended welfare [37]. Mepham's ethical matrix has since been applied and referred to in different research areas and to different issues, such as the use of genetic engineering in food production, xenotransplantation, and animal husbandry ([38], p. 17). It also underwent subject-specific modifications and additions. For example, Mepham's ethical matrix was combined with Dietrich's model of moral judgment and Bybee's concept of evaluating scientific literature with reference to agriculture-related issues, thus taking it beyond its use as a mere reflection tool [39].

Another example of how Mepham's ethical matrix can map the ethical complexity of the social field can be found in the work of Jochen Ostheimer [40]. Since both ethical reflection and the freedom of science are continuously pressured by the researchers' respective social environments [41], the freedom of science and ethics must be considered in relation to each other, particularly regarding their societal embeddedness.¹⁰ The ethical dimension of social spaces at the organizational and societal level arises simply from the plurality of participants in these spaces, who often pursue

conflicting interests and who must be weighed against each other in terms of a successful life and their individual rights to freedom ([40], p. 241f.).

Against this background, we propose something new: an ethical matrix that serves as a central reflection tool for research and science and enables an operationalization of ethical reflection in sciences. It consists of the following three dimensions (see Figure 1):

- (1) A first dimension considers the respective phases of a scientific knowledge process so that the responsible ethical analysis also extends over *the entire research process* (here, the questions of the goals, the means used, the methods and the consequences are heard).
- (2) A second dimension lists the group of affected parties, which can be narrower or broader, up to and including global and comprehensive affected parties.
- (3) A third dimension consists of the ethical evaluation standards in the narrower sense, i.e., those normative criteria that should guide the evaluation.

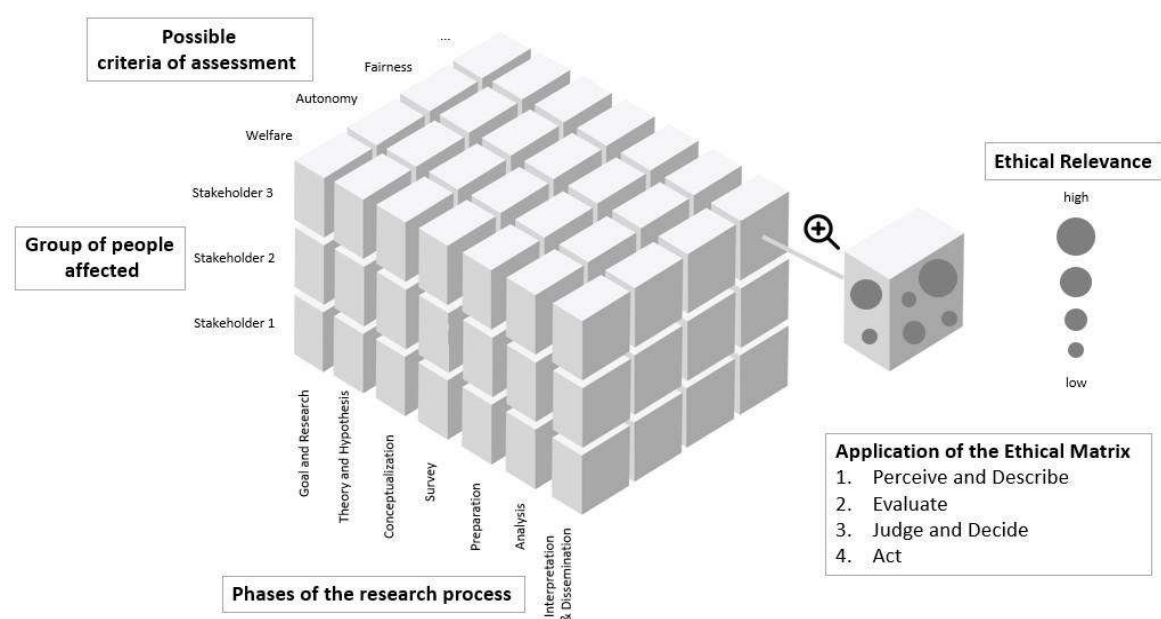


Figure 1. Systematic review of initial ethical suspicion within research practice.

The matrix expresses the intertwining of the three dimensions: in each phase of the scientific research process (1st dimension), the question arises about the actors or affected parties (2nd dimension) as well as the criteria of assessment (3rd dimension). The ethical relevance can be assessed differently in each case: Who is affected in which phase of the research and in which respect? The matrix application focuses primarily on the first two aspects of the ethical four-step of perceiving, evaluating, deciding, and acting. In the following, the individual dimensions are examined in more detail.

First dimension: Phases of the research process

Regarding the research phases, two models can be distinguished. A simple model, which can also be applied to more hermeneutically working disciplines, is based on three phases: Here, (1) a discovery (*what*), (2) a justification (*how*), and (3) an exploitation (*why* and *whereupon*) contexts are distinguished [42].

In our model, which is more oriented toward empirically working disciplines, distinguishes seven phases of the research process:

- I. *Goal and research question*: Critical questioning of the selection of the research object, the formulation of the problem and the design of the research question.
- II. *Theory and hypothesis* development: Critical selection and development of the theoretical background and hypothesis development.
- III. *Conceptualization*: account for the construction of the survey instrument, determination of the research design, choice of methodology, sample; also, clarification of the scope of one's models and questioning of one's axioms.
- IV. *Survey*: data collection *lege artis* and explication of leading categories.

- V. *Preparation*: mapping the different types of knowledge generated; bringing different forms of existing and generated knowledge into the conversation.
- VI. *Analysis*: data evaluation *lege artis* and explication of leading interpretive categories
- VII. *Interpretation and dissemination*: Classifying the results by systematically considering their implications for normative content; assessing the consequences of the research findings; and questioning the social impact of the research

Second dimension: Groups of people affected

In the respective research phases, those groups must then be determined as influenced or can be influenced by a research concern. In addition to the scientists, the research institution, civil society, etc., future generations, non-human living beings and the environment in general also come into focus here. The ethical matrix is not limited to reconciling the interests of groups that can articulate themselves; rather, it is the responsibility of the actors involved to also consider other ethical positions, including those of hypothetical groups.

In order to identify all relevant groupings, it is helpful to distinguish five levels. In addition to an individual, organizational, and societal level, a transcultural and environmental ethical perspective must be included in the ethical matrix ([43], p. 320f.). Each of these five categories needs to be further specified, but they represent the basis of any ethical consideration. In light of the fundamental destruction of the basis of life and its impact on other mentioned levels, the environmental-ethical perspective must be given special consideration and should be understood today as normatively binding in the form of ecological guardrails ([44], p. 86f.) since this refers precisely to the complexity of non-knowledge and unintended non-linear consequence assessments (ch. 3.3).

Third dimension: Possible normative criteria of assessment

Following Mepham, the principles of *welfare*, *autonomy*, and *fairness* are suitable evaluation standards. These three principles are based on different ethical theories, meaning that no single theory must be applied as the only valid one. In the principle of welfare, utilitarian approaches are incorporated into the ethical matrix, as the goal is to maximize utility through scientific research. Theories of the Good Life are also relevant, and they often diverge strongly from utilitarian procedures and their utility calculations. At this point, it also becomes clear that the ethical matrix supports ethical decision-making and is not a linear procedure. Thus, Beauchamp and Childress have already pointed out that they would have come to partially divergent evaluations even with the ethical traditions and their respective weighting ([37], p. 383f.). The second principle of autonomy is considered a deontological value since others (persons) are to be conceived as ends in themselves or as moral subjects themselves. The principle of autonomy is to be understood as the heir of Kant's categorical imperative. The third principle of fairness follows the justice-theoretical approach of Rawls, which represents a normative reference point for postulated ethical reflection or judgment formation and enjoys a high status within philosophical research. Despite criticisms that have been made of Rawls, the idea of justice remains important as one of the most significant normative ideas in contemporary ethics ([45], p. 10f.). This principle appears in numerous variants, which in turn contain manifold manifestations.¹¹

In addition to these three *prima facie* principles or categories, alternative models of an ethical matrix work with several categories, such as the MEESTAR project funded by the BMBF ([43], p. 320ff.). However, these further categories mostly result from the conditions of a concrete research field and, therefore, do not have the necessary abstraction and general ethical foundation that is needed for a generally valid ethical matrix to accompany a research project that has not yet been concretized. However, this also means that the three principles can only serve as an initial orientation but must still be individually supplemented or adapted for the respective scientific fields and questions. By arranging the relevant interest groups for the research question in the first column of a table and the principles in the first row, you can clearly examine ethically relevant inquiries at the intersections of the matrix.

Scientists can initially make this assessment regarding the identified groups themselves, which presupposes the ability to abstract from one's position, at least to a certain extent and to make a change of perspective. But presumably, depending on their composition, various interest groups will weigh the ethical principles differently, possibly even modifying the principles ([45], p. 12ff.), so it would be preferable to include them discursively in the ethical evaluation so that each of the groups can ethically evaluate the issue according to these individual viewpoints. A matrix drawn up by the scientists can serve as a starting point for the discourse but must be completed by the perspective of those affected.

4.2.1. Application of the Ethical Matrix

Within the ethical four-step procedure described by Dietrich et al. 2012 [39]—namely (I) perceive and describe, (II) evaluate, (III) decide, and (IV) act—the ethical matrix operationalizes the first two steps. The presented matrix is a

tool to perceive, describe and evaluate research projects from an ethical perspective. The matrix does not provide final judgments and instructions for action but forms the basis for them.

Step 1: Perceive and Describe

In a first step, the ethical matrix helps compile all the information required to form an ethical judgment as completely as possible. This includes a precise description of the research project and the elaboration of effects, consequences, implications and, in particular, the groups affected by the research and possible consequences. For the intended ethical judgment to be formed, as many potential consequences as possible must first be anticipated and (where possible) given a probability of occurrence.

The aim here is to obtain an overview of possible consequences with a reasonable amount of effort in order to be able to use this as a basis for evaluation and judgment. With reasonable effort' implies that, in real-world contexts, the description of the situation must be concluded at a certain point. In this context, the amount of time and material effort that seems reasonable for preparing the ethical judgment will not be the same for every case but will depend on how much is "at stake". Possible unintended consequences must also be considered, a step that is accompanied by epistemic uncertainty. In fact, methods may be discarded due to their consequences. However, this should be distinguished from an impact assessment of the research. At this point, we are confronted with a dilemma: On the one hand, any research must be ethically checked, but on the other hand, we first have to decide what research is ethically relevant.

Step 2: Evaluate

It is precisely in this step that substantive guidelines for individual scientific fields are needed. Here the ethical principles must be determined. As has already been presented above, Mepham proposed as *prima facie* principles *welfare*, *autonomy* and *fairness*, according to which the discourse can be structured ([47], p. 8f.). Sound judgments are possible only when based on broad evaluation standards. The principles can be applied to any group of stakeholders. Methodologically, it makes sense to first make a reasoned judgment or weighing within each respective category, as they offer higher commensurability, before comparing the categories against one another ([40], p. 246f.). This is because there is the possibility that the same thing promotes the welfare of a group but restricts its autonomy. These differences are important for forming a judgment in step 3.

Step 3: Judge and Decide

Especially in questions of application-oriented ethics, mixed *judgments* are of central importance, in which descriptive statements about the world are combined with evaluative and/or normative elements. Since an ethical judgment is not about determining what is the case—i.e., how the world is—but about how to act, ethics is, in principle, a prescriptive, not a descriptive, discipline. This cannot mean, however, that descriptive statements are irrelevant to ethical judgment. Especially regarding application-oriented ethics, good judgments can only be made if the descriptive description of the facts relevant to the question is as comprehensive and precise as possible (see step 1). However, no judgment or recommendation for action can be derived from this alone. It must be supplemented by a normative component, for example, in the form of general rules of action or principles. An ethical judgment is thus always mixed in this sense [12], ([13], p. 8, p. 234).

Step 4: Act

Fourth, guides to the ethical assessment of research must also consider the step of action. It is often mistakenly assumed that an insight into what must be done also implies implementation in action. However, examples from individual life (such as healthy lifestyles) and from society as a whole (such as climate protection) show that this is not the case. However, the implementation of ethical judgments is not solely the individual's responsibility, but also requires institutionalized control and promotion. Accordingly, the ethical matrix does not offer a top-down logic in opposition to a bottom-up application by scientists, as in Mepham ([47], p. 15), but the ethical reflection level of the institution and that of the scientists themselves must be related to each other in the sense of ethical empowerment of the researchers with simultaneous support by the control institutions. Especially research funding and research funding institutions have a central role to play here. The allocation of financial research support is the decisive steering instrument for ethically responsible science.

The individual actors in science have a moral duty to consider and implement their ethical judgments. However, beyond virtue-ethical approaches, there is also a need for an institutional safeguard, according to which the protagonists' values are also supported institutionally.

4.2.2. Problems and Responses

Two possible objections are raised below:

First objection: The ethical matrix is not capable of solving moral problems.

Reply: That is correct. However, it is not the claim of the ethical matrix to deliver solutions to certain moral problems. One of the reasons for this is that heterogeneous problem interpretations cannot be merged rashly into a supposedly shared problem definition. Therefore, no ethical judgment is won with the creation of an ethical matrix alone. For ethical judgments cannot be deduced from ethical matrices. They are not a tool for formalizing ethical judgments, but merely provide a structuring aid based on which ethical judgments can be formed. The matrix helps collect all relevant empirical data so that they can be weighed against each other in making judgments. The matrix structures the different interests of all groups significantly influenced by a research project and helps to represent and reflect their value attitudes.

Especially regarding application-oriented ethics, good judgments can only be made if the descriptive description of the facts relevant to the question is as comprehensive and precise as possible. However, no recommendation for action can be derived from this alone. This must be supplemented by a normative component, for example, in the form of general rules of action or principles ([13], p. 8), ([39], p. 234). The ethical judgment must evaluate and weigh possible consequences and implications based on fundamental values/principles/norms—and the weighing also concerns the different weights of the individual fields or partial cubes of the matrix.

Second objection: The consequences of research projects cannot be determined in advance.

Response: In fact, it is difficult for research projects to be kept vague in many places for factual reasons. This is because essential decisions can only be made during the project since the necessary knowledge has yet to be acquired. In addition, research is always confronted with unpredictable events, whether from outside or inherent in the implementation. However, it is not only these that prevent exact planning. Rather, deliberate vagueness at various points ensures precisely the flexibility needed to make situational decisions about the further course of the project. However, these epistemic challenges do not absolve us of the responsibility to make an assessment.

Nevertheless, only when the research project has been described in sufficient detail and an adequate manner it can be determined whether it is ethically sensitive in principle. The consideration of ethical aspects cannot be secondary to a description of the empirical ‘facts’ ([48], pp. 125–131). This is because describing a research project as accurately as possible and analyzing its ethical implications is reciprocal. Even obtaining the most accurate (empirical) descriptive categories possible can be ethically sensitive. Conversely, ethical evaluation cannot be finalized until as much empirical data as possible has been gathered. Nevertheless, it makes sense to distinguish the analysis first from the next steps methodologically.

5. Summary and Outlook

The ethical matrix further developed in this article represents a model for ethical reflection in and for the sciences, which is designed for further development and differentiation. Ethical reflection is to be understood as *a necessary monitoring of the entire process of scientific knowledge acquisition*, which, in view of potential consequences, may even go far beyond this. To be able to carry out a differentiated ethical consideration of what is morally desirable—with a view to the goals, the methods used, and the consequences—the circles of those affected should first be determined according to the proposed matrix. This can be done on a small scale or a wide scale depending on the normative background assumptions, followed by a detailed examination of the relevance of central normative categories (autonomy, fairness, welfare) along with benefit or harm categories. Identifying real or potential moral problems can start the process, as can ideas about achieving desirable states. These considerations can and should be made at potentially any stage of a scientific process. Responsibility in the sciences is understood as a method that accounts in a transparent and reasoned way for how ethical problems are perceived, evaluated, decided, and resolved in the entire research process.

Finally, the ethical considerations also invite a critical look at the ambivalences of *science itself*. Modern science often follows, at least implicitly, the logic of economics, which now seems to threaten the critical impetus of science as a whole in favor of maximizing supposed scientific output. In the sense of a critically distanced science, it must be allowed to refrain from making judgments in concrete situations. Science must not be required to make recommendations for action in every situation. In the sense of its orientation towards society, science does aim to make such recommendations for action. Still, honesty demands that it should sometimes be allowed to withhold judgment until this can be made on a well-founded basis. In this way, research differs fundamentally from entrepreneurial thinking, which tends to accept risks and must make decisions despite a lack of data. It is therefore also important to debate the ethically justifiable handling of non-knowledge, for example, due to the limits of predictability of possible consequences.

Particularly, for issues that rely heavily on scientific expertise, the limits of knowledge must also be considered from an epistemological perspective. Here, a “cognitive infrastructure of dealing with non-knowledge”([49], p. 317) would be required so that a systematic handling of epistemic knowledge limits becomes possible, for example, when types of risk are distinguished and a differentiated moral judgment is also oriented to them. Furthermore, a temporary withholding of judgment by the sciences can also be an ethically appropriate position on the way to forming a judgment, as can keeping an assessment open in view of serious deficiencies in knowledge or possible misjudgments (cf. *in dubio pro reo*) until more detailed data/information is available. For example Rudolf Schüssler shows that crucial progress in the theory of ethics started with *knowned ignorance* [50].

Science is obliged to provide information but not obliged to always give recommendations for action in every situation. In cases of doubt, this may mean that an intuitional approach based on the safest possible avoidance of harm is advisable in matters of high ethical relevance.

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Ethics Statement

Not applicable for studies not involving humans.

Informed Consent Statement

Not applicable for studies not involving humans.

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Footnotes

1. The term lifeworld refers to Jürgen Habermas’ concept of the socio-cultural conditions of a rational lifestyle [4].
2. Accordingly, the discussion on ethical dilemmas in relation to sustainability has also reached a new level [5].
3. Another example would be the now successful scientific search for water on the moon. However, this discovery, which at first seems ethically irrelevant, is now being made the basis of a potential construction of a lunar colony, for which considerable fossil and financial resources, also from the public purse, would be consumed.
4. The importance of ethics in the sciences is also shown by the debates concerning academic integrity. Due to public scandals in academic fields the interest in academic values like honesty, trust, fairness, respect, responsibility, and courage has increased in recent years [15]. Nevertheless, the topic of academic integrity is not considered in this article.
5. However, moral norms must be distinguished from purposive and legal norms as well as from those of etiquette and politeness. On the latter differentiation [16].
6. Peter Janich has pointed out this important distinction between science and its object: “We say ‘sociological’ when we mean ‘social’, and we say ‘psychological’ when we mean ‘psychical’. To explain: poverty is a social problem; whether poverty depends on the level of education is a sociological problem. If you have anxiety, you have a psychological problem; if you want to define a technical term “anxiety,” you have a psychological problem. Pyramids are archaic buildings, and their explorers are archaeologists” [17].

7. This is a very common definition, but not a general one. Paul Ricoeur, for example, defined morality as a deontological category and ethics as a teleological one [20]
8. Here, a plurality of different moral value and norm conceptions can arise, which can also be traced back to different ethical theoretical conceptions or even to political preferences. Respecting this diversity of applied standards and allowing it to flow into the decision-making process is a central task of ethical thinking, in which one critically assures oneself of the arguments and reflects on and weighs up the procedure as well as the justifications ([25], p. 13f.).
9. Even the recently published “Code of Academic Freedom” of the University of Hamburg is not free of this: “Academic freedom does not release researchers from the ethical duty to account for the consequences of their own actions” ([30], p. 6) (translated by authorship). Rather, the accountability should be extended to include not only the possible consequences, but also the goals and the means to achieve them.
10. Insofar our proposal is not in contradiction with the idea of academic freedom, which is guaranteed in the legal systems of many countries, in some cases even in the constitution. It is not possible to go into the specific foundations of academic freedom in the various legal systems here. In general, however, it can be said that academic freedom as a right of defense against state interference, for example, does not release from the obligation of ethical reflection. Positive law provides only a general framework within which research is legally possible. However, as in other areas, there are also actions and procedures in science that are legal but morally problematic. It is conceivable, for example, that a research project is legal in accordance with scientific freedom, but discriminates against certain social groups. Just as economic reasons can speak against a research project that is in principle covered by academic freedom, moral reasons can also speak against it. Furthermore, scientific freedom does not provide any indication of what research should be carried out on and is in this regard totally undefined. Ethical considerations should, however, also be taken into account when setting research objectives.
11. An overview of common theories of justice is provided by [45,46].

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