The epistemic integrity of scientific research

Jan De Winter [a], Laszlo Kosolosky [a]

[a] *Centre for Logic and Philosophy of Science, Department of Philosophy and moral sciences, Ghent University, Blandijnberg 2, 9000 Ghent, Belgium*

Abstract

We live in a world in which scientific expertise and its epistemic authority become more important. On the other hand, the financial interests in research, which could potentially corrupt science, are increasing. Due to these two tendencies, a concern for the integrity of scientific research becomes increasingly vital. This concern is, however, hollow if we do not have a clear account of research integrity. Therefore, it is important that we explicate this concept. Following Rudolf Carnap's characterization of the task of explication, this means that we should develop a concept that is (1) similar to our common sense notion of research integrity, (2) exact, (3) fruitful, and (4) as simple as possible. Since existing concepts do not meet these four requirements, we develop a new concept in this article. We describe a concept of epistemic integrity that is based on the property of deceptiveness, and argue that this concept does meet Carnap's four requirements of explication. To illustrate and support our claims we use several examples from scientific practice, mainly from biomedical research.

Keywords: epistemic integrity; research integrity; scientific integrity; deception; biomedical research; explication

1. Introduction

A lot of philosophers of science, politicians, and scientists, as well as the general public, consider it crucial that the integrity of scientific research is protected. Given such concerns, it is very remarkable that it is so hard to pin down what the concept "integrity" exactly stands for (Resnik 2011, p. 399). What is exactly at stake here? What is exactly threatened when we say that something threatens the integrity of scientific research? What does it mean for scientific research to have integrity?

In this article, we explicate the concept of research integrity. Carnap characterizes the task of explication as follows:

If a concept is given as explicandum, the task consists in finding another concept as its explicatum which fulfils the following requirements to a sufficient degree.

1. The explicatum is to be similar to the explicandum in such a way that, in most cases in which the explicandum has so far been used, the explicatum can be used; however, close similarity is not required, and considerable differences are permitted.

2. The characterization of the explicatum, that is, the rules of its use (for instance, in the form of a definition), is to be given in an exact form, so as to introduce the explicatum into a well-connected system of scientific concepts.

3. The explicatum is to be a fruitful concept, that is, useful for the formulation of many universal statements (empirical laws in the case of a nonlogical concept, logical theorems in the case of a logical concept).

4. The explicatum should be as simple as possible; this means as simple as the more important requirements (1), (2), and (3) permit. (Carnap 1950, p. 7)

Carnap states that philosophers, scientists, and mathematicians make explications very frequently. Following Weber, De Vreese & Van Bouwel (forthcoming), we wish to note, however, that the fruitfulness of philosophical explications (see third requirement) may not lie in their usefulness for formulating empirical generalizations (like scientific explications) and/or mathematical/logical theorems (like mathematical/logical explications), but rather in their usefulness for formulating clear guidelines for scientists. What we aim at in this article is then to introduce a concept, which we call "epistemic integrity,"[1] that is (1) similar to our common sense notion of research integrity, (2) exact, that is, clear and well-defined, (3) fruitful, that is, useful for the development and justification of norms for individuals and institutions involved in science, and (4) as simple as requirements (1), (2), and (3) permit.

Admittedly, several definitions of concepts like "research integrity," "integrity of the research process," and "scientific integrity" have already been offered, but these do not meet the requirements of explication to a sufficient degree. Take, for instance, Nicholas Steneck's (2006) definition. He defines research integrity as "possessing and steadfastly adhering to professional standards, as outlined by professional organizations, research institutions and, when relevant, the government and public" (Steneck 2006, p. 56). This is not very helpful to, say, a professional organization that wants to develop professional standards to which research should adhere in order to have (the highest degree of) integrity. Any standards this organization develops will guarantee research integrity according to the definition, and so the definition does not offer any guidance in outlining professional standards, which renders it useless for the organization under consideration. This means that Steneck's notion of research integrity does not meet the third requirement of explication – it is not fruitful – and therefore his account cannot be regarded as a good explication.

Other accounts of research integrity have the problem that they are insufficiently exact. For instance, Haack (2007), National Academy of Sciences (1992), Office of Research Integrity (2007), and Petrovečki & Scheetz (2001) refer to the notion of honesty, but do not (sufficiently) explain what they mean by it. Consider the National Academy of Sciences' concept of integrity of the research process: "By *integrity of the research process*, the panel means the adherence by scientists and their institutions to honest and verifiable methods in processing, performing,

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[1] The reason why we call our explicatum "*epistemic* integrity" is that there seem to be two distinct notions of research integrity in use – an epistemic notion, which focuses on the reliability of the results of research, and a moral notion, which concerns the moral acceptability of research practices. In this article, we only focus on the epistemic notion, as this is, we believe the more common, and also the more interesting notion of research integrity. We should also mention that our explication is only meant to apply to the epistemology of *science*, and not necessarily to other epistemologies.

evaluating, and reporting research activities" (National Academy of Sciences 1992, p. 17). The document includes examples of dishonest research practices, but it does not specify what honesty exactly *is*. What does it mean for a method to be honest/dishonest? How can we distinguish honest from dishonest methods? As these questions are not answered, the National Academy of Sciences' concept of integrity of the research process remains vague. Susan Haack (2007) does say something about how her value of honesty should be understood, but she does so in terms of respect for evidence, avoiding self-deception, and readiness to follow in good faith wherever the evidence takes you; concepts that are not any clearer than the concept of honesty itself, it seems to us. Hence, in our opinion, she does not succeed in making her account of the integrity of science sufficiently exact. Other insufficiently clarified concepts that accounts of research integrity refer to, besides "honesty," are: "verifiability" (National Academy of Sciences 1992; Office of Research Integrity 2007), "sharing" (Haack 2007), and "honorable research practices" (Petrovečki & Scheetz 2001).

In the next sections, we develop a concept of epistemic integrity that does succeed, as we will argue, in explicating the notion of research integrity. As our concept of epistemic integrity is based on the property of deceptiveness, we start by defining this property in the next section, and we clarify this definition on the basis of some examples from scientific practice. In section 3, we define the concept of epistemic integrity, and in section 4, we show that this concept fulfills the four requirements of explication. We conclude in section 5.

2. Deceptiveness

Before we introduce our concept of epistemic integrity, we should clarify what we mean by deceptiveness, as we will refer to this property in our explication. We focus on deceptiveness of statements. When is a statement deceptive? Firstly, we should remark that whether or not a statement is deceptive depends on whom it is communicated to and his/her background assumptions. Consider a clinical trial in which part of the study population is given the most adequate doses of a new test drug, and the other part is given inadequate doses of a competing product.[2] The percentage of patients that recover from a certain health condition is significantly higher in the test group. Suppose the study leader would then report that he conducted a clinical trial in which part of the study population received the test drug, and the other part received the competing product, and that a significantly higher percentage of patients recovered from their condition in the test group, without mentioning that the competing product was administered in inadequate doses. This report is deceptive – it causes people to overestimate the relative effectiveness of the test drug – but only because it is generally assumed that in active-controlled trials, all products are administered in adequate doses. People who do not make this assumption may not be misled. Those who assume that the competing product is administered in inadequate doses will not overestimate the relative effectiveness of the test drug as a result of the study leader's report, and so this report is not deceptive to them.

So the first question we have to answer is: When is a statement s, stated by person P_1, deceptive to a person P_2? We consider s deceptive to P_2 if and only if (i) s is presented to P_2 as a true statement, and (ii) either (a) s is false, or (b) P_2 infers a false statement s' from s and it is

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[2] This example is not unrealistic. The commercialization of biomedical science has stimulated epistemically problematic research practices such as the one in the example (Reiss 2010, p. 432). A new test drug for a certain condition is sometimes compared to inadequate doses of some other product (Rochon et al. 1994; Tandon & Fleischhacker 2005), or to a product that is administered in an inadequate way (Johansen & Gøtzsche 1999).

legitimate for P_2 to make this inference (given what is usually the case when a statement like s is true, what persons like P_1 usually mean by statements like s, what P_1 says about the interpretation of s, etc.). s is more deceptive to P_2 as P_2's inference from s to s' is more legitimate. The general degree of deceptiveness of a statement s is higher as s is more deceptive to a higher percentage of the people to whom it is communicated.

This account can be clarified on the basis of some examples. We start with a standard example of deception in science: a scientist, let us call him "Dr. Smith," fabricates certain data, presents these data as the results of empirical investigations, and makes a certain claim, say that drug D does not increase the risk of heart failure (s_1), on the basis of his so-called empirical data. Why is s_1 deceptive? In case drug D does increase the risk of heart failure, s_1 is deceptive because it is false, while Dr. Smith presents it as true (conditions (i) and (ii)(a) are met). But even if drug D does not increase the risk of heart failure, and s_1 is true, it is nevertheless highly deceptive. The reason is that people will infer from it that empirical research, namely Dr. Smith's empirical research, shows that drug D does not increase the risk of heart failure (s_1'). This inference is legitimate because Dr. Smith presents his claim as a conclusion based on data that he obtained empirically. Because the data were in fact fabricated, s_1' is false, and hence, s_1 is deceptive (conditions (i) and (ii)(b) are met).

Now consider a second case. Suppose a scientist states that research does not reveal whether or not climate change is occurring (s_2), while there actually is an abundance of scientific evidence suggesting that it is. Although the scientist's statement may be true as he interprets it – e.g., research does not provide a 100% certainty about climate change – it can nevertheless be highly deceptive. This is because a lot of people will infer from s_2 that the scientific arguments for climate change do not substantially outweigh the scientific arguments against climate change (s_2'), which is false, and this inference is legitimate because s_2' is in fact a more obvious interpretation of s_2 than the scientist's interpretation. s_2 would be less deceptive if the scientist explained what he meant and what he didn't mean by s_2. The more this is highlighted (think of, e.g., mentioning it directly after stating s_2 versus referring to an article in which the correct interpretation is in a footnote), the less legitimate it is for the audience to keep inferring s_2' from s_2, and thus, the less deceptive s_2.

In the aforementioned example of the test drug being compared to inadequate doses of a competing product, the problem is similar. A lot of people will interpret the study leader's claim that the percentage of patients recovering from their health condition was significantly higher in the test group (s_3) as follows: in the clinical trial he conducted, the percentage of patients recovering from their health condition was significantly higher in the group receiving *adequate doses of* the test drug than in the group receiving *adequate doses of* the competing product (s_3'). Although the latter statement is false, it is legitimate for the audience to infer s_3' from s_3, because (1) it is generally assumed that in active-controlled trials, all products are administered in adequate doses, and (2) the study leader did not mention that the competing product was administered in inadequate doses. Because conditions (i) and (ii)(b) of our account of deceptiveness are met, s_3 is deceptive (to the people inferring s_3' from s_3). To people who assume that the competing product was administered in inadequate doses, s_3 is not deceptive, since they will not infer the false statement s_3' from it.

3. Epistemic integrity

Now, let us introduce our notion of epistemic integrity. While deceptiveness is, as we characterized it, a property of statements, epistemic integrity is a property of practices resulting in certain statements. More specifically, we define the epistemic integrity of a practice as a function of the degree to which the statements resulting from this practice are deceptive. The more deceptive these statements, the lower the epistemic integrity of the practice. Applied to scientific research, we get: the more deceptive the (so-called) results or conclusions of scientific research, the lower the epistemic integrity of this research. To illustrate this, we can again refer to the example of comparing adequate doses of a new test drug to inadequate doses of a competing product. If the report of such a study is highly deceptive (because it conceals the fact that the competing product was administered in inadequate doses), then the epistemic integrity of the research is low. So the epistemic integrity of research is determined on the basis of its results (more specifically, on the basis of how deceptive these results are).

Besides research itself, other kinds of practices in science could have a degree of epistemic integrity as well. Take, for instance, the fabrication of data which are presented as the results of empirical investigations. Since the data are fabricated, no actual research is involved. But because the practice under consideration results in a deceptive report, it could be said to have low epistemic integrity.

Finally, we should mention an important constraint on what we mean by 'statements resulting from a practice.' Here, we assume that for a statement to be considered a result of a certain practice, it should be produced within this practice, by persons or entities who are actually involved in the practice. The epistemic integrity of the practice only depends on the deceptiveness of such statements. So, for instance, if a scientist who is not involved in a certain research project draws false conclusions from it, and presents them as true, this does not entail that the research upon which he relies has low epistemic integrity. His analysis of the research and its results may have low epistemic integrity, but the epistemic integrity of the research project itself is not compromised as long as those involved in the project have not made any deceptive claims themselves.

4. The four requirements of explication

Is our concept of epistemic integrity a good explicatum for the concept of research integrity? In this section we examine whether it fulfils the four requirements of explication we mentioned in the introduction: similarity to the explicandum, exactness, fruitfulness, and simplicity.

4.1. Similarity to the explicandum

The first question is whether epistemic integrity is, as we define it, sufficiently similar to our common sense notion of research integrity. As already mentioned, close similarity is not required, and considerable differences are permitted. What is required for good explication is that in most cases in which the explicandum has so far been used, the explicatum can be used (Carnap 1950, p. 7). Does our concept of epistemic integrity satisfy this requirement?

To support the claim that it does, let us take a look at a particular case in which the concept "integrity" is applied to a context of scientific research. As we have called our explicatum "epistemic integrity," we look into a case in which this specific term is used as well: Justin

Biddle's 2007 essay on the Vioxx affair. The Vioxx affair concerns the questionable research on Vioxx, a painkiller owned by pharmaceutical giant Merck & Co., Inc. In the abstract of the paper, Biddle states that "the research was organized in such a way as to allow short-term commercial interests to compromise epistemic integrity" (Biddle 2007, p. 21). Is this use of the term "epistemic integrity" compatible with our concept of epistemic integrity? Let us argue that it is.

Biddle mentions two reasons for believing that Merck's research on Vioxx was epistemically irresponsible:

> The first is that, between 2000 (or even earlier) and 2004, Merck consistently mischaracterized the current state of knowledge regarding the possible cardiovascular side effects of Vioxx. The hypothesis that Vioxx did not possess dangerous cardiovascular side effects was, until 2004, uncertain, and Merck *knew* that it was uncertain. Despite this, the company consistently and publicly asserted that Vioxx was safe. Secondly, there are serious questions about whether Merck honestly reported data that was unfavorable to its financial interests. Since the withdrawal of the drug, information has come to light suggesting that Merck scientists did not report all of the cardiovascular events that they should have, thus calling into question at least two of the studies that reflected favorably upon Vioxx. (Biddle 2007, p. 27)

Our account of deceptiveness implies that the two questionable research practices that this passage refers to both involve the production of deceptive claims. Firstly, consider the mischaracterization of the current state of knowledge regarding the possible cardiovascular side effects of Vioxx. An obvious implication of statements like "Merck & Co., Inc. today reconfirmed the favorable cardiovascular safety profile of Vioxx® (rofecoxib)" (press release by Merck, entitled "Merck confirms favorable cardiovascular safety profile of Vioxx®," dated May 22, 2001), is "today, Merck has sufficient scientific evidence to accept that Vioxx is safe." Therefore, it is legitimate to infer the latter from the former statement, and we can expect a lot of people to have made this inference. Because it is not true that Merck had, at the time, sufficient scientific evidence to accept that Vioxx was safe, the statement "Merck & Co., Inc. today reconfirmed the favorable cardiovascular safety profile of Vioxx® (rofecoxib)" was highly deceptive (conditions (i) and (ii)(b) of our account of deceptiveness are met). The second questionable research practice, inadequate reporting of unfavorable data, also involved the production of highly deceptive claims. When Merck scientists reported that in the VIGOR trial, 17 heart attacks occurred in the Vioxx group, while in fact there were 20, and that in the Advantage trial, five patients in the Vioxx group suffered heart attack or sudden cardiac death, while there were actually six or more, they presented false statements as true statements. Therefore, these statements were highly deceptive (conditions (i) and (ii)(a) of our account of deceptiveness are met).

Because Merck's research on Vioxx resulted in highly deceptive statements, it had low epistemic integrity. This could be explained by Merck's short-term commercial interests. The deceptive statements served these interests better than the truth – making the evidence for Vioxx's safety appear more compelling than it actually was, promoted the sale of Vioxx in the short term – and this may be the reason why these statements were produced. If we endorse this explanation, as we think Biddle would, then we can conclude that in the Vioxx affair, short-term commercial interests were allowed to compromise epistemic integrity, which is exactly what Biddle claims in his abstract. Thus, our concept of epistemic integrity is compatible with Biddle's use of the term.

Note that our analysis of the Vioxx case does not refer to any intentions. This corresponds with common sense: it is common sense that, e.g., because Merck scientists claimed that, in the VIGOR trial, there were 17 heart attacks in the Vioxx group, while in fact there were 20, epistemic integrity was compromised, regardless of whether the Merck scientists *intentionally* reported a false number. Suppose they *unintentionally* reported a false number because they were blinded by the company's short-term commercial interests; still we would say that research integrity was undermined.[3] This is a problem for accounts of research integrity that are based on the principle of honesty (e.g., Haack 2007; National Academy of Sciences 1992; Office of Research Integrity 2007; Petrovečki & Scheetz 2001), since dishonesty requires that there was the intention to deceive (Resnik 1998, p. 54).[4]

Besides Biddle's use of the term, our concept of epistemic integrity is also compatible with Nicholas Steneck's (2006) discussion of irresponsible behavior in research. He mentions fabrication, falsification, plagiarism, misrepresentation, inaccuracy, and bias as behaviors that damage research integrity. In 4.3 of this article we show, for each of these behaviors, that our concept of epistemic integrity implies that it undermines the epistemic integrity of research. Another example is Susan Haack's (2007) account of the integrity of science. She defines it as the adherence to the values of honesty and sharing. In 4.3 of this article we show why honesty and sharing are important to protect the epistemic integrity of scientific research. There is also an overlap between the examples Haack gives of threats to scientific integrity and the examples we give in this article (e.g., she also refers to the Vioxx case). So her use of the terms "integrity of science" and "scientific integrity" is more or less compatible with our concept of epistemic integrity.

We can of course not conclude on the basis of three examples (Biddle, Steneck, and Haack) that our explicatum can be used in most cases in which the explicandum has so far been used. But because exploring a larger variety of cases does not fit within the scope of this article, we leave this matter to further research. Here, we only hope to have given at least some initial plausibility to the claim that our concept of epistemic integrity fulfils the first requirement of explication.

4.2. Exactness

In defining our concept of epistemic integrity, we have not used terms such as "honesty," "verifiability," "sharing," or "honorable research practices" without clearly specifying what they stand for, as some others have done in developing a notion of research integrity (see section 1 of this article). Instead, we have referred to a notion of deceptiveness that we have first specified considerably. We have presented a definition of deceptiveness and clarified this definition on the

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[3] This is also in accordance with the requirements for findings of research misconduct as found in U. S. federal regulations:

A finding of research misconduct made under this part requires that–
(a) There be a significant departure from accepted practices of the relevant research community; and
(b) The misconduct be committed intentionally, knowingly, or recklessly; and
(c) The allegation be proven by a preponderance of the evidence. (45 CFR 93.104)

This standard of evidence implies that a behavior can be regarded as research misconduct even if the misconduct was not intended.
[4] Those who define research integrity in terms of honesty might respond that they disagree with Resnik (1998) that dishonesty requires the intention to deceive. They should then, however, have clarified what honesty/dishonesty does mean according to them, and they have failed to do so (see section 1 of this article).

basis of several examples. We have also clarified what we mean by 'statements resulting from a practice' (as it is, according to our account, the deceptiveness of such statements that determine the epistemic integrity of the practice). Therefore, we consider our explicatum sufficiently clear and well-defined, and hence, we consider the second requirement of explication to be fulfilled.

4.3. Fruitfulness

Is our concept of epistemic integrity useful for the development and justification of norms for individuals and institutions involved in science? As such norms have already been developed in earlier work (e.g., National Academy of Sciences 2002; Resnik 1998; Shamoo & Resnik 2009), we will not start from scratch here. Let us start from the standards for science developed in Resnik (1998). Resnik proposes the following standards:

Honesty: Scientists should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and truthful in all aspects of the research process.
Carefulness: Scientists should avoid errors in research, especially in presenting results. They should minimize experimental, methodological, and human errors and avoid self-deception, bias, and conflicts of interest.
Openness: Scientists should share data, results, methods, ideas, techniques, and tools. They should allow other scientists to review their work and be open to criticism and new ideas.
Freedom: Scientists should be free to conduct research on any problem or hypothesis. They should be allowed to pursue new ideas and criticize old ones.
Credit: Credit should be given where credit is due but not where it is not due.
Education: Scientists should educate prospective scientists and insure that they learn how to conduct good science. Scientists should educate and inform the public about science.
Social responsibility: Scientists should avoid causing harms to society and they should attempt to produce social benefits. Scientists should be responsible for the consequences of their research and they should inform the public about those consequences.
Legality: In the process of research, scientists should obey the laws pertaining to their work.
Opportunity: Scientists should not be unfairly denied the opportunity to use scientific resources or advance in the scientific profession.
Mutual respect: Scientists should treat colleagues with respect.
Efficiency: Scientists should use resources efficiently.
Respect for subjects: Scientists should not violate rights or dignity when using human subjects in experiments. Scientists should treat non-human, animal subjects with appropriate respect and care when using them in experiments. (Resnik 1998, chapter 4)

What we will try to show now is that our concept of epistemic integrity is useful to justify and refine some of these standards.

Resnik uses different grounds in justifying his standards. A first is that violating the standard hinders the achievement of the goals of science. Resnik distinguishes two kinds of goals: epistemic and practical. The epistemic goals are related to the advancement of human knowledge, and the practical goals concern solving problems in engineering, medicine, economics, agriculture, and other areas of applied research (Resnik 1998, p. 39). A second kind of justification is that adhering to the standard promotes cooperation and trust in science, and a third is that it promotes the public's trust in science. Fourthly, most standards are also justified on moral grounds. We will here only focus on Resnik's epistemic justification of standards, that is,

the justification of a standard on the ground that adhering to it is important for the advancement of human knowledge.

The problem with this kind of justification is that it is not clear what Resnik means by human knowledge. It is also not always clear why and how violating the relevant standards exactly impedes the advancement of human knowledge. Therefore, the claim that a certain standard is justified because violating it hinders the advancement of human knowledge, is not very informative. This is where our concept of epistemic integrity comes in. We believe that it enables us to give an alternative, more informative epistemic justification of several of Resnik's standards.

What we want is that practices in science have the highest degree of epistemic integrity, that is, we want the claims produced in science to be non-deceptive. Most of Resnik's standards for science can be justified on the basis of this desideratum. We distinguish between three kinds of standards: those that can be completely justified on the basis of this desideratum, those that can only partially be justified on the basis of this desideratum, and those that cannot be justified on the basis of this desideratum at all. The standards belonging to the latter category are: social responsibility, legality, efficiency, and respect for subjects. Adherence to these standards is important for moral reasons, not because violating them damages the epistemic integrity of scientific research.

The standards that can be completely justified on the basis of the ideal of high epistemic integrity of scientific practices are: honesty, carefulness, openness, and freedom. Firstly, take the principle of honesty: scientists should not fabricate, falsify, or misrepresent data or results, and they should be objective, unbiased, and truthful in all aspects of the research process. When scientists misrepresent data or results, e.g., when they describe a certain method of research and claim that certain data were obtained through this method while in fact they were not (e.g., because they were fabricated or falsified), they make a deceptive claim. They present a false statement ("this method delivered these data") as a true statement, and therefore it is deceptive. This means that their (so-called) research has low epistemic integrity. Since we want scientific research to have the highest degree of epistemic integrity, the conclusion is that scientists should not misrepresent data or results.

Our concept of epistemic integrity can also be used to explain why it is important that scientists are objective and unbiased in different aspects of the research process. To illustrate this, consider decisions on whether or not to publish certain results. In biomedical science, such decisions are sometimes biased; findings that are unfavorable to a certain drug (e.g., the drug is ineffective or not safe) are not published, while favorable findings are published more than once (Melander et al. 2003; Schott et al. 2010, pp. 296-298). When this is the case, people who consult the relevant publications might infer that most research is favorable to the drug while this is in fact false, and this inference is legitimate because all research findings are supposed to be published – not just the favorable ones. If a lot of people actually make this inference, the collection of publications can be considered highly deceptive, which means that the epistemic integrity of the body of research resulting in this collection of publications is low. So in order to guarantee that research has the highest degree of epistemic integrity, we should make sure that scientists are objective and unbiased in deciding whether or not to publish certain results.

Now consider the principle of carefulness: scientists should avoid errors in research, especially in presenting results, they should minimize experimental, methodological, and human errors, and they should avoid self-deception, bias, and conflicts of interest. Different kinds of errors could result in deceptive claims. When an instrument produces some false data (experimental error), and these data are presented as accurate, a deceptive claim is made. Deceptive claims could also

be caused by methodological errors. For instance, if biomedical scientists compare adequate doses of a drug to inadequate doses of a competing product, interpret the results as saying something about the products' relative effectiveness for treating a certain condition, assuming that both are administered in their most adequate doses (methodological error), and then present this false conclusion as true, they make a deceptive claim. Finally, when scientists make a human error such as a miscalculation or inaccurate recording of data, and present the outcome as accurate, a deceptive claim is made as well.

How bias could result in deceptive claims should be clear by now. The comparison of adequate doses of a product one favors to inadequate doses of a competing product is an example of bias, and we also indicated how publication bias could lead to a highly deceptive collection of publications. Since such biases typically occur in cases in which those involved in research have conflicts of interest, we can conclude that the threat of deception is especially present in cases in which those involved in research have a conflict of interest. As errors, bias, and conflicts of interest all increase the likelihood that deceptive claims are made, a good strategy to protect the epistemic integrity of scientific research is to avoid errors, bias, and conflicts of interest, which is exactly what Resnik's principle of carefulness recommends.

A third principle that can be completely justified on the basis of our concept of epistemic integrity is the principle of openness: scientists should share data, results, methods, ideas, techniques, and tools, and they should allow other scientists to review their work and be open to criticism and new ideas. Openness is important because it facilitates the detection of deceptive claims by outsiders. For example, when the use of inadequate doses of a drug in a clinical trial results in a deceptive claim, then this could easily be detected if the actual doses used are shared, but not when they are kept secret. The detection of deceptive claims by outsiders is not only valuable because this enables us to correct them or replace them by non-deceptive claims, but also because it prevents the production of deceptive claims. The easier it is for outsiders to detect deceptive claims, the more important it is for scientists to make sure that their claims are non-deceptive, since their reputation will be damaged if some of their claims are shown to be deceptive. So by making it easier for outsiders to detect deceptive claims, openness contributes to the non-deceptiveness of claims made in science, and thus, it promotes the epistemic integrity of scientific research.

Fourthly, consider the principle of freedom: scientists should be free to conduct research on any problem or hypothesis, and they should be allowed to pursue new ideas and criticize old ones. We already saw how making it easier for outsiders to detect deceptive claims promotes the epistemic integrity of research. But for outsiders to detect deceptive claims, it is not only important that information is shared with them (openness), but also that scientists are allowed to investigate, for any claim made, whether or not it is deceptive. Therefore, scientists' freedom to criticize claims made by others should be guaranteed.

There are also some standards that can only partially be justified on the basis of our concept of epistemic integrity: credit, education, opportunity, and mutual respect. Adherence to these standards is important regardless of whether or not violating them compromises epistemic integrity. However, some behaviors that violate them compromise epistemic integrity, and this is a reason not to practice such behaviors. Take the principle of credit: credit should be given where credit is due but not where it is not due. The main reason why this standard should be respected is that all people, including scientists, should be given just rewards for their contributions and efforts (Resnik 1998, p. 62). But some aspects of the principle of credit can also be justified on the basis of our concept of epistemic integrity. Suppose for instance that a scientist writes a text in which he presents certain ideas as his own original work, while in fact he stole these ideas

from someone else (plagiarism). He then violates the principle of credit because he does not give credit where credit is due. Since the reader will infer from the text that the author has developed these ideas himself, which is not the case, the text is deceptive, which means that epistemic integrity is damaged. So for practices in science to have the highest degree of epistemic integrity, scientists should not plagiarize.

Another example is the use of guest authors and ghostwriters. In biomedical science, persons who did not make a significant contribution to a paper – typically academically affiliated investigators that are not employed by the company that financed the research – are listed as authors (guest authors) (Ross et al. 2008), while company employees who did make a significant contribution are not (ghostwriters) (Gøtzsche et al. 2007). This gives the reader a false impression of who conducted the research and who contributed what to the paper. Therefore, the statements pertaining to authorship are deceptive. So here, too, violating the principle of credit – authorship credit is not given where it is due – compromises epistemic integrity.

A second principle that can be partly justified on the basis of our concept of epistemic integrity, is the principle of education: scientists should educate prospective scientists and insure that they learn how to conduct good science, and they should educate and inform the public about science. If we want scientific research to maintain a high degree of epistemic integrity in the future, it is crucial that prospective scientists learn how to make sure that their claims are non-deceptive. They should, for instance, learn how to avoid different kinds of errors and bias, since these could all result in deceptive claims as we have seen. If scientists would not educate prospective scientists in this way, the epistemic integrity of future scientific research is threatened. Scientists should also educate and inform the public about how to interpret different scientific claims in order to avoid that people (legitimately) infer false statements from true scientific claims (which would make the scientific claims deceptive). This justification of the principle of education is, however, only partial, since prospective scientists should learn more than just how to make their claims non-deceptive.

Thirdly, we can offer a partial epistemic justification of the principle that scientists should not be unfairly denied the opportunity to use scientific resources or advance in the scientific profession (principle of opportunity). We can expect that the deceptiveness of a claim is more likely to be detected if it is investigated by people with different backgrounds, who have different perspectives on the claim. Therefore, it is important that people with different backgrounds get equal opportunities in science. As this will make it more likely that the deceptiveness of a claim is identified, we can expect more deceptive claims to be corrected or replaced by non-deceptive claims, and the incentive for scientists to make sure that their claims are non-deceptive will be stronger (as they will be more likely to get caught). This epistemic justification of the principle of opportunity is partial because even in a case in which unfairly denying someone the opportunity to use scientific resources or advance in the scientific profession (e.g., on the basis of his skin color) can be shown not to threaten the epistemic integrity of scientific research in any way, it is still unacceptable (on moral grounds).

A final principle we consider is the principle of mutual respect between scientists, which implies that "scientists should not harm one another, either physically or psychologically, that they should respect personal privacy, that they should not tamper with each other's experiments or results, and so forth" (Resnik 1998, p. 67). If there would not be mutual respect in science, scientists would probably be less inclined to make sure that other scientists are not deceived by the claims they make. As a consequence, we can expect more claims in science to be deceptive, and the epistemic integrity of a lot of research would be lower. Therefore, it is important that scientists adhere to the principle of mutual respect. Of course, even in cases in which one

scientist can harm another without threatening epistemic integrity, scientists should not do so (on moral grounds). Therefore, our epistemic justification of the principle of mutual respect is only partial.

Finally, we wish to point out that our concept of epistemic integrity is not only useful to justify most of Resnik's standards for science, but also to refine them. Suppose a scientist fabricates certain data (e.g., in order to establish methodological or conceptual problems), that he is clear about the fact that the data are fabricated, and that there is no way in which he gives the impression that the data are not fabricated. As the principle of honesty states that scientists should not fabricate data, it implies that the scientist misbehaves. But since the scientist does not make any deceptive claim – he is clear about the fact that the data were fabricated – the epistemic integrity of his research is not undermined. Therefore, there is no reason to consider his behavior unacceptable. Data fabrication is only unacceptable when the fabricated data are presented as empirical data, that is, as the results of empirical research. The reason is that only in the latter kind of cases does data fabrication result in deceptive claims, and is the epistemic integrity of the (so-called) research undermined.

We can also refine the principle of openness on the basis of our concept of epistemic integrity. As a specification to this principle, we can add that when scientists publish in academic journals, they should disclose their financial interests, such as those that are due to industry ties (also see Schachman 2006, p. 6901); certain other interests, such as the interest to publish in high-impact journals in order to advance one's career, should not be mentioned. The reason is that if financial ties to industry are not disclosed in an academic article, a lot of people will (legitimately) infer that the reported conclusions result from independent research, while this is not the case. If, on the other hand, interests such as the interest to publish in high-impact journals are not mentioned, people will not infer that such interests were absent; on the contrary, we take such interests for granted. We can then, on the basis of our account of epistemic integrity, conclude that the disclosure of industry ties (in academic articles) is important for epistemic integrity, while mentioning taken-for-granted career interests is not.

As our concept of epistemic integrity is, as we have shown, useful for the justification and refinement of standards for science, we consider it a fruitful concept. Hence, the third requirement of explication is satisfied.

4.4. Simplicity

In order to show that our concept of epistemic integrity is as simple as the three other requirements of explication permit, we argue that no parts of our explication can be omitted without violating the other requirements. More specifically, we argue, for each part of our definition of deceptiveness (on which our explication is based), that if it is omitted, our explicatum will be less similar to our common sense notion of research integrity. For most parts, we also argue that omitting them will make our explicatum less fruitful.

The first part we consider is condition (i) of our account of deceptiveness, which is that the deceptive statement is presented as a true statement (see section 2). Consider the following case: a scientist describes a certain hypothesis, which includes a false statement *s*, and then rejects it on the basis of empirical data. Although *s* is false, it is not deceptive because the scientist does not present it as true; he presents it as part of an hypothesis he rejects. If condition (i) would be omitted, *s* would be deceptive (condition (ii)(a) is met), which means that the epistemic integrity of the scientist's research would be undermined. This conflicts with our common sense notion of

research integrity; we would not say that in the case under consideration, research integrity is threatened.

Furthermore, omitting condition (i) would also make our concept of epistemic integrity less useful for the development/justification of standards for science. It would imply that scientists should not describe hypotheses that contain false statements (otherwise epistemic integrity is undermined). This is, of course, not the kind of standard we want for science. As long as one is clear about the fact that what one is describing is only an hypothesis, which may be false, there is nothing wrong with describing an hypothesis that contains a false statement.

Secondly, consider condition (ii)(a) of our account of deceptiveness. Can we omit (ii)(a) without weakening our explication? It is common sense that research integrity is damaged when researchers lie. For instance, when Tobacco Institute Researchers conduct a study which clearly reveals that smokers have a higher risk of lung cancer, and they claim the opposite, that is, that their study demonstrates that smokers do not have a higher risk of lung cancer (s_4), then the study has a low degree of research integrity. We might infer other false statements from s_4, such as "if I start smoking, this will not increase the risk of me getting lung cancer" (s_4'), but this is not required for research integrity to be undermined; it is sufficient that the Tobacco Institute Researchers present a false statement, s_4, as true. This corresponds with our concept of epistemic integrity: the fact that conditions (i) and (ii)(a) are met is sufficient for s_4 to be deceptive, and it is not necessary that the audience infers false statements from s_4. If we would omit (ii)(a), it *would* be necessary that the audience infers false statements from s_4 for s_4 to be deceptive, and hence for epistemic integrity to be undermined. This conflicts with our common sense notion of research integrity.

Omitting (ii)(a) would also make our concept of epistemic integrity less fruitful. It would then not enable us to justify the following norm: scientists should not make false claims even when the audience will not infer any false statements from these claims. By including (ii)(a), our concept of epistemic integrity does enable us to justify this norm: even when the audience does not infer any false statements from a false claim (so that condition (ii)(b) is not met), the claim is still deceptive (because conditions (i) and (ii)(a) are met), and hence, epistemic integrity is damaged.

Some might have trouble with the view that presenting a false statement as true is sufficient for epistemic integrity to be undermined.[5] Consider the following scenario. Suppose that a study results in several claims, some of which are true and some of which are false, and that we know which claims are trustworthy and which are not. Accordingly, we do not believe any of the false statements, but only the true ones. Some might then maintain that the epistemic integrity of the study is not undermined by the false claims, as no one believes them anyway. The reason why we have not opted for such a view is that the ideal is, in our opinion, that all claims made in science are trustworthy, and not just the ones that are actually trusted (note that we often do not know in advance which claims will be trusted by the audience and which not). Our concept of epistemic

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[5] This point, which was made by an anonymous reviewer of this article, is inspired by Richard Posner's view that for plagiarism, it is not sufficient that the plagiarizing work is presented as original; the audience should also do something because it believes that the plagiarizing work is original, something that it would not have done had it known the truth (Posner 2007, p. 19). This would explain why college professors do not have to cite in their PowerPoint slides in class (except for direct quotes): in such cases the audience does not falsely believe that the college professor is the original author of the work. Note, however, that our account of epistemic integrity can explain why such cases are not problematic as well: (1) the college professor does not state that he is the original author of the work (he just doesn't cite the original authors), and so he does not present a false statement as true (condition (ii)(a) is not met), and (2) the audience does not infer from the PowerPoint slides the false statement that the college professor is the original author (condition (ii)(b) is not met).

integrity reflects this ideal: it implies that research that only results in true claims has higher epistemic integrity than research that also results in false claims, even if the latter claims are not believed by the audience.

Now consider condition (ii)(b). We have added (ii)(b) to permit that true claims can nevertheless be deceptive. Take for instance statement s_3, discussed in section 2. We have seen that when adequate doses of a new test drug are compared to inadequate doses of a competing product in a clinical trial, and the study leader claims that the percentage of patients recovering from their health condition was significantly higher in the test group (s_3) without mentioning that the competing product was administered in inadequate doses, then s_3 is deceptive even though it is true. Accordingly, epistemic integrity is undermined. But if (ii)(b) would be omitted, only false claims would be deceptive, and epistemic integrity would not be undermined in the case at hand. This conflicts with our common sense notion of research integrity, as we would say that research integrity *is* undermined in the case at hand.

Another reason why (ii)(b) cannot be omitted is that it would make our concept of epistemic integrity less fruitful. Now our concept of epistemic integrity can be used to support the norm that scientists should not engage in practices that result in deceptive claims such as s_3. If (ii)(b) would be omitted, it could not.

A final question is whether we can omit the second part of condition (ii)(b). Is it sufficient that the audience infers a false statement from a claim for this claim to be deceptive, or should this inference also be legitimate? We stated that the inference should also be legitimate because we want to avoid that the audience can turn non-deceptive claims into deceptive ones by drawing absurd conclusions from them. For instance, if the audience infers from the claim that smoking increases the risk of lung cancer (s_5) that the earth is flat (s_5'), and deceptiveness would not require that the inference from s to s' is legitimate, then this would mean that s_5 is deceptive (conditions (i) and (ii)(b) would be met), and that epistemic integrity is undermined. This conflicts with our common sense notion of research integrity, since research integrity is, according to common sense, not undermined when the audience infers s_5' from s_5.

As no parts of our account of deceptiveness, on which our concept of epistemic integrity is based, can be omitted without violating at least one of the other requirements of explication, we consider our concept of epistemic integrity as simple as possible. The fourth requirement of explication is fulfilled.

5. Conclusion

In this article, we tried to explicate the concept of research integrity in a way that is in accordance with Carnap's characterization of the task of explication. More specifically, we introduced a concept we called "epistemic integrity," and defined the epistemic integrity of a practice as a function of the degree to which the statements resulting from this practice are deceptive – the more deceptive these statements, the lower the epistemic integrity of the practice. Next, we argued that this concept of epistemic integrity is (1) similar to our common sense notion of research integrity, (2) exact, (3) fruitful, and (4) as simple as possible. As these are Carnap's four requirements of explication, we conclude that our concept of epistemic integrity is a good explicatum for the concept of research integrity.

We believe that our concept of epistemic integrity is also very valuable for future research. If we want to improve the quality of scientific research, we should look at epistemically problematic research practices, investigate their causes, and develop and evaluate different

strategies to tackle the relevant problems. Our concept of epistemic integrity can help us in identifying epistemically problematic research practices, and it enables us to explain why these research practices are exactly epistemically problematic. Furthermore, it is also useful to assess potential solutions. We can implement different potential solutions and examine how each affects the epistemic integrity of scientific research. The more a potential solution promotes the epistemic integrity of scientific research, the better it is.

Acknowledgments

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