Integrity in Science

A study on the use and genealogy of the term 'integrity' within the scientific arena

A thesis presented for the degree of Master of Science

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HONEST

ETHICS

Abstract

Integrity is widely considered to be an essential aspect of research, but there seems to be little consensus about the definition or exact meaning of 'scientific integrity'. The understanding of integrity ranges from the minimal (FFP) to the maximum, blending into science ethics, but underneath this obvious range are more subtle differences that are not immediately evident. In the debate on scientific integrity, the concept is often presented as such an essential part of performing 'good research' that it can hardly been imagined that integrity was once not discussed within the scope of research. In addition, the debate is often presented as a single one, being similar among scientists, science policymakers and newspaper journalists. Both assumptions are contested in this research.

Rather than performing a conceptual analysis through philosophical reasoning and discussion, we aimed at clarifying the discourse of 'scientific integrity' by studying its usage in written documents within, or about, science. To this end, large numbers of scientific publications, policy documents and newspaper articles were analysed by means of scientometrics and content analysis techniques. We sampled articles referring to integrity in science from the *Web of Science* database, European policy documents and worldwide English newspapers. The texts were analysed on their usage of the term 'integrity' and of frequently co-occurring terms and concepts. A comparison was made between the usage in the various media, as well as between different temporal periods in which they were published.

From the analysis, we conclude that there are clear differences between the discourse of 'integrity' in policy documents and scientific publications as well as between distinct temporal periods. Remarkably we see a clear difference between the tendency of 'promoting good science' in scientific publications and older policy documents, while there is the tendency of 'repressing misconduct' in more recent policy documents. In addition, the entrance of the term 'integrity' to the scientific debate dates back only several decades, forming a reaction on the apparent increase of notified cases of scientific misconduct.

Preface

This thesis is a final prove of competence for obtaining the master of science (MSc) degree in Mathematics from the Radboud University located in Nijmegen, The Netherlands.

It is only on those rare, fortunate days that one gets the opportunity to do just that what comes so close to what you wanted to do. To study a phenomenon that is essential in research is, for a mathematician, not too uncommon. Indeed, being such an omnipresent component of science, studying mathematics is like studying the foundations of science. However, to study not just an essential aspect of science but an essential aspect of life, that, my dear reader, is wonderful.

To study the concept of integrity has been of great pleasure to me. Holding fascination for the concept and astonishment for the frequency in which it seems lacking, I could not have described the essence of integrity more beautifully than the French philosopher Molière did:

"If everyone were clothed with integrity, if every heart were just, frank, kindly, the other virtues would be well-nigh useless."

By describing the different viewpoints on the concept of integrity, I hope this thesis will shed light on the manner in which the term 'integrity' is used and how the term is understood by various actors. In this way, my thesis may provide a basis for defining the concept of 'integrity' in research and elucidate the opportunities for finding shared understandings.

As such, I hope that, albeit in the most marginal extent, this thesis will contribute to the clothing of scientists with integrity, rendering just, frank hearts, within and outside of science.

I would like to thank everyone who helped me in any way while working on this thesis. In particular, of course, my thanks go to Willem Halffman for his support and guidance throughout the process, his critical feedback and personal involvement in my project. Carrying out the project has been a particularly pleasant experience, not in the last place because of the fruitful collaboration with Willem.

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1. Introduction

Integrity is widely considered to be an essential aspect of science and research. With research misconduct in the headlines of academic publications and newspaper articles, the attention and interest for integrity in science is easily witnessed. Research integrity and its absence are reckoned to be important to all stakeholders within and outside science (Godecharle, Nemery, & Dierickx, 2014). Therefore, these issues have been subject to extensive research (Fanelli, 2013; Hiney, 2015; OECD, 2010; Steneck, 2006).

As one commonly reads, misconduct shakes science to its very foundation: It erodes the trust (Hiney, 2015). Undoubtedly trust is one of the major pillars that underpins the foundations of science. Indeed, researchers should be able to rely on the progress made by their colleagues (Shamoo & Resnik, 2009); on the statements they express; and, probably most important, on the manner in which these statements have been formed. And even more general: society as a whole, and in particular those who consume science (either as a patient, in business or in any other form), should be able to rely on the correctness and quality of scientific statements and products. Especially because these parties are not, or to a very little extent, able to verify the correctness of these statements (Drenth, 2005).

Considering that scientific integrity is closely linked to such essential aspects of science, the growing interest in research to this phenomenon is easily explained. However, in this research, little attention is being paid to the very concept itself. There seems to be little consensus about the precise meaning of 'scientific integrity'. The understanding of integrity ranges from the minimal, only considering falsification, fabrication and plagiarism (FFP), to the maximum, blending into science ethics, but underneath this obvious range are more subtle differences that are not immediately evident. The absence of a clear and commonly held understanding of integrity in research is sometimes believed to hamper the promotion of scientific integrity and the prevention of misconduct (Science Europe, 2015) but is also an interesting social phenomenon in itself.

Even though integrity is reckoned as crucial to the scientific enterprise, scientific misconduct is of all times and recently novel examples of (severe) misconduct have come to light (ORI, 2015). Scientific misconduct 'damages the scientific enterprise, is a misuse of public funds, and undermines the trust of citizens in science and in government' (OECD, 2010). Indeed, specific cases, like the Stapel-affair, have been shown to have major negative impact on society's perception of science (Abma, 2013). In spite of the fact that clear indications on the incidence of scientific misconduct are not available, it is suggested that it is substantial (Fanelli, 2009; Martinson, Anderson, & de Vries, 2005) and conceivably increasing (Fanelli, 2013).

For this and other reasons, there is a growing need for research into the nature and discourse of scientific misconduct and scientific integrity (PRINTEGER, 2015). In the debate on scientific integrity, the concept is often presented as such an essential part of performing 'good research' that one can hardly imagine integrity once not being discussed within the scope of research. However, the results in this report will show that it certainly has not always been a point of discussion. While research dates back hundreds or thousands of years, the discussion on integrity in research is much younger, originating only several decades ago.

With my research I will contribute to the research done within the framework of the PRINTEGER project, mainly to the first phase of that project (PRINTEGER, 2015). The research will be primarily focused on the use and the origin of the term 'integrity'.

The research will be focused on the genealogy of the term 'research integrity' and the meaning of the term in contemporary science. Thereby I will try to create an overview of what and where the term 'integrity' in science originates from, what has brought the term within the scope of research and how its use has developed over time. Moreover I will investigate what the term 'integrity' is currently used for within the scientific debate and try to identify patterns as to why some aspects of research are classified under the caption of integrity while others are not. The main aim of the research is to get a grounded vision on the scope of the term 'integrity'. This can facilitate in defining the framework and boundaries of the rest of the PRINTEGER project and more generally provide a basis for defining the concept of 'integrity' in research and science policy statements.

Research integrity is not only discussed among scientists. Hence, science policymakers' and newspaper journalists' conceptions of 'integrity' will be incorporated in the research. Scientists, science policymakers and journalists will be jointly studied on their usage of the term 'integrity', and its counterpart 'misconduct', in order to gather a full-scale overview of the meaning of the term 'integrity' in the agora of science. The debate on research integrity is often presented as a single one, being similar in various forms of media. However, questions can be raised whether there actually exists a single discourse on integrity in research or should we conclude that its discourse is different in diverse media?

Rather than performing a conceptual analysis through philosophical reasoning and discussion, we aim at clarifying the discourse of 'scientific integrity' by studying its usage in daily practice. To this end, large numbers of scientific publications, policy documents and newspaper articles will be analysed on their usage of the term 'integrity' and of frequently co-occurring terms and concepts.

Research questions

These research aims have led to the following research question:

How are the terms 'scientific integrity' and 'research integrity' used and understood in the scientific and public discourse and how has this developed over time?

When stating the 'scientific discourse' I refer to the written documents produced by scientists: scientific publications. Under the heading 'public discourse' I will refer to the written documents from the public realm of science, being science policy documents and newspaper articles.

Hence I distinguish between three types of media being:

- Scientific publications
- Science policy documents, including codes of conduct and guidelines
- Newspaper articles

This will be done to enable a comparative study on the way in which the concept of integrity is discussed and defined by scientists, policymakers and journalists. In order to answer the research question, the following sub questions are set:

- 1. How does the usage of the term 'integrity' in these media develop over time?
- 2. What aspects and concepts of science are linked to 'integrity' and what components of science are focused on?

3. What variations can be spotted between the usages of the term 'integrity' within scientific publications, policy documents and newspaper articles?

The first sub question is set to get a grasp on the origin of the term integrity within the scientific arena. I will try to investigate when and how the term was introduced to the scope of research. Moreover, I will account for the development of the usage of the term starting from its origin in the scientific debate up to its contemporary use and try to identify reasons for the way this development has taken place.

The second sub question is set to identify the aspects within research that the term 'integrity' is employed for. I will identify what components of research are considered to be connected to the concept of 'integrity' and what components are not. Last, the third sub questions is set to enable a comparative study between the scientific and the public discourse on integrity in science.

In addition to answering the above three sub questions, findings from the analysis will be judged against trends indicated in the literature regarding the development of integrity in science and the manner in which it is discussed. Arguments will be sought for the differences that can be spotted and potential reasons for the usage of specific terms in combination with 'integrity' will be discussed.

Outline of report

First we will present an overview of the available literature on the concept of 'integrity'. We will clarify some of the definitions of the concept and its counterpart 'misconduct' in science. In addition, several dimensions of different definitions will be categorised and various approaches in defining integrity and misconduct will be discussed. Lastly, chapter two will deal with the manifold options of fostering integrity in research or preventing misconduct.

Chapter three discusses the employed research methods. In particular, light will be shed on the techniques of *scientometrics* and textual content analysis. The various analyses and manners of presentation will be described and detailed information about the gathered data will be presented.

In chapters four and five, the results of our analyses will be offered. First, an overview concerning the amount of published papers containing several key phrases such as 'research integrity / misconduct' and 'scientific integrity / misconduct' and the dates of publication will be presented. This provides an overview of the development of attention for certain phenomena and how these waves of attention are related. This will be done both for scientific publications as well as newspaper articles. Chapter four will be concluded by a brief comparison of these media.

Subsequently, chapter five introduces the results of full-text analyses performed on various samples of scientific publications, newspaper articles and policy documents. The most relevant results will be discussed. Successively the results will be contrasted with the trends and dimensions discussed in the theoretical framework. This latter part will be the core of chapter six.

Lastly, concluding answers to the research questions will be stated in chapter seven, followed by a discussion of additional relevant findings, implications of the results and recommendations for potential future research directions.

2. Theoretical framework

The term 'integrity'

The Oxford dictionary defines 'integrity' as "The state of being whole and undivided", as well as "The quality of being honest and having strong moral principles" (Oxford Dictionaries, 2015). It originates from the Latin word 'integritas' meaning 'intact' (Oxford Dictionaries, 2015). The term 'integrity' is employed in many sectors of society, having its use in science, politics, economy, ethics and psychology. Within the various uses of the term 'integrity', come many different meanings and aspects.

While in politics the term 'integrity' mainly refers to the values of being transparent, non-corrupt and honest (Kaptein, 2014), the term is used in a strong connection with 'adherence to a moral-code' when it is used within the context of business and economy (Business Dictionary, 2015). Detailed and well-written overviews of integrity within the context of politics and psychology, sociology and economics can be found in (Kaptein, 2014), respectively (Erhard, Michael, & Zaffron, 2010). In this last source, a fundamental model for the concept of integrity is provided in which the interaction with the concepts of ethics, morality and legality are discussed and in which the four concepts are clearly analysed and put in a coherent framework (Erhard et al., 2010). Within their work, Erhard et al. describe integrity as the phenomenon of 'honouring one's word', whereby the authors mean: to do what you told you would do, at the time you said you would do it (Erhard et al., 2010).

Already here we spot some crucial differences in defining the concept of integrity, ranging from strict adherence to codes to the value based act of 'honouring one's word' and from being transparent to being honest.

Defining integrity and misconduct

There are many definitions of integrity and misconduct and they vary widely. A systematic overview of these definitions is possible by identifying different dimensions along which these definitions differ. The dimensions described in the following section are based on the understanding of the variation by scholars studying the debate around integrity. Here, we will use the secondary literature about integrity, in order to focus the attention in the empirical analysis of the subsequent chapters.

Broadness and intentionality

According to Fanelli, differences in the definition of integrity and misconduct take place along two main lines of contention: Broadness and level of intentionality (Fanelli, 2011). On the line of broadness one can distinguish between the very narrow definitions of misconduct, limiting it to falsification, fabrication and plagiarism (FFP); the broader definitions include several aspects currently referred to as questionable research practices; and the conceptually open definitions include unethical behaviours not strictly linked to research practices (Fanelli, 2011).

The line of intentionality mainly refers to the definition of misconduct. Along this line one can distinguish between three main categories: intentional acts, those performed with the intention to deceive; grossly negligent acts, done in 'reckless regard for the truth'; and careless acts, which discard 'the standards of a reasonable, normal person' (Fanelli, 2011).

Several reasons for the diversity of definitions can be identified:

- Goals of definition: "If the definition is set to prevent researchers from fraud, then a narrow definition is preferred. If the goal is to promote responsible conduct of research (RCR) or foster research integrity then definitions must enter the grey areas and therefore should be broader and have lower intentionality thresholds. Moreover, if the aim is to promote higher ethical or political values, then definitions will go beyond research practice and enter the white realm of generic ethical values" (Fanelli, 2011).
- 2) Beliefs about the capacity of research communities to self-correct and self-police and beliefs about the level of control that society should exert on research (Fanelli, 2011).
- 3) Different words are used to express the same concept (Fanelli, 2011).

However broad or narrow a definition is set, according to Salwén any definition has one specific condition to satisfy. In giving an explicit critique on the definition of scientific misconduct adopted by the Swedish Research Council, Salwén suggests that any definition of integrity or misconduct in science should at least satisfy the 'ordinary language condition': "It should be consisted with how the terms are used by scientists" (Salwen, 2015). In this, he opts for a uniform way of defining misconduct and integrity pointing to policymakers and scientists.

In addition, several claims have been made on the reasons why to care about research integrity. Notably the paper by Science Europe (2015) describes seven reasons why research integrity is important. In essence, the authors conclude that the importance of research integrity boils down to the concept of trust: Research integrity is important because researchers must be able to 'trust' each other. They must also be trusted by society. (Hiney, 2015; Science Europe, 2015)

Value-based or norm-based

Besides the dimensions discussed by Fanelli, other grounds for the diversity in definitions of 'integrity' and 'misconduct' in research have been proposed. Godecharle et al. (2013) distinguish two main approaches to defining integrity and misconduct. They use the terms 'positive approach', for those guidelines emphasizing the principles of research integrity, and 'negative approach', for those focussing on a definition of misconduct (Godecharle, Nemery, & Dierickx, 2013). In order to better understand the diversity in guidelines and codes of conducts, they translated the distinction between the two approaches into the ethical concepts of values and norms, distinguishing between a value-based and a norm-based approach, respectively (Godecharle et al., 2014). As they state, definitions of misconduct are based on norms. Subsequently, "the unavoidable differences in research contexts will lead to diverse definitions", as is asserted. A value-based approach is more reliant on the underlying values of researchers, which are "more likely to be universally accepted" (Godecharle et al., 2014).

A similar distinction is made by Steneck (Steneck, 2006). Regarding several definitions of misconduct, integrity and responsible conduct of research, he distinguishes between those defining research integrity in terms of 'moral principles' and those defining it in terms of 'professional standards'. In this, the former is closely related to the value-based approach as indicated by Godecharle et al., whereas the latter resembles the norm-based approach. In his article, Steneck furthermore poses that "defining research integrity in terms of both moral principles *and* professional standards is problematic." Hence opting for a choice of either of the two.

Besides the focus on the moral-based and rules-based definitions of misconduct and integrity, Steneck also claims the existence of a trend in the definitions, moving from a 'public interest'-based definition towards a 'scientific/research'-based definition. He states that "... the clause that had initially been designed to broaden government authority in the public's interest is now used to restrict that authority to protect the perceived interest of the research community" (Steneck, 2006). Subsequently, Steneck opts for a revision of definitions, in which the former focus on public's (i.e. those not directly involved in science or its policy) interest is restored and in which the 'institutional aspects' of integrity are more intensively highlighted.

Components of research

In a 2005 study by Martinson et al., it was shown that the frequency of scientists engaging in questionable research practices widely exceeds the number of scientists engaging in FFP (Martinson et al., 2005). It is therefore suggested that definitions of misconduct restricting to FFP are too limited because only a small proportions of acts harming the essence of science are captured under this definition. In addition, numerous acts of misconduct were specified, resulting in the following list:

- 1. Falsifying or 'cooking' research data
- 2. Ignoring major aspects of human-subject requirements
- 3. Not properly disclosing involvement in firms whose products are based on one's own research
- 4. Relationships with students, research subjects or clients that may be interpreted as questionable
- 5. Using another's ideas without obtaining permission or giving due credit
- 6. Unauthorized use of confidential information in connection with one's own research
- 7. Failing to present data that contradict one's own previous research
- 8. Circumventing certain minor aspects of human-subject requirements
- 9. Overlooking others' use of flawed data or questionable interpretation of data
- 10. Changing the design, methodology or results of a study in response to pressure from a funding source
- 11. Publishing the same data or results in two or more publications
- 12. Inappropriately assigning authorship credit
- 13. Withholding details of methodology or results in papers or proposals
- 14. Using inadequate or inappropriate research designs
- 15. Dropping observations or data points from analyses based on a gut feeling that they were inaccurate
- 16. Inadequate record keeping related to research projects

In this, we identify several components of research:

- Data management (1,5,6,7,9, 15)
- Human or societal aspects and personal contact (2, 4, 8)
- Authorship and publication (3, 5, 11, 12, 13)
- Funding of research (3, 10)
- Methodology of research (9, 10, 13, 14, 15, 16)

The above specified behaviours arose from focus-group discussions in which scientists from top-tier research universities commented on the misbehaviours that were of greatest concern to them (Martinson et al., 2005). Considering the 'ordinary language condition' (Salwen, 2015), it might therefore only seem natural that the derived aspects of research that they refer to, should be ubiquitous in documents defining or discussing research integrity.

The list of core aspects of research related to misconduct and integrity that we established above, closely resembles the categorisation of scientific misconduct given by the OECD in (OECD, 2010). Minor differences can be spotted in the fact that the above list does not include 'personal misconduct' (which according to the OECD refers to 'inappropriate personal behaviour' and 'insensitivity to social or cultural norms'). In contrast, the OECD does not explicitly refer to 'human or societal aspects' in their categorisation, though 'abuse of laboratory animals' and 'violation of human subject protocols' are listed (under the heading 'research practice misconduct', which further seems to refer to methodological aspects of research).

Integrity and ethics

Concerning the broadness of the definition of integrity, we note that the above listed aspects of research that are closely related to integrity are also viewed to be closely related to ethics in research. In the papers of Pimple (2002) and Resnik (2015), a categorisation of research ethics is presented. Table 2.1 presents the description of principals linked to ethics in research as they were found by Resnik (Resnik, 2015).

In this, a clear overlap with questionable research practises can be spotted. Only the societal aspects of research (animal welfare and public responsibility) are more stressed in the articles on ethics than on integrity (Pimple, 2002). In addition, the aspects identified by Resnik refer more explicitly to values in research, adhering a strong value-based approach to defining ethics in research (Resnik, 2015). Despite of the clear overlap of definitions, in the articles by Pimple and Resnik, integrity is only considered to be a part of what it means to perform 'ethical research', hence considering all other aspects to lie outside of the scope of integrity and thus adopting a fairly narrow approach to the concept. In general we conclude that it is ambiguous where to draw a line between integrity and ethics.

Different authors tend to adopt different positions and hold different opinions regarding the boundary line between integrity and ethics. As we saw, in the papers of Pimple (2002) and Resnik (2015), the one concept is viewed as just one of the many parts constituting the other. However, considering the definition of integrity and misconduct, as given by the OECD (2010) or the ESF (2011), we conclude that here, to have integrity means that one also takes duty of care for the human and animal subjects that are used in research. In addition, dealing with the "socio-ethical *context* of research" is considered to be a part of what it means to have integrity in science (ESF/ALLEA, 2011).

Principal	Explanation
Honesty	Strive for honesty in all scientific communications. Honestly report data, results, methods and procedures, and publication status. Do not fabricate, falsify, or misrepresent data. Do not deceive colleagues, granting agencies, or the public.
Objectivity	Strive to avoid bias in experimental design, data analysis, data interpretation, peer review, personnel decisions, grant writing, expert testimony, and other aspects of research where objectivity is expected or required. Avoid or minimize bias or self-deception. Disclose personal or financial interests that may affect research.
Integrity	Keep your promises and agreements; act with sincerity; strive for consistency of thought and action.
Carefulness	Avoid careless errors and negligence; carefully and critically examine your own work and the work of your peers. Keep good records of research activities, such as data collection, research design, and

	correspondence with agencies or journals.	
Openness	Share data, results, ideas, tools, resources. Be open to criticism and new ideas.	
Respect for Intellectual Property	Honour patents, copyrights, and other forms of intellectual property. Do not use unpublished data, methods, or results without permission. Give credit where credit is due. Give proper acknowledgement or credit for all contributions to research. Never plagiarize.	
Confidentiality	Protect confidential communications, such as papers or grants submitted for publication, personnel records, trade or military secrets, and patient records.	
Responsible Publication	Publish in order to advance research and scholarship, not to advance just your own career. Avoid wasteful and duplicative publication.	
Responsible Mentoring	Help to educate, mentor, and advise students. Promote their welfare and allow them to make their own decisions.	
Respect for colleagues	Respect your colleagues and treat them fairly.	
Social Responsibility	Strive to promote social good and prevent or mitigate social harms through research, public education, and advocacy.	
Non-Discrimination	Avoid discrimination against colleagues or students on the basis of sex, race, ethnicity, or other factors that are not related to their scientific competence and integrity.	
Competence	Maintain and improve your own professional competence and expertise through lifelong education and learning; take steps to promote competence in science as a whole.	
Legality	Know and obey relevant laws and institutional and governmental policies.	
Animal Care	Show proper respect and care for animals when using them in research. Do not conduct unnecessary or poorly designed animal experiments.	
Human Subjects Protection	When conducting research on human subjects, minimize harms and risks and maximize benefits; respect human dignity, privacy, and autonomy; take special precautions with vulnerable populations; and strive to distribute the benefits and burdens of research fairly.	

Table 2.1: Principals related to ethics in research (Resnik, 2015)

Fostering integrity and preventing misconduct

As with the plurality of definitions of integrity and misconduct in science, a wide spectrum of potential measures to foster integrity and prevent scientific misconduct is suggested. These range from training and mentoring to focussing on sanctions and promoting policies.

Not only does a distinction between the value-based and norm-based approach in defining misconduct and integrity lead to different definitions, it also applies toward the possible prevention of research misconduct and promotion of integrity, according to Godecharle et al. (2014). Adhering to a value-based approach might lead to a focus on training and the use of role models, whereas adhering to a norm-based approach would make one more likely to focus on generating clear and applied rules and potential sanctions. Even more general, one might expect a report written in a norm-based (or

'negative') fashion to be more focused on the repression of misconduct rather than on the promotion of 'good science' in the form of responsible conduct of research. For a document written in a value-based manner the contrary might be expected.

Studying the incentives of researchers to commit misconduct, Fanelli et al. (2015) show that the chances of a researcher engaging in misconduct are highest "in countries that lack research integrity policies, in countries where individual publication performance is rewarded with cash, in cultures and situations were mutual criticism is hampered and in the earliest phases of a researcher's career." Therefore, it is suggested that: "Efforts to reduce and prevent misconduct,..., might be most effective if focused on promoting research integrity policies, improving mentoring and training, and encouraging transparent communication amongst researchers" (Fanelli, Costas, & Lariviere, 2015).

In this recommendation, and also more in general, we may distinguish between several activities promoting integrity in science. The differences occur mainly in the dimension of individual versus structural activities and on the dimension of promotion versus prevention. In the first dimension, we distinguish between activities focussing on the individual behaviour of researchers and activities focussing on the characteristics of the environment in which researchers work. In the second dimension, a distinction is made between activities focussing on the promotion of integrity and responsible conduct of research on the one hand and activities focussing on the prevention of misconduct on the other. For example, additional attention for writing new policies will be categorised as an activity that focuses on the research environment (rather than the individual researcher) and on the prevention of misconduct (rather than the promotion of integrity), whereas improving mentoring and training would classify as examples of activities that aim at promoting integrity and focus on the behaviour of an individual researcher. Other concrete examples that are suggested to foster research integrity or prevent research misconduct are: increased open-access publishing (Nguyen, 2012), redefining the concept of misconduct (Fanelli, 2013), renewal of the funding and rewarding system of research (Martinson, Crain, De Vries, & Anderson, 2010), encouraging the publication of both positive and negative results, as well as both statistically significant and non-significant ones (Ioannidis & Trikalinos, 2007).

Among the means to foster integrity and prevent misconduct in science, there have been indicated several which are understood to be the 'best available means'. Indeed, Hiney (2015) suggests that "Training in research integrity is commonly held to be the best available means of preventing misconduct." Moreover: "In the eyes of many researchers peer review is the best kind of self-policing available" (Hiney, 2015).

Previous research

Besides the conceptual research on the meaning of the term 'integrity' in economics, conducted by Erhard et al. (2010), little conceptual research is known that specifically focuses on integrity in research. Indeed, there have recently been specific calls for research in this area in order to clarify the concept of 'scientific integrity' within the realm of the different sciences (Fanelli et al., 2015). Intensive research has been performed on the frequency and the amount of cases of scientific misconduct that have occurred. An overview of these researches and a meta-analysis of the results of them have been published in (Fanelli, 2009). In addition, a recent paper by Science Europe presents an overview of the contemporary meaning of the concept of 'research integrity' and difficulties that the concept is currently facing (Hiney, 2015).

As far as known to the authors, there has not yet been performed any comparative study on the way in which the concept of integrity is discussed and defined by scientists, journalists and

policymakers. Also in this respect, recent calls for additional research have been made (for example in: (Godecharle et al., 2014)).

As is clear, an overwhelming variety of definitions of scientific integrity and scientific misconduct is available and some of these tend to show major differences. Many efforts have been undertaken on the formation of novel codes and guidelines for research integrity. Currently there are numerous guidelines for scientific integrity, usually specific for a single country or even for a single research institute (VSNU, 2012). With the existence of so many codes and guidelines to prevent scientific misconduct come plenty different classifications of aspects that are considered to be misconduct and what aspects are considered to be linked to the phenomenon of scientific integrity (Hiney, 2015).

These differences take place along the lines of:

- Broadness (narrow vs. broad definitions)
- Positive or negative approaches
- Individual or structural measures
- Focus on promotion or repression

Major differences between definitions and approaches of scientists, policymakers and journalists are believed to be undesirable as they lead to misunderstandings and different varied focusses. In particular, differences between policymakers' approaches and scientists' approaches, which is to say: between approaches of those setting the norms and those having to live up against them, are considered to be one of the factors that may lead to misconduct.

In addition, the debate on research integrity is commonly presented as if there is only one debate. However, in my research I will show that there are major differences between the debates on research integrity within science, policy and media, each having its specific focus on various components of research and measures to resolve a lack of integrity. The differences in definitions, both within and between the various debates, will be outlined in the remaining of this document.

3. Methods

This chapter will present the employed methods in our research. First, a general overview of the technique of *scientometrics* will be given and subsequently detailed accounts of the performed analyses and manners for presentation of results will be presented. Lastly, we will give a full account of the gathered data and the manner in which these specific data were sampled.

Scientometrics

In order to answer the research questions, we will employ the approach of *scientometrics*, which can be defined as the "quantitative study of science, communication in science, and science policy" (Hess, 1997). Scientometrics is a methodological approach in which science literature becomes the subject of quantitative research. Originally, scientometrics started off as an index to improve the information retrieval in science. It however soon resulted in a novel instrument in the empirical study of sciences and in currently used tools to measure scientific impact and citation scores, such as the Science Citation Index (Leydesdorff & Milojevic, 2015). Besides a study of scientific progress and impact, as well as the formation of tools to establish science indicators, scientometrics has developed a part of research that uses insights from the quantitative study of science and technology for evaluation and policy purposes (Leydesdorff & Milojevic, 2015). The aim of the scientometrics research area is to form a map of science: "the visualization of the topology of relationships between elements or aspects of science" (Rip, 1988).

Mapping science can have multiple goals and purposes. First, it can be employed for the purpose of information retrieving from scientific journals. Second, it can be used to create understanding of the dynamics of science and lastly it has been used for informing science-policy decisions about the allocation of resources (funding) and rewards (Leydesdorff & Milojevic, 2015). Scientometric analysis focuses on revealing the internal structure of intellectual domains, that is: mapping the components of disciplines, fields, or specialties on the basis of evidence from the literatures under study. This can be achieved by mapping subject terms, documents, authors' œuvres, or journals. The basic data are co-occurrence counts, co-word counts and journal-journal citation records.

Co –word analysis is a technique that employs the relation and patterns of co-occurrence of pairs of units (words or phrases) in a text to identify relationships between ideas within the subject area. Various indexes based on frequencies of co-occurrence of units, such as the proximity index, are used to measure the strength of relationships. Based on these indices, units of the text are clustered into groups in network maps. For example, a proximity map can be used to reveal the connections between areas of the subject that might not have been noticed by simply reading the documents. By comparing the network maps of different time periods, the dynamics of science and the development of specific subjects in science can be detected (Qin, 1999).

Precisely these co-word counts were employed in our research to answer the research questions stated in chapter one. Documents have been searched for the term 'integrity' and the (frequent) occurrence of other relevant terms. By means of this, a model was made of the usage of the term 'integrity' within the written texts. In this, we have limited ourselves to documents written in English as it is believed that these form a complete overview of the overall collection of scientific journals, policy documents and newspaper articles. Next to forming a model of the contemporary usage of the term, the method described below also provided us with a model for the genealogy of the term 'scientific integrity' when differentiation was made between publishing dates of the articles studied in the

analysis. Performing the analysis both on science policy documents as well as on scientific publications and newspaper articles presented us with the desired differentiation between the three types of media.

Summarizing, quantitative methods from the field of scientometrics – word counts, and cooccurrence counts – were used to obtain qualitative information about the employment of the term 'integrity' within science. By using quantitative methods, we counted the number of times that specific words and phrases are used in combination with, or with reference to, the term 'integrity'. The overview of these words and phrases then yielded an insight in the usage of the term 'integrity' and the aspects that it refers to. This analysis was performed in the dimension of time (past and contemporary usage of the term) and in the dimension of different media (comparing scientific publications to science policy documents and newspaper articles). The choice for this specific method was based on the options that it provides for including enormous amounts of data within the scope of the research, much more than would be possible when using qualitative methods such as questionnaires or interviews. Moreover, the availability of specialist tools within the area of scientometrics research allowed us to perform various specific analyses on the obtained data. A description of the performed analyses and the employed data will be presented below.

Analyses

The approach employed to answer the research questions is in some respects similar to the one described by Walterbusch et al. (2014). In their research, Walterbusch et al., identified the genealogy and the use of the word 'trust' in scientific literature from the past fifty years. The analyses in our research were performed using the quantitative content- and text mining program *KH Coder* (Sourceforge.net, 2016). Before executing the analysis, the following steps were undertaken:

- a) The data collected was prepared for software-aided quantitative analysis as follows:
 - i. Spel check: Incorrectly spelled words can lead to imprecise and potentially invalid results. The software-aided analyses requires every word to be spelled correctly and consistently (hence, differences between American English and British English were also deleted.)
 - ii. Removal of hyphenation: the software used in the analysis accepts compound words with dashes, but it cannot differentiate between dashes and hyphens; therefore, hyphens should be removed.
- b) Pre-processing data: The collected data has to be pre-processed in order for the software to be able to conduct its research. Pre-processing was conducted in the following manner:
 - i. All plurals were made singular.
 - ii. All verbs were transformed into the present tense.
 - iii. So-called *stop words* were removed. These are words or phrases that are commonly used in texts, which are of minor importance for content analysis. These include words such as 'the', 'and', 'or', 'as' etc. The standard list of stop words published in the *KH Coder* documentation (Sourceforge.net, 2016) was extended with the words: 'c', 'p' and '%', to form the list of stop words employed in this analysis.
 - iv. POS tagging: all terms were given a tag identifying them as 'nouns', 'verbs', 'adjectives', 'adverbs' or 'propernoun' (i.e. names of persons, institutions etc.).

After preparing the data for the analysis, several forms of analysis were performed:

<u>Co – occurrence networks</u>

In this type of analysis, a *co-occurrence network* of a specific term is constructed. In order to do this, one first specifies a unit of search, which is either 'sentences' or 'paragraphs'. Subsequently, all units containing the specific search term are gathered. All terms occurring in the gathered units are then compared on the basis of the *Jaccard index*, which is defined as follows:

For two words X and Y, the Jaccard index J(X,Y) is computed as:

$$J(X,Y) = \frac{\#(X \text{ and } Y)}{\#(X \text{ or } Y)} = \frac{\#(X \text{ and } Y)}{\#(X) + \#(Y) - \#(X \text{ and } Y)}$$

In this, #(X) is the number of units containing X, where 'unit' refers to either sentence or paragraph (i.e. we count the number of times that X and Y occur in the same unit, relative to the number of units that contains either X or Y).

Unless otherwise stated, all co-occurrence networks presented in this report contain the sixty strongest connections that are present among all terms in the given units (i.e. all pairs of words that are present in the given units are considered and the sixty pairs having the highest Jaccard index are shown in the figure). In this figure, a line (in this field of research usually called 'edge') between two words indicates that these two words form one of the sixty pairs of strongest connections. In addition, thicker edges correspond to stronger connections (i.e. higher Jaccard indices). A cluster of words that is connected is given the same colour and larger nodes correspond to more frequently used words. Furthermore we note that the positioning of the words does *not* indicate a level of connection between them. Nodes that are nearby but not connected by an edge do, in general, not represent a stronger connection between the occurrences of the corresponding words, than nodes that are further apart. Figures 5.2 and 5.10 present examples of co-occurrence networks. In the networks propernouns are not included except for the propernoun 'Integrity'. Hence the term 'integrity' may occur twice in a network, once as a noun and once as part of a name of an institute, office etc. These cases can be distinguished by the fact that the latter will be written with a capital, whereas the former will not.

Theme analysis

In this type of analysis, groups of words called 'themes' are analysed, rather than single words. Under the term 'theme' we represent a cluster of words that refer to a common phenomenon. In table 3.1 an overview of the themes that we distinguish and some of the words that have been grouped under this theme are presented. A complete list of the themes and all words that have been categorised under them can be found in appendix B. The classification of the themes was done primarily inductively, by considering the word lists and frequency tables of a set of ten policy documents and ten scientific publications. Going through these lists, themes were identified using the described techniques in (Ryan & Bernard, 2000). Notably, variants of the techniques 'cutting and sorting' and 'word lists and KWIC' described in (Ryan & Bernard, 2000) were used. Subsequently, words were selected by-hand and classified under the identified themes. Lastly, the list of themes and corresponding words were replenished under consideration of the identified themes and aspects as described in chapter two, theoretical framework.

In the analysis, we followed the same procedures as with the co-occurrence networks but instead of counting individual words, we counted how often a certain theme (i.e. a word assigned to that theme) is used. In the analysis we were interested in absolute frequencies of usages of the themes, as well as in co-occurrences of the various themes in the same paragraph. In the co-occurrence networks for themes that we present in this document, the measure of co-occurrence of two themes is again the *Jaccard index* and the figures express the twenty strongest connections. Once again, thicker edges correspond to higher Jaccard indices and thicker nodes correspond to more frequently used themes. In addition, the positioning of the nodes does not provide any information about the connection of the themes. Nodes that are nearby but not connected by an edge do, in general, not represent a stronger connection between the occurrences of the corresponding themes than nodes that are further apart.

Theme	Examples of words	
Authorship	Author, authorship, journal, paper, publication, publish	
Education	Education, training, train, educate	
Finance	Fund, funding, grant, finance, tax, money, cost	
Institution	Institution, federal, community, national,	
	government	
Integrity	Integrity, ethical, ethic	
Misconduct	Misconduct, plagiarism, fraud, fabrication,	
	falsification	
Policy	Policy, guideline, code, recommendation	
Promote	Promote, protect, development, improve, 'best	
	practice'	
Repression	Sanction, punish, corrective, accuse, allegation	
Science	Science, scientist, research, researcher, academic	
Society	Society, public, environment, health, human	
Virtue	Trust, honesty, trustworthy, responsibility,	
	respect, faith, dignity	

Table 3.1: Classification of themes

Description of data

For the analysis, the following sets of data have been studied. Without further reference the listed documents have been studied in full-text:

Scientific publications

The information of scientific publications was collected from the *Web of Science* database (Thomson Reuters, 2016). Within this database publications from all scientific domains are included. It includes the following databases:

- Science Citation Index Expanded
- Social Sciences Citation Index
- Arts & Humanities Citation Index
- Conference Proceedings Citation Index (Thomson Reuters, 2016)

We specify several sets of documents that have been studied:

 Abstracts of scientific publications: For the analysis we selected all publications that contain either of the phrases: 'scientific integrity', 'research integrity', 'scientific misconduct' or 'research misconduct' in their title or abstract. Subsequently, all available abstracts of these articles were analysed. This resulted in a set of 637 abstracts. Furthermore, we specified three periods in order to do an analysis on the evolution of the usage of the term 'integrity' in scientific publications over the years: 1991-1995: containing 68 articles

2001-2005: containing 86 articles

2011-2015: containing 210 articles

2. Top frequency articles: We performed an analysis on the full-texts of articles in the Web of Science database, that contain the words 'scientific integrity', 'research integrity' and/or 'scientific misconduct' most frequently in their abstract. There are ten articles in the database that contain at least five occurrences of either of the above three specified terms. These ten articles have been subject to the analysis that will be described here. The ten articles that were used can be found in the Web of Science database under the following association numbers (use the 'advanced search' option and query 'ut =' followed by the association number):

Article	Association	number
1	00032791110	0017
2	00035500760	0012
3	00016724420	0003
4	00033198090	0005
5	00033933360	8000
6	00030158060	0004
7	00032689370	0006
8	00033436630	0001
9	00028680450	0001
10	00022747490	0009

3. *Science and Nature publications:* As a last set of data we collected the publications in the *Web of Science* database that were published in *Science* or *Nature* and that contain the phrase 'research integrity' or 'scientific integrity' in their title, abstract or keywords. The gathered articles were subdivided over three periods:

OLD :	period 1987 - 1990 (5 Nature, 7 Science, all that was available)
MIDDLE :	period 1995 - 2000 (10 Nature, 10 Science - selection based on most citation)
NEW :	period 2010 – 2015 (9 Nature, 8 Science, all that was available)

For the first and last period all available articles were gathered (i.e. all published articles that matched the search terms). For the middle period, there were more than ten articles per journal available. A selection was made on the basis of number of citations, selecting the papers that were most frequently cited. This decision was based on the assumption that the articles with

most citations have the highest probability of being influential on the discourse of integrity. The temporal phases were chosen in such a way that the middle period corresponds to the first period of the sample of policy documents, which will be described in the subsequent paragraph. The choice for the range of the first period was grounded on the availability of publications, starting at 1987.

Policy documents

Policy documents were collected from a list of key policy documents that was established as part of the WP2 work package of the PRINTEGER project (PRINTEGER, 2015). The list of policy documents consists of 126 documents from institutes and organisations all over the world. The list includes the following information: organisation that produced the document, name of the document, date, region, target group, type of the document (e.g. guidelines, statement, report), whether following the policy stated in the document is mandatory, and whether the document describes procedures for dealing with alleged misconduct. The entire list can be found on (PRINTEGER, 2016).

Based on this list, two sets of documents were collected:

1. *Temporal division*: 20 documents were collected: The most recent ten documents and the ten oldest documents from the list of key policy documents. The ten most recent documents all date from 2014 or 2015 (6 from 2014, 4 from 2015), while the ten oldest documents data from the period 1995-2001 (1 from 1995, 1 from 1997, 1 from 1998, 2 from 1999, 3 from 2000, 2 from 2001).

From the recent documents six were classified as '(university) policy', three were classified as 'guideline' and one as 'recommendation'. The oldest documents were classified as 'guideline' (4), '(university) policy' (4), 'declaration' (1) and as 'rules for conduct' (1).

2. Geographical division: Policy documents from five European countries were collected: the selected countries are: Germany, Italy, Norway, the Netherlands and the UK. A specific focus on European documents was chosen because of the European nature of the PRINTEGER project for which part of the research was performed. In order to gather a uniform set of data we selected the university and institute policies (hence only policy documents specific for one research institute or university and not those from national policies or umbrella organisations) that were available in English. These documents were gathered to allow for specific comparison between the documents of different countries. Documents were gathered from the list established in the PRINTEGER work package 2, which is shown in (PRINTEGER, 2016). This resulted in a set of 10 British documents, 9 Dutch documents, 8 German documents, 4 Italian and 5 Norwegian documents. To avoid effects caused by temporal differences with respect to publication date of the documents, all documents in this set were gathered from the period from 2002 onwards, with the vast majority of documents dating from after 2010.

Newspaper articles

Newspaper articles were gathered through the *LexisNexis* search engine (Lexisnexis, 2016). Only articles from newspapers written in English were gathered. Via the search engine *LexisNexis*, data was retrieved via the search term " 'research integrity' OR 'scientific integrity' " and searches were performed for articles that contain either of these phrases in their title or lead. We then divided the search results in three periods:

- OLD : 15 articles from 1987 1990 (all articles)
- MIDDLE : 19 articles from 1995-2000 (sorted on relevance, top 19 selected after deletion by-hand of articles that are not actually about research integrity or are close duplicates of other articles)
- NEW : 19 articles from 2010-2015 (sorted on relevance, top 19 selected after deletion by-hand of articles that are not actually about research integrity or are close duplicates of other articles)

In the first phase, the OLD phase (1987-1990), there were fifteen articles that matched our search terms and we selected them all (after checking that they were actually on the topic of integrity in science and research). In the other phases, MIDDLE (1995-2000) and NEW (2010-2015), there were more articles that matched the search terms. Therefore, we sorted the articles on relevance (a standard option in *LexisNexis*). Subsequently, the top 19 articles from the list were selected, after deleting those that were (almost precise) duplicates of one another and those that were considered too far off-topic. The phases were chosen such that the dates matched those of the temporal periods used in the analyses of the scientific publications.

Summary

Table 3.2 presents an overview of the datasets that have been employed for the analysis in our research. It mentions the medium (Scientific articles, policy documents or newspaper articles), the specific document set and the total number of words and paragraphs in the studied texts. The number of words that is indicated equals the number of words in the texts after pre-processing, which means that the stop words are not included in the word count here. It should be noted that the paragraphs in policy documents usually do not take more than a single sentence due to the point-wise structure of the texts. Therefore the number of words per paragraphs after pre-processing is fairly low.

Medium	Document set	Number of words	Number of paragraphs
Scientific articles	Abstracts of scientific publications	9061	987
	Top frequency articles	4847	586
	Science and Nature publications	9329	1020
Policy documents	Temporal division	7970	3840
	Geographical division	14686	6267
Newspaper articles	Temporal division	7444	764

Table 3.2 : Summary of datasets

4. Results: The timing of integrity

Integrity is widely considered to be an essential aspect of research. However, it has not always been around in the scientific debate. In fact, the concept has only been discussed for a fairly limited number of years, especially when compared to the length of the period in which scientific research has been performed.

This chapter maps the use of integrity in time. Herewith it will contribute to answering the first sub question and, by considering various media, the third sub question set in chapter one. Due to a lack of a large and consistent database of policy documents, the analyses in this chapter are limited to scientific publications and newspaper articles.

Scientific publications

In this section we will briefly discuss the results of a search through scientific publications via the *Web of Science* database. When saying that we 'search' in Web of Science, in this section, we refer to a search through the following information fields of a publication record:

- Title
- Abstract
- Keywords
- Keywords Plus

It should be noted that all articles in Web of Science are included in these searches and that searches are not restricted to the data sets described in chapter three.

Commencement of usage

First, we will discuss at what time in history the usage of terms related to integrity in science are noticeable in scientific literature. Figure 4.1 presents the number of hits in Web of Science for the search terms: "research integrity", "scientific integrity", "misconduct" and on the combination of the terms "ethics" and "science".

As shown in figure 4.1, the number of publications on all terms rises, starting from 1990 onwards. Interestingly, attention for the concept of 'misconduct' precedes the attention for the other phenomena, seeing a rise in the number of publications already in the 1980s. It is not until ten years later that substantial usage of the term 'integrity' can be spotted in scientific literature.

Concerning the number of publications on the four aspects indicated in the figure below, we note that the growth rate is much higher than that of science in general. Indeed, Bornmann and Mutz computed that the number of published scientific papers currently grows exponentially with a doubling period of about 24 years (Bornmann & Mutz, 2016). However, the number of publications on the concepts of 'research-' and 'scientific integrity' has grown over four times over the past 24 years, while the number of publications on the concepts of misconduct in science and ethics in science has grown with a factor five respectively ten. Hence, also relatively the attention for the concepts of integrity, misconduct and ethics in science has grown drastically in the last few decades.

The start of the interest for the concept of integrity in scientific journals started in the late 1980s and early 1990's, with publications in high-impact journals such as *Nature* and *Science*. The first major paper putting attention to the phenomenon of fraud in science and raising questions about the integrity of science can be found in 1987 with the *Nature*-publication of Stewart and Feder (1987). In their article, they particularly discuss the case of misconduct by the young scientist Darsee and the consequences of

his single case for science in general. The highly cited paper by Stewart and Feder is subsequently followed by comments and commentaries in high-impact journals by among others Braunwald (1987)



Figure 4.1: Uusage of key terms in scientific debate

and Dawson (1987) in *Nature* and Mason and Bivens (1990) in *Science*. With the publication of these articles, the attention of science in the phenomenon was established. Furthermore, we notice that the vast majority of the early papers on integrity originate from North-American institutes. It is not until 1995 that the first papers concerning integrity are published from European institutes (to be specific, from Scandinavian institutes).

In figure 4.2 below we plotted the sum of the number of publications referring to research-, scientific- or academic integrity, as well as the number of publications referring to either of the terms research -, scientific – or academic misconduct in science and the number of publications referring to both integrity and misconduct. As can be seen, the number of publications referring to misconduct greatly exceeds the number of publications referring to integrity. Moreover, we conclude that nearly all publications referring to integrity also mention an explicit phrase referring to misconduct in science. Hence, it seems rare for scientists to discuss integrity without mentioning misconduct, while vice versa, discussing misconduct without mentioning integrity, is quite common.



Figure 4.2: Overlap of articles referring to integrity and to misconduct.

Within both figure 4.1 and 4.2, some clear peaks can be spotted. These seem to be the effect of a single or very few cases of severe misconduct. Indeed, the peaks in figure 4.2 can be explained by the large amount of attention gained by the cases around AIDS researcher Robert Gallo and the case around Thereza Imanishi-Kari and nobel laureate David Baltimore in the early 1990's and the case around the Korean scientist Hwang Woo-suk in 2006. It can be concluded that even in scientific publications, attention for scientific misconduct is fairly case dependent.

Forms of misconduct

Last, figure 4.3 presents the number of hits in Web of Science when searching for different forms of scientific misconduct. In this we focused on the currently most acknowledged forms of misconduct and hence restricted ourselves to FFP and the term 'scientific fraud'.

We conclude that main attention is offered to the concept of plagiarism, while little attention seems to be drawn by the concepts of data fabrication, falsification and scientific fraud. Of particular interest is the attention paid to the concept of plagiarism with a peak in 1980, losing some attention afterwards and retaining it in the 1990's. As it seems, there is one article by E. Garfield in 1980 (Garfield, 1980) that is in particular responsible for the number of hits on plagiarism in 1980 (having over 150 citations). Curiously however, within his article the word 'integrity' is not used a single time. In addition, the word 'integrity' pops-up extremely rarely in the articles commenting on Garfield's paper and other articles on plagiarism from the early 1980s. As it seems, back in 1980, integrity was not commonly referred to as a concept related to plagiarism in science.

In general there seem to be two early cases of misconduct that have drawn the attention of the scientific community and raised concerns about the concept of misconduct, its causes and its consequences. These were the cases of the Jordanian scientist Alsabti, found guilty of plagiarism (Anonymous, 1980) and the American scientist John Darsee, found guilty of data fabrication (Stewart & Feder, 1987).



Figure 4.3: Forms of misconduct addressed in scientific publications

Newspaper articles

In this section we will comment on searches within the search engine *Lexisnexis (Lexisnexis, 2016)*. With *Lexisnexis* we have searched for the use of terms referring to the concept of scientific integrity within newspapers. This has been done both for newspapers written in English as well as in Dutch.

When searching through newspaper articles, the *Lexisnexis* search engine searches through:

- The title and subtitle of the article
- The lead
- The body (or main part) of the article
- The name of the author(s) and of the newspaper
- Subjects (adjusted to the article by the search engine).

In the first part of this section we will comment on the searches through newspapers written in English and the second part of the section will be devoted to similar searches through Dutch newspapers.

English newspaper articles

Once again, we will first address the timing of the first usage of integrity or misconduct in English newspaper articles. Figure 4.4 shows the usages of the term 'integrity' (in combination with either 'research', 'scientific' or 'academic') and 'misconduct' (in combination with either 'research', 'scientific' or 'academic'). In addition, it shows the number of articles in which both terms referring to integrity as well as terms referring to misconduct are used. Interestingly, this figure shows that the number of articles referring to either 'integrity' or 'misconduct' grows very similarly, while relatively few articles refer to both aspects. In general, we see that in the beginning of the 1990's there is an initial increase in the number of articles referring to integrity in science, whereas a further major augmentation takes place between 2003 and 2006. After some decline in the attention for the subject in the years 2008-2010, the number of articles using either of the terms (especially the term 'Academic integrity') has grown strongly from 2011 onwards.



Figure 4.4: Usage of key terms in English newspaper articles

figure 4.5 shows the number of articles in which the authors explicitly mention either of the most common forms of scientific misconduct. In the figure, we see that in the past fifteen years plagiarism is

by far the most frequently referred to form of misconduct. Prior to that, in the period 1985 – 2000, newspaper articles more commonly contained a phrase referring to 'scientific fraud'. In addition, the fabrication of data in science is a concept that is discussed to some extent in newspapers, whereas the act of 'falsification' in research is hardly referred to.

What is interesting to note is that the attention for the concept of 'Scientific fraud' precedes the attention for the concept of 'misconduct' in science, with mentioning of 'Scientific fraud' starting in 1985 and mentioning of 'misconduct' only after 1990. This suggests that, initially, journalists used the term 'fraud' rather than 'misconduct' to describe acts of misbehaviour in research.



Figure 4.5: Forms of misconduct addressed in English newspaper articles

Dutch newspaper articles

In this section, we will briefly comment on the searches done through Dutch newspapers in Lexisnexis. The first figure below, figure 4.6, shows the number of Dutch articles referring to 'wetenschappelijke integriteit' (scientific / research integrity), 'wangedrag' (misconduct) and 'wetenschappelijke fraude' (scientific fraud). We observe that there is very little attention for integrity until the year 2011 (the year of the Stapel-affair), in which there is major occurrence of the concept.

Besides the sudden, rapid increase in usage of the term 'integrity' after the disclosure of the Stapelaffair, more interesting information can be obtained from figure 4.6. First, we see a clear peak at 1996 – 1997, in the usage of the term 'Wangedrag' (Misconduct). In this period there was attention for the affair around professor Diekstra, who was accused of acts of plagiarism. In addition, a small peak can be spotted in 2006 (the Wang-case) and in 2012 (around the German politician Zu Guttenberg). In the latter both cases, the peak can be spotted in the usage of the term 'integrity'. In general it is remarkable that Dutch newspapers, contrary to their English congeners and the scientific publications, show more frequent usage of the term 'integrity' rather than 'misconduct' or 'fraud'. Moreover, the term 'fraud' is more common than the term 'misconduct'.



Figure 4.6: Integrity and misconduct in Dutch newspaper articles

From the above analyses it becomes clear that the coverage of the concept 'integrity in research' in newspapers is heavily dependent on the direct input of events taken place in science. Whereas Dutch newspapers only started to properly consider integrity in research after the Stapel-affair, English newspapers gather their input from a more global range, but it is still case-dependent.

Comparison

Comparing the newspaper articles with the scientific journals, we conclude that the attention for misconduct and integrity is much more simultaneous in newspapers. Where in scientific journals we tend to see attention for misconduct first and attention for integrity only afterwards, the attention for these two phenomena seems to coincide in newspaper articles. However, we also see that in scientific literature, the percentage of publications referring to both integrity as well as misconduct is much higher than in newspaper articles. Hence, even though newspaper articles do not seem to report on the combination of integrity and misconduct as much as scientific publications do, the attention for the two concepts seems to be more related in newspapers than in scientific journals.

Contrary to what might have been expected, the attention for integrity and misconduct in science appears more early in scientific journals than it does in newspapers. In both media, major attention can be spotted in (or around) 1990, but scientific publications start their reporting already in the middle 1980s.

Furthermore, an interesting difference can be spotted in the fact that in scientific journals authors tend to write about 'research integrity' and 'research misconduct', in newspaper articles this seems to be replaced by the terms 'academic integrity' and 'academic misconduct'.

As a last remark, we observe that the number of articles written in newspapers is much less steady and continuous than that in scientific journals. The number of articles in newspapers, as might have been expected, seems to be more dependent on direct input from events happening and it therefore fluctuates more than the number of scientific publications.

5. Results: full-text analyses

Various definitions of the integrity in research have been presented. These definitions are believed to differ along various dimensions and lines of contention, ranging from broadness to intentionality and from individual to structural components of research. Nonetheless, the debate around integrity is usually presented as a single one, being similar in various forms of media. In this chapter we show that, after all, the discourse of integrity is different in various sectors of research.

This chapter maps the approaches to the concept of integrity in research by scientists, policymakers and newspaper journalists. The results of various analyses presented in this chapter will support in answering the second and third sub questions, set out in chapter one. For reasons of clarity and brevity, only few of the obtained results will be presented and discussed in detail. Supplementary results and figures will be presented in the first appendix to this document and will be omitted from discussion in this chapter.

Scientific publications

First, the results of full-text analyses in scientific publications will be presented and discussed. As described in chapter three, methods, there are three sets of scientific publications that have been studied:

- 1) Abstracts of all articles in the *Web-of-Science* database (Thomson Reuters, 2016)that contain either of the phrases 'research / scientific' ' integrity/misconduct' in their title or abstract.
- 2) Full-texts of articles in the *Web-of-Science* database (Thomson Reuters, 2016) that contain the phrases 'research / scientific' ' integrity/misconduct' most often in their abstract.
- 3) Full-texts of Science and Nature articles from three temporal periods using the terms 'scientific-' or 'research integrity'.

The results of the analyses on these documents will be presented separately.

Abstracts of scientific publications

First, we will consider the results of the theme analysis performed on the documents. Figure 5.1 presents the results of this analysis, showing the percentage of paragraphs referring to a particular theme and the standard error bars. This is done for documents from three temporal phases (1991-1995, 2001-2005 and 2011-2015) and for the entire set of documents (from the period 1991-2015).

Within this figure there are several aspects that are particularly interesting. First, we note that the usages of the various themes are very constant throughout the various temporal phases. For most terms, only very limited differences can be spotted between the frequencies of usage in the different temporal phases, though there are some differences that we may highlight:

- The theme 'misconduct' is used relatively frequent in the first period (1991-1995), in which its usage is even greater than that of the theme 'integrity'. Afterwards, the usage declines in the second period and increases again in the last period. From this perspective, we might conclude that the attention for 'misconduct' has been taken over by that for 'integrity' after an initial prevalence of the theme 'misconduct'. Indeed, in the later period 'integrity' is used significantly more often than the term 'misconduct' while this was vice versa in earlier periods.
- The usage of the theme 'repression' shows a similar pattern as that of misconduct, being more strongly present in the first and last period than in the middle one.



Figure 5.1: Theme analysis of abstracts of scientific articles, including standard error morgins

- The usage of the theme 'promotion' shows an exact opposite trend, having a peak at the middle period. However, the theme 'promote' is much more frequently used than the theme 'repression' in all phases.
- The theme 'authorship' has been declining in its usage after the first period, but shows a major increase in its usage in the most recent period.
- Lastly, the theme 'society' shows a substantial decline in usage over the years. Having its most frequent usage in the oldest period, it has been continuously declining in attention ever since.

The subsequent figure, figure 5.2, presents the co-occurrences of the various themes in the texts. We only show the co-occurrence network based on the entire set of documents (corresponding to the sample 'all' in figure 5.1). The figures of the individual phases are highly similar, showing a clear consistency in usage of terms referring to integrity in scientific publications, and can be found in appendix A, figures A.1-A.3.

As was described in chapter three, methods, figure 5.2 shows the twenty strongest connections between the various themes and indicates stronger connections by thicker lines. Clusters of themes with mutual strong connections are given the same colour. The choice of colour is arbitrary and does not possess any significance.

We conclude that in general, the theme 'integrity' is most strongly linked to the theme 'science', which is mainly caused by the usage of phrases like 'research integrity', 'scientific integrity' and 'integrity in science'. Furthermore, the themes 'society' and 'promote' are closely connected to 'integrity', whereas the themes 'authorship' and 'science' are most strongly connected to misconduct. Considering the various temporal phases we conclude that the theme 'integrity' has a close connection to the theme 'science' in all phases. In addition, it is connected to the theme 'society' in all figures (see appendix), as well as to the theme 'institution' and it has a particularly strong connection to 'promote' in all periods. Besides this, we note that a strong connection of the theme 'integrity' and 'society' pops-up in the second period and between 'integrity' and 'policy' in the last. Furthermore, we note that the concepts 'misconduct' and 'authorship' gain a strong relation over the years.



Figure 5.2: Co-occurrence networks of themes in abstracts of scientific publications (entire dataset)

Concerning the individual words rather than themes, the co-occurrence networks of the term 'integrity' are presented in the appendix, figures A.4 - A.7. In addition we present a table, table A.1, showing the usage of specific key terms, in number of occurrences per thousand words. There are several interesting aspects that show up in these figures.

First, we note, as in all other documents that we studied, the shift from 'scientific integrity' in the earlier phase to 'research integrity' in the later phases. Second, the word 'provide' is very closely linked to 'integrity' in the first and second phase (as well as in the overall analysis). Reading through the documents for the occasions that the two words co-occur does not show some specific meaning or relation between the two terms.

Considering the terms that are not directly connected to the term 'integrity' but do show up in the figures, we note that several terms relating to the concept of 'authorship' show up. Indeed, we observe terms as 'author', 'publish', 'article' and 'journal' showing up. This is, however, not the case for the oldest documents. In the figure for the period 1991-1995, only the terms 'article' and 'author' are present, though not connected.

In addition, several 'positive' terms show up in the figures: 'promote'-'responsible'-'conduct' (not always connected in this fashion).

In the 1991-1995 figure the term 'sanction', referring to repression of misconduct, also shows up, while it does not in the later phases. This is in line with the earlier findings based on the theme analysis. With regard to the importance of research integrity for the relation of science with society, we note the

cluster 'important'-'role'-'society' in the figure of the middle phase and the tandems 'health'-'public' in the figure of the entire database, and 'public'-'attention' in the figure for the first phase.

Lastly, we note that 'ethical' and 'ethic' are present in nearly all figures (in all figures, at least one of the two is present) and usually they are quite close to 'integrity' (the path from integrity to either of the terms is short). In particular, in the figure for all documents the terms 'integrity' and 'ethical' have a strong direct connection. Hence, we conclude that the concept of 'integrity' is used together with the concept 'ethics' suggesting a broad definition of 'integrity'.

Top frequency articles

Secondly we present the results for the articles showing most frequent usage of key terms 'research /scientific integrity/misconduct'. In this we will be very brief, because the results closely resemble the results of the analyses of the abstracts of scientific publications. In particular, the results of the analyses of abstracts from the entire database (period 1991-2015) are similar to that of the analysis presented in this section.



Figure 5.3: Co-occurrence network of themes in full-texts of top frequency articles

As we observe, figures 5.1 and 5.3 are highly similar. Besides the presence of the theme 'virtues' in figure 5.3 and its absence in figure 5.1, only minor differences can be identified. Accordingly, the results for the individual terms and co-occurrence networks of terms rather than themes also show major similarities. We conclude that, concerning their usage of terms related to integrity in science, the abstracts of scientific articles are representative for the rest of the articles. As such, the amount of

analysed abstracts provides major validation and robustness of the results and conclusions presented in this report.

Science and Nature publications

Lastly, we present the outcomes of analyses of publications in the journals *Science* and *Nature*. The publications in these journals, referring to integrity in their title or abstract, were subdivided in three temporal phases: 1987-1990 (OLD), 1995-2000 (MIDDLE) and 2010-2015 (NEW), containing 12, 20 and 17 publications respectively.

Figure 5.4 presents the results of the analysis, including the standard error. From the results we conclude the following:

- In the NEW phase a strong increase in the use of the themes 'authorship' and, to lesser extent, 'education' can be spotted, compared to the earlier phases. These trends were spotted in the earlier analyses as well.
- In the earlier stages there is (slightly) more attention for the theme 'repression' as compared to 'promote', whereas in the NEW phase these figures have altered and the attention for 'promote' exceeds the attention for 'repression'.
- In the OLD phase there is significantly more attention for the theme 'policy' compared to the later phases.
- The NEW phase has relatively a very low number of paragraphs that do not contain any of the themes. Hence we might conclude that in the recent publications scientists actually tend to devote very large proportions of their articles to matters that are closely related to the term 'integrity'.



Figure 5.4: Theme analysis of full-texts in Science and Nature publications, including standard error morgins

Preparing co-occurrence networks of themes, the earlier spotted trends are confirmed. Indeed, we see that integrity finds itself in the same cluster as 'education' and 'promote' in the NEW phase (see figure 5.5). Meanwhile, the term 'education' is not even present in the two other diagrams (representing the fact that none of the twenty strongest connections in the other phases included the theme 'education'). The diagrams for the OLD and MIDDLE phase are presented in the appendix, figures A.8 and A.9. Second, we note that the themes 'repression' and/or 'misconduct' seem to have a strong connection to the theme 'authorship' in all of the phases. The same goes for the themes 'finance' and 'institution' and for the combination 'society' and 'institution'.



Figure 5.5: Co-occurrence networks of themes in Science and Nature publications, NEW phase

These trends are further confirmed by the co-occurrence networks of individual words, presented in appendix A, figures A.10 – A.12. From these networks we conclude that 'integrity' is connected to 'misconduct' in the first two phases, while it is not in the last. Second, the MIDDLE phase shows many terms referring to organisational structures such as 'institution(al)', 'government', 'federal', 'community', 'commission' and 'agency', many of which disappear in the network of the NEW phase. In contrast, we observe that the NEW phase holds words in its diagram like 'training', 'strengthen', 'improve', 'promote' and 'protect', referring to a promotion of good conduct (rather than the punishment of misconduct). This is in line with the conclusions from the previously discussed analyses. Moreover, the figure for the middle period holds terms referring to publishing and authorship like 'review(er)', 'manuscript' and 'editor'.

Policy documents

In this section the results of full-text analyses on policy documents will be presented and discussed. For this media, two samples of documents were studied. From the list of key policy documents established in PRINTEGER work package 2 (PRINTEGER, 2015) we gathered a set of documents

- 1) Providing a range of temporal phases
- 2) Providing a range of geographical origins

A precise description of the sampled documents can be found in chapter three, methods. The full list of key policy documents from which the analysed documents were sampled, can be found online on (PRINTEGER, 2016).

Temporal division

First, the theme analyses of the documents gathered from two temporal phases will be discussed. As described in chapter three, we gathered the ten oldest documents from the list (this category will be called OLD) and the ten most recent documents from the list presented in (PRINTEGER, 2016) (which will be called NEW).

Figure 5.6 shows percentage of paragraphs that contain a reference to the various themes in both the OLD and the NEW phase. In addition, the standard errors for all categories are presented.



Figure 5.6: Theme analysis in policy documents, temporal division, including standard error morgins

In this we observe that the differences between the older texts and the more recent texts are very limited in their usage of the various themes. Usually, the difference between the older and more recent texts is below 2 %. There are just two exceptions to this: first, the fact that the themes 'promote' and

'virtue' are used significantly more in the older texts compared to the more recent texts. In addition, the attention for 'policy' increases in the more recent texts.

In the subsequent figures, 5.7 and 5.8, we present the co-occurrences of the various themes in the texts. Hereby we may analyse not only how often several themes are used but also get a view on how their usages are related and what themes are used more frequently together in the same paragraph. The networks show the twenty strongest co-occurrences (indicated by edges) in which thicker edges correspond to stronger connections. The employed measure of co-occurrence is again the *Jaccard index*. All analyses were done on the paragraph level.



Figure 5.7: Co-occurrence network of themes in full-texts of OLD policy documents

Several trends may be spotted: the concept of integrity is most strongly connected to the concepts of 'virtue' and 'promote' in the older texts, while in the more recent texts it is most strongly connected to the themes 'misconduct', 'repression' and 'institution'. Also interesting, the concept of 'finance' shows up in the figure of the more recent texts (connected to 'institution', 'science' and 'integrity') while it does not appear in the earlier phase.


Figure 5.8: Co-occurrence network of themes in full-texts of NEW policy documents

The trends found in the results of the theme analysis, can also be found when considering individual words rather than themes. From the co-occurrence networks of the terms 'integrity' and 'misconduct' in both the OLD and the NEW documents, we extract the interesting fact that in the most recent texts 'integrity' has the strongest connection to the terms 'misconduct', 'breach' and 'research', two of them being rather 'negative' words referring to a (potential) lack of 'integrity'. In the older texts, we find 'integrity' in the same cluster as more 'positive' words as 'good' and 'promote'. As it seems, in the later years, more emphasis was grown on the lack of integrity and researchers or scientists 'breaching' with the rules, whereas in the older documents the emphasis was on 'promoting good science' or 'promoting good practice'. This statement is enforced by the terms that are present outside the cluster of 'integrity' but within the top-60 words of co-occurrence with the term. In the older documents we find words as 'trust', 'dignity', 'respect', 'responsible', 'responsiblity' and 'caring'. Those words are all absent in the figure on the most recent texts. In contrast, the most recent texts refer to the concepts of 'sanction' and 'corrective'-'action', which are not present among the top 60 in the older texts.

In addition we see, as we saw earlier analysing scientific publications, that over the years there can be spotted a shift from the use of the phrase 'scientific integrity' to the phrase 'research integrity'. Figure 5.9 presents the co-occurrence network of 'integrity' in the NEW phase. The co-occurrence network for 'integrity' of the OLD phase, as well as the networks for 'misconduct' in the OLD and NEW phase, are presented in appendix A, figures A.13-A.15.



Figure 5.9: Co-occurrence network of 'integrity' in NEW policy documents

When considering the co-occurrence networks of 'misconduct' somewhat similar results and trends can be spotted as in the figures for the networks of 'integrity'. Again, the more recent documents tend to have a stronger connection between the term 'misconduct' and the more 'negative' terms such as 'failure', 'concealment', 'unreasonable', 'correction' and 'sanction'. All of these words are absent in the figures of the older texts. In contrast, the older texts mention the words 'faith', 'good' and 'protect', which seem to address the problem of 'misconduct' more from the side of prevention, rather than repression.

As could have been expected, in both the older and the more recent texts we see many words that refer to an 'investigation' of misconduct by a 'committee' or 'commission', leading to 'recommendations' and 'responses' written down in a 'report' or 'statement'.

An interesting aspect to note is that in the co-occurrence networks of 'integrity' and 'misconduct' there appear strong concepts 'european'-'national' in the OLD documents which are not present in the NEW documents. It could indicate a selection bias in the data selection, having a favour for European documents in the OLD set as compared to the NEW set. However, it is rather the opposite: The set of OLD documents contains twice as many non-European texts compared to the NEW documents. Hence, we should conclude that policy documents make clearer connections to the national or European level

in the OLD phase as compared to the new phase. This could be explained from the trend of institutionalising science in the last decades.

Geographical division

Next, we will present the results of analyses done on a sample of policy documents originating from different European countries. The documents were sampled from institutions in: Germany, Italy, Norway, The Netherlands and the UK. Information about the selected documents can be found in chapter three, methods.

Considering the results of the theme analysis of these documents, we spot some remarkable differences between European countries. Figure 5.10 shows the usage of the various themes in policy documents originating from various European countries.



Figure 5.10: Theme analysis in policy documents, geographical division, including standard error margins

First, we note that there are some differences between the usage of the theme 'integrity' compared to the theme 'misconduct'. Mainly in Dutch and Norwegian texts, the former theme is used in considerably more paragraphs than the latter. In German documents however, we spot a nearly tenfold higher usage of the theme 'misconduct'.

A second remarkable aspect is the usage of the theme 'society', which is remarkably low in German texts and remarkably high in Norwegian documents.

Furthermore, a relatively frequent usage of the theme 'institution' can be spotted in Dutch and Italian documents. This also holds for the theme 'authorship' in Dutch and German documents. Lastly, the extremely low attention for 'repression' in Norwegian texts is striking. In general, we spot a clear adherence to a value-based, positive approach in Norwegian documents, while mainly German documents tend to adhere a norm-based, negative approach (Godecharle et al., 2014; Steneck, 2006).

Some of the trends described above are also visible, and are hence confirmed, by the co-occurrence networks of themes for the various countries. For reasons of clarity and brevity, these figures are omitted here, and can be found in appendix A, figures A.16-A.20. Focusing on the role of the theme 'integrity' in the figures we conclude that 'integrity' has a strong connection to 'policy' and 'institution' in the British, Dutch and Norwegian documents. However, it is has strong connection to 'society' in German policy documents and is connected to 'virtues' and 'institution' in Italian documents. In addition, there is a strong connection between 'authorship' and 'integrity' in the Dutch documents. Moreover, the themes 'virtues' and 'integrity' are connected in the network for Norwegian documents, as might have been expected considering the previous results.

Furthermore, the theme 'misconduct' co-occurs most frequently with the theme 'repression' in British documents, with 'institution' and 'science' in the German documents and – remarkably – with 'virtues' in Dutch texts. In the other figures the theme 'misconduct' is not present (showing that it is only weakly connected to other themes in the Italian and Norwegian documents).

Last, we will analyse the usage of individual words within the selected documents. The cooccurrence networks are presented in appendix A, figures A.21-A.25. With regard to these figures we first note that the term 'integrity' shows up only in the co-occurrence networks for the Netherlands, the UK and Norway, indicating that the term has no particularly strong connections to any other term in the German and Italian documents. In the Norwegian and British documents we observe that it is connected to 'research' and 'researcher'. Most interestingly, the term 'integrity' is strongly connected to 'violation' and 'complain' in the Dutch document, showing clear attention for a lack of integrity in research.

Furthermore, we note that the term 'honesty' shows up in three of the five figures (being only absent in the Dutch and German figures). In addition, we spot the words 'fairness', 'impartiality' and 'equity' in the Italian figure, showing the strong attention for virtues in these documents that we discovered earlier in the theme analysis.

Besides these terms, we see other 'positive' terms such as: 'trust' (German and Italian), 'good'-'practice' (British and Norwegian), 'promote'-'high'-'standard' (Italian), 'protect'-'reputation' (British) and 'restore'-'confidence' (German). Interestingly 'trust' and 'society', postulated as one of the key reasons to consider research integrity, have a strong connection in German documents.

Interestingly, we saw that 'integrity' and 'institution' were closely linked as themes in the Italian texts, though in the co-occurrence network of 'integrity' we find the terms 'personal' and 'individual', while the terms referring to institutions are not present.

In general, we observe only few terms referring to the concept of 'authorship' and 'publication' in the networks. Only the figure for the UK contains the words 'peer'-'review' as terms that refer to this phenomenon (even though the themes 'integrity' and 'authorship' were closely connected in the Dutch documents). In addition, the British figure is also the only one to address the theme 'finance', by stating the terms 'fund' and 'funding'.

As other remarkable aspects, we note that the Norwegian figure explicitly shows the terms 'misconduct', 'plagiarism', 'falsification' and 'fabrication' (suggesting a narrow definition of integrity and misconduct), while all these terms are absent in the other figures. In addition, the Dutch texts show clear attention for the concept of education by stating the terms 'education' and 'teaching'. Lastly, we note that only the German documents show a term referring to repression of misconduct occur in the networks by means of the term 'penalize'.

Newspaper articles

Results from the analyses based on the newspaper articles will be the last results to be presented in this chapter. For analysis, the newspapers were subdivided in three temporal periods 1987-1990 (OLD), 1995-2000 (MIDDLE) and 2010-2015 (NEW). The presentation of the results in this section will once again be commenced by the results of the theme analysis, shown in figure 5.11.



Figure 5.11: Theme analysis in newspaper articles, including standard error margins

Within this figure, several remarkable aspects can be noticed:

- Overall there is extremely little attention for the theme 'education' within the newspaper articles. In addition, the themes 'promote' as well as 'repression' gain just little attention. This might be called surprising especially for the latter one. It could have been expected that newspapers would, among others, focus on the sanctions that were given to researchers found guilty of misconduct. This however, does not seem to be the case.
- Over the years the attention for the themes 'authorship', 'integrity', 'policy' and 'virtues' has considerably increased. The usage of these themes in the NEW texts is substantially greater than it was in the MIDDLE and OLD texts.
- There is relatively a lot of attention for the theme 'society' in the MIDDLE phase. This attention increases from the OLD to the MIDDLE phase and gradually decreases again afterwards.
- Curiously, in the NEW phase, there is more attention for the theme 'integrity' than there is for the theme 'misconduct' while in the earlier phases this was not the case, showing heavily more attention for 'misconduct' than for 'integrity'.

Considering the co-occurrence networks of themes for newspaper articles, several trends described above were confirmed. The co-occurrence networks are presented in appendix A, figures A.26 - A.28. Within these figures, numerous remarkable aspects can be spotted: First, we note that the concepts of 'misconduct' and 'repression' are closely related in the newspapers of all phases. The same goes for 'science' and 'institution'.

Second, we note that in the OLD newspapers there are strong connections between the themes 'integrity' and 'promote' and the themes 'authorship' and 'policy'. These connections strongly weaken or even disappear in the later phases.

Third, it is interesting that in the NEW newspapers the themes of 'integrity' and 'finance' and 'institution' are so strongly related. Especially the connection with 'finance' can be considered surprising. Indeed, we saw an increase in the usage of specific words that related to 'finance' in the NEW phase, though these words were distributed over fewer paragraphs than in the more early phases. Hence we conclude that the paragraphs that discuss the theme 'finance' contain relatively many words referring to this theme and in these paragraphs also the theme 'integrity' is commonly present.

On the level of individual terms, interesting aspects can be found in the co-occurrence networks of 'integrity' in the MIDDLE and NEW phase, presented in the appendix, figures A.29 and A.30.

In the figure of the MIDDLE phase, several aspects pop-up that we did not came across in the figures of the other media. For example, a close connection between the words 'patient' and 'safety' can be spotted (something that might be at stake when 'integrity' is missing in research in the medical sciences). In addition, there is a cluster of words referring to 'money', 'taxpayer' and 'study', indicating that it is usually the 'money' of the 'taxpayer' that is used to finance the 'studies' of scientists and researchers.

Also interestingly, the words 'misconduct', 'falsify' and 'fabricate' are connected to each other. Two forms of misconduct show up here, but plagiarism is not one of them. This is the opposite of what we observed in the figures of the other media (notably that of the scientific publications) where it was only plagiarism that showed up in the figures while fabrication and falsification were absent. One possible explanation for this is the potential reference to specific cases of (severe) misconduct. However, it is still surprising that only newspaper journalists specifically refer to these types of misconduct while scientists and policymakers do not.

With respect to the figure for the NEW phase, we observe that combinations as 'best' and 'practice' as well as 'highest' and 'standard' occur. These are positive words referring to performing science itself. The words referring to societal aspects (such as 'patient' and 'taxpayer') that were listed in the previous phase are not present anymore. Hence, it seems that the attention for societal aspects that was present in the MIDDLE phase decreases again in the NEW phase. In the NEW phase attention is put again on the nature of science itself. This confirms the patters that were spotted in the theme analysis.

Comparison

After performing full-text analyses on the articles in various media concerning the concept of 'integrity' in science and research, several conclusions can be drawn regarding the usage of the term 'integrity' in these documents. Besides the results for the single media, which are presented in the several sections focusing on a specific medium, we will derive some conclusions about similarities and differences between the various media. Those conclusions will be presented in this section. In this analysis we distinguish the following types of articles:

Scientific publications: Refers to the analysis of abstracts from the Web of Science database

<u>Top frequency articles</u>: Refers to the scientific publications that use the key terms 'integrity' and 'misconduct' most frequently in their abstract. These articles were studied in full-text.

<u>Science and Nature publications</u>: Refers to the publications in *Science* and *Nature* that were analysed in full-text.

<u>Policy documents</u>: With no further reference to date or location of publication this refers to the whole of policy documents that have been studied in full-text.

Newspaper articles: Refers to the English newspaper articles that were studied in full-text

Let us first consider the term 'integrity' itself. Compared with the other major term in our documents, the term 'misconduct', we see that nearly all documents use the term 'misconduct' more frequently. In the *Science* and *Nature* publications we even see a great difference in the usages, showing a frequency of the term 'misconduct' of five to ten fold the frequency of the term 'integrity' is some periods. However, the OLD and NEW newspapers and the middle-aged scientific publications form an exception to this trend. In these documents, an equally, or even slightly more, frequent usage of the term 'integrity' was observed. A potential explanation for this is the fact that the term 'fraud' seems to be used for the same concept as 'misconduct' in newspapers. Especially in the OLD phase, we see frequent usage of the term 'fraud'.

Secondly, table 5.13 presents the results of the theme analysis in the various media. The table presents per phase and per media the themes that are connected with the theme 'integrity', sorted by strength of their connection. In this, we observe that the theme 'science' is connected to 'integrity' in nearly all phases and media. The same goes for the theme 'institution', although connection only emerges in the later phases in policy documents and *Science* and *Nature* publications. Moreover, a trend from 'promote' and 'virtues' in the older phases to 'misconduct' and 'repression' in the later phases can be spotted both in newspapers and in policy documents (where the alteration is greatest in policy documents). In scientific publications, this trend is not visible. It is even the contrary: a strong connection between 'promote' and 'integrity' can be spotted in all phases.

Medium	OLD phase	MIDDLE phase	NEW phase
Scientific publications	Promote	Promote	Promote
	Science	Society	Policy
	Authorship	Science	Science
	Policy	Institution	Institution
	Institution	Authorship	Authorship
	Society	Policy	Society
Science and Nature	Virtues	Misconduct	Promote
publications	Science	Institution	Education
		Science	Science
		Society	Institution
Policy documents		Virtues	Repression
		Promote	Misconduct
		Policy	Institution
			Science
			Finance
			Policy
Newspaper articles	Promote	Misconduct	Science
	Society	Science	Institution
	Institution	Society	Finance
	Science	-	Policy
			Misconduct

Table 5.13 - Theme analysis: themes connected to 'integrity' in various media and phases, sorted in descending order of strength of connection.

Lastly, the themes 'policy' and 'finance' show up in the later phases of newspapers and policy documents, while being very strongly present at the last phase of scientific publications. This is not the case in *Science* and *Nature* publications, in these documents the attention for policy even seems to drop over the years.

Besides the trends outlined above, an interesting pattern regarding the theme 'authorship' can be observed. This theme drastically gains attention in the scientific publications and *Science* and *Nature* publications when proceeding from the older documents to the more recent ones. However, in newspapers this attention significantly declines and in policy documents it is stable at a very low level.

Another interesting aspect in the documents is the connection between the term 'integrity' and terms referring to societal concepts. In all phases we see only very limited attention for the theme 'society' (in absolute numbers). The fact that the theme 'society' shows up as one that has a connection with the theme 'integrity' in the MIDDLE phase of *Science* and *Nature* publications should in this respect not be overestimated. We do not see any term relating society to integrity in the co-occurrence network of the term 'integrity' and in addition the absolute frequencies of terms referring to 'society' is (very) low. In contrast, quite high absolute frequencies of terms referring to society in the OLD policy documents are observed. Interesting here is to see that this attention drops completely in the NEW phase. Moreover, in newspapers we see relatively high frequencies of terms under the heading of the theme 'society' in the OLD and MIDDLE phase. In addition, there are some specific terms referring to 'society' that show up in the co-occurrence networks of 'integrity'. These terms include: 'patient'-'safety', 'taxpayer' and 'hospital'.

In scientific publications in general we see a declining level of attention for the theme 'society' when considering absolute frequencies. Although the connection between 'integrity' and 'society' is notably strong in the middle phase. Overall, the tandem 'public'-'health' shows up in the co-occurrence networks of 'integrity' in scientific publications.

Hence, we conclude that the connection between 'integrity' and 'society' is weak in *Science* and *Nature* articles, while it was stronger in policy documents and newspapers. However, also in these media, the connection is weakening, resulting in a weak connection between these concepts in general in contemporary documents.

In addition to the connection with 'society', also the connection with terms referring to 'institution' shows an interesting pattern. In general, we conclude that the concepts 'integrity' and 'institution' become more related in the more recent documents, although they were already related in the older documents anyway. This holds especially for the scientific publications and the policy documents. Interesting to note here is that in general the connection between 'institution' and 'misconduct' is even stronger. As it seems, for all media, an institution plays a significant role in handling misconduct, more than it is responsible for promoting or maintaining 'good conduct'.

6. Reflection

In this section we will reflect on the results of our analyses, as presented in chapter five, upon the theoretical framework as unfolded in chapter two. The trends found in our data and those suggested by other authors will be compared and reasons for differences and similarities will be suggested.

Defining integrity and misconduct

Table 6.1 presents an overview of the results from our analysis with respect to the suggested dimensions and lines of contention that were outlined in the theoretical framework. We examined the trends in scientific publications, policy documents and newspaper articles on the basis of (1) their definitions being narrow or broad, (2) the authors taking a value-based or a norm-based approach and (3) identified the aspects of research that were most commonly discussed. Because of the great discrepancies between the older and more recent policy documents we separated the policy documents in two classes.

Because there is only very limited usage of the terms referring to the culpability and intentionality of actions, we did not include the dimension of intentionality in our reflection, even though it was put forward by Fanelli as a key line of contention of definitions (Fanelli, 2011).

Documents	Narrow vs. broad	Value- vs. norm-based	Aspects of research
Scientific publications	Broad	Value-based	Authorship Methodology Society
Older Policy documents	Broad	Value-based	Society Methodology
Recent policy documents	Narrow	Norm-based	Finance
Newspaper articles	No clear indication for either	Minor shift from value- to norm-based	Shift from society towards finance

Table 6.1: dimensions of defining integrity and misconduct

Narrow versus broad

From the results of our analyses we conclude that scientific publications tend to use a broad definition for integrity, considering the fact that the terms 'ethic' and 'ethical' are closely connected to the term 'integrity' in the co-occurrence networks for scientific publications. To somewhat lesser extent, this also holds for the older policy documents. In the more recent policy documents the terms referring to FFP show up more frequently in the co-occurrence networks of integrity and misconduct, while the terms referring to ethics are absent. For the newspaper articles, no clear indication can be found from our analysis for either very narrow, or for more broad definitions.

Value-based versus norm-based approach

Regarding the adopted approach (value- or norm-based) in the texts, clear distinctions can be spotted between the scientific publications and older policy documents on the one hand and the more recent policy documents on the other. Whereas the former are characterised by frequent usage of terms referring to values and virtues, the latter shows a more frequent usage of terms referring to sanctioning

and punishing misbehaviour in research. In the newspaper articles, the adopted approach does not show as clearly as in the other documents. Nevertheless, a more value-based approach can be spotted in the older documents while in the more recent newspapers a slightly more norm-based approach can be identified, considering the theme analysis of these documents.

Interestingly, we spot a correspondence between documents adopting a broader view on integrity and misconduct and those adhering a positive, value-based approach in defining it. Similarly, those documents adopting a narrow definition tend to adhere a norm-based approach.

Aspects of research

Last, we identified the aspects of research that were most frequently referred to in the given documents. The scientific articles tend to refer to the concept of authorship and publication most often, while having substantial attention for methodology and (in lesser extent) society. In both the policy documents and newspaper articles, a shift of attention from societal aspects to financial and funding aspects of research is identified. Also, some minor attention for the methodology of research can be spotted in the older policy documents.

With regard to the aspect 'data management' we note that the term 'data' (for instance in data, database, data analysis, data storage, etc.) is hardly used in all the documents. Hence, there is only very limited explicit reference to this aspect of research in all media, even though it has been put forward as a major aspect of concern by scientists (Martinson et al., 2005).

Additional

The trend spotted by Steneck in (Steneck, 2006) concerning a shift from 'public interest' to 'scientific/research interest' of definitions of integrity and misconduct, cannot be confirmed by our data. Indeed, we see a slight decline in the usage of the word 'public' in nearly all documents (except newspapers, where its usage is stable). Moreover, we cannot spot an increase in the usage of terms referring to science or research, nor does the connection between the terms 'integrity' or 'misconduct' with terms referring to 'science' increase over the years. Hence, no explicit evidence for this trend can be observed.

Moreover, there is a striking similarity between documents from different sources and phases. Notably, scientific articles and older policy documents highly resemble each other with respect to the dimensions discussed in this section. A possible explanation for this might be that several decades ago there was substantial overlay in the groups of 'scientists' and 'policymakers', scientists perhaps often being the ones who wrote the policy documents and codes of conduct. In contemporary science, these groups have plausibly been divided and it are no longer scientists themselves who write science policy documents.

Promoting integrity or preventing misconduct

This section will comment on the manner in which integrity is suggested to be promoted and misconduct is suggested to be prevented or repressed. The discussion will be based on the dimensions sketched in the theoretical framework. In table 6.2 the documents are examined on whether they:

- (1) suggest an individual or institutional / structural measure
- (2) suggest a way of promoting integrity or repressing misconduct
- (3) focus on educational /training measures or policy aspects

Documents	Individual vs. institutional	Promotion vs. repression	Education vs. policy
Scientific publications	Both	Promotion	Shift from education to policy
Older Policy documents	Individual	Promotion	Strong favour for Policy
Recent policy documents	Institutional	Repression	Strong favour for Policy
Newspaper articles	No clear indication for either in older documents, in recent documents the focus lies on institutional aspects	Minor shift from promotion to repression	Policy

Table 6.1: dimensions of approach in fostering integrity and preventing misconduct

Individual versus institutional

With respect to the first dimension in which measures to promote integrity or prevent misconduct in science tend to differ, the individual – institutional dimension, a clear favour for individual aspects can be noticed in the older policy documents, while the institutional aspects are very apparent in the more recent policy documents. In scientific publications, references to both individual and structural aspects were found, while newspaper articles do not present a clear favour for any of the two. Although terms referring to institutions are frequently used in (especially more recent) newspapers, they do not seem to be closely related to the term 'integrity' in this medium.

Promotion versus repression

With regard to this dimension, we conclude that many similarities can be found between the results here and the approach that was considered in defining integrity and misconduct (value- or norm-based). Indeed, scientific articles and older policy documents tend to focus on promoting integrity, while the more recent policy documents tend to focus on repressing and preventing misconduct. In newspaper articles, we can spot a minor shift from a focus on promotion to a focus on repression. As might have been expected, we thus tend to spot a similarity between the way of defining integrity and misconduct and the focus in responding to a lack of integrity.

Education versus policy

With regard to the two most frequently considered measures for fostering integrity and preventing misconduct, improving training and education or increasing attention for policy, we conclude that most documents tend to favour the policy approach. The term and theme 'integrity' are predominantly connected to terms referring to policy rather than to those referring to education. Especially in the policy documents this favour is evident. In these documents, the terms referring to education and training are hardly mentioned at all.

In scientific publications, the terms referring to education and training of scientists are frequently used. However, also in these documents the connection between the terms 'integrity' and 'misconduct' with those terms referring to policy matters is growing stronger, while the usage of terms referring to educational aspects is gradually declining.

This observation may lead to the question whether many of the actors in the debate around scientific integrity consider education as an insufficient means to guarantee integrity.

Additional claims

With regard to the additional claims outlined in the theoretical framework we conclude that little evidence can be found to support them. First, the suggestion that training in research integrity is commonly held to be the best available means of preventing misconduct, cannot be supported by our data. Indeed, education and training are frequently referred to by scientists. However, they are not by policymakers and journalists and even scientists seem to mention the increased attention for policy and guidelines more frequently than the option of training and educating scientists.

Second, there is only very limited reference to the concept of 'trust' or 'trustworthiness'. Hence, the claim that research integrity is important because of the fact that 'scientists need to be able to trust their colleagues' and 'society needs to be able to rely on science' (Hiney, 2015) is not explicitly referred to by scientists in their publications, nor do policymakers mention it frequently in their codes of conduct or guidelines. Even though there can be spotted an increase in the frequency of usage of the term 'trust' in scientific publications, it remains a quite uncommon term. However, it might have been expected that in many scientific articles concerning research integrity, scientists would have made a statement in their abstract about the reasons why the phenomenon is so important. Therefore, the absence of the words 'trust', 'trusting', 'trustworthiness' etc. indicates that it might after all not be the most important reason stated by scientists to behave according to the rules of integrity.

For the claim of peer-review being the best way of self-policing according to scientists, we could not find any supportive nor disputing evidence. In just some of the documents peer-review is closely connected to the term 'integrity' (especially in the older policy documents), while in many it is not. However, in this case, the absence of the phrase 'peer'-'review' can hardly be considered as an indication of scientists not believing in the importance or strength of the phenomenon in promoting research integrity, because there is no specific need to mention such an opinion even if it would be held.

Conclusion

In general, we conclude that in the majority of dimensions of both defining integrity and misconduct as well as promoting or preventing them, scientific publications and policy documents tend to choose different sides. Indeed, both in the way of defining integrity as well as promoting it a divergence in attention can be spotted between these documents. Whereas scientific articles and policy documents tend to disagree in many dimensions in the older documents, in the more recent documents they tend to disagree on the basis of many facets: using a broad definition (science) and a narrow definition (policy), adopting a positive approach (science) and a negative (policy), focussing on promotion (science) and on repression (policy) and on methodological, societal and publication aspects (science) or on financial aspects (policy).

7. Conclusion

In this chapter we will answer the research and sub questions stated in chapter one and we will discuss important and remarkable additional conclusions that can be derived from the results presented in chapters four and five.

Genealogy

First, we will focus on the first sub question: "How does the usage of the term 'integrity' develop over time in the various media?"

Concerning the genealogy of the term 'integrity' in the scientific arena, we conclude that the term saw its first major introduction in scientific publications in the late 1980s and early 1990s, among others introduced by Stewart and Feder (1987). The term 'integrity', as related to science and research, originated from the United States and only found its way in European scientific publications in 1995. After its original introduction in scientific records, the term was rapidly incorporated in newspaper articles and policy documents. Considering the fact that the introduction of the term 'misconduct' was prior to that of 'integrity', the latter was initially used as a response to the former. When the prevalence of misconduct in research became evident, scientists called for an increase in the standards of integrity in research, considering 'integrity' as the counterpart of 'misconduct'. In subsequent years, the meaning of the term 'integrity' as well as its usage have been subject to heated debate, which has followed different lines in different media. In scientific publications, we conclude that integrity is considered a value and a virtue, closely related to ethics in research. As such, it forms the basis of 'good scientific practices' and should be promoted. Moreover, 'integrity' in research is commonly used in the debate about authorship in research and what it means to be an author.

In science policy documents, the term 'integrity' has gradually lost its connection with ethics and is currently used in a more narrow fashion. Opposite to scientific publications, the term 'integrity' has become more directly used as the opposite of 'misconduct' in science, in science policy documents. The concept of 'integrity' is increasingly approached from a negative and norm-based perspective in policy documents, stressing the need to prevent misconduct and providing ways of sanctioning behaviour that shows a lack of integrity.

In general, attention for integrity in science is increasing, concluding from the fact that the number of articles in science and newspapers are growing, both in absolute as relative numbers.

Usage and understanding

Secondly, we will comment on the second sub question: "What aspects and concepts of science are linked to 'integrity' and what components of science are focused on?"

As was shown in the figures and tables in chapter five, the following aspects of research were most prominently linked to 'research integrity' in the various media:

Scientific publications: The themes and aspects most commonly referred to in combination with integrity are: Authorship, methodology and society. In addition, the phenomenon of promoting integrity (through various ways like increasing training and education for scientists and focussing on promoting research integrity policies) is commonly referred to.

Science policy documents:	In older documents, the aspects of society and methodology are most commonly stressed, while there is a shift to the reference to sanctions and financial aspects in recent policy reports. The older documents additionally show clear references to virtues that underpin the concept of integrity and these documents hence focus on the promotion of responsible conduct of research. Lastly, a trend from individual aspects to institutional and structural aspects of research is noticed.
Newspaper articles:	In newspaper articles focus rests on the aspects related to society in the older documents and on financial aspects in more recent documents.

iewspaper articles: In newspaper articles focus rests on the aspects related to society in the older documents and on financial aspects in more recent documents. Moreover, we see a shift from focus on promoting integrity to that of repressing misconduct and from individual aspects to institutional aspects.

Comparison

Last, the answer to the third sub question will be discussed: "What variations can be spotted between the usages of the term 'integrity' within scientific publications, policy documents and newspaper articles?"

Most interestingly, clear differences can be spotted in the approach towards using the term 'integrity' between scientists and science policymakers. Major differences in a value-based, positive approach adopted by scientists and a norm-based, negative approach adopted by policymakers are spotted, yielding a broad definition in scientific publications and a narrow in policy documents; a focus on authorship, methodology and education aspects in scientific articles and a focus on financial aspects and sanctions in policy documents. Furthermore, the approaches between the two major media in science seem to be rapidly diverging, showing major shifts in attention and approach in only two decades. One could argue that one of the reasons that the policy documents tend to adopt a more negative approach is because codes of conduct, by their nature, are normative. However, in our samples only one document was classified as a code of conduct and hence the normative nature of codes of conduct only modestly affects the results of our analyses. In addition, it can be wondered whether the shift in the policy documents to a more norm-based position is surprising, since policymakers might have to introduce concrete measures as a reaction to the seemingly widespread occurrence of misconduct. However, these two phenomena do not necessarily exclude each other. It seems to be perfectly achievable to state specific measures for dealing with cases of misconduct while still holding a valuebased approach to the concept of integrity and focussing on promotion rather than repression.

Newspapers journalists seem, in multiple aspects, to hold a position intermediate between that of scientists and policymakers, showing no clear evidence of holding either a very narrow or broad definition of integrity, adopting no clear positive or negative approach to the phenomenon and linking integrity to aspects that are either frequently considered by scientists (e.g. societal aspects) or by policymakers (financial aspects).

Undoubtedly there are several connections between the various media studied. As became clear from the timing analysis, coverage of the concept of research integrity in newspapers is nourished by input from scientific publications. In addition, as with many policy aspects, the formation of novel policy documents, including codes of conducts and guidelines, is likely to be dependent on the reporting of (severe) cases of misconduct and the outcry that it creates. Among others, newspaper articles can be considered as one of the major forms of such reporting. As a last part of the cycle, several scientific

articles have been published that specifically comment on novel policy documents, their strengths and their weaknesses (for example (Salwen, 2015)). Hence, the various media serve, with their publications, as nourishment for other media, forming a cycle in which comments are commented on by other actors. Considering these interrelations of causal effects and motivations to publish, it should be deemed even more surprising that the approach to the concept of integrity varies so widely between the various media.

Implications

Concluding from the answers to our research and sub questions, we note that the scientific and public discourse on integrity differ in some major facets. Notably, the approach adopted by policymakers tends to diverge rapidly from that adopted by scientists. It is particularly doubtful whether such a distinction in approach is desirable. Indeed, major discrepancies between the focus of those setting and formulating the norms and those having to live up to them, can hardly be considered advisable. It is a rather commonly held opinion that those rules and norms that one does not support himself are precisely the rules that one is most likely to breach with. In our case, the fact that scientists and policymakers seem to use different definitions of what it means to do 'proper science' or not to commit misconduct, may well lead to behaviour that is not in line with the suggested codes and norms. Therefore, we recommend science policymakers to adapt their approach towards defining and discussing the concept of integrity to fit in with the daily focus and practices of scientists. We believe that this might be a first, and rather achievable, manner to foster integrity in science.

Limitations and future directions

This study has taken a step in the clarification of the discourse of integrity in the scope of science. In addition, the genealogy of the term 'integrity' in science was elucidated. We intended to consider an as broad as possible sample of texts from the various media.

As it became clear in our study, the discourse of integrity is not similar in scientific publications and policy documents. However, in the analysis the discourse was assumed to be similar in the various research areas within science. No clear indications for specific differences were found, but more intensive research should be done to confirm this.

The performed analyses are based on the frequency of occurrence of certain words and themes. The results therefore express statements about the occurrence and co-occurrence of these words and themes. However, the particular connection of the phrases cannot be specified by our research. For instance, we cannot distinguish between sentences linking the terms 'integrity' and 'training' in a positive or in a negative fashion. More detailed research investigating the words in context could shed some further light on the specific connection of the studied concepts.

With respect to the timing of the debate's commencement we noted that discussion about integrity and misconduct in science started in the 1980s. This statement must be interpreted with caution, because it specifically refers to the contemporary debate around integrity, using the terms that are contemporarily employed for discussing integrity and misconduct. Prior to the 1980s discussion about what it means to do 'good' science might have been ongoing, but were conducted in a different fashion, using different words. Partially these words have been identified, for example the word 'fraud' which was used as substitute for the contemporary term 'misconduct'. However, more and other terms might have been used in previous discussion about the concept of performing 'good' and 'responsible' science.

Lastly, the analyses were performed on as large as possible datasets and we intended to consider an as broad as possible sample of texts from the various media. It can, however, not be excluded that in the

selection of the data some bias has been incorporated with respect to geographical origin or scientific domain of the documents.

Clarifying the different dimensions in the debate on integrity in science, the results of our study can provide a basis for defining the concept of 'integrity' in research and science policy statements. Respecting the difference in the discourse between various domains and finding common ground for shared principles and focus points, based on the results of this research, will facilitate in finding a uniformly accepted approach to the concept. As indicated by many other authors (Godecharle et al., 2014; Hiney, 2015; OECD, 2010; Steneck, 2006), this should be one of the key elements of future research on research integrity.

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Appendix A : figures and tables

Below we present the figures and tables that are referred to in chapter five.

Scientific publications

Abstracts of scientific publications



Figure A.1 – Co-occurrence network of themes in abstracts of 1991-1995 scientific publications



Figure A.2 - Co-occurrence network of themes in abstracts of 2001-2005 scientific publications



Figure A.3– Co-occurrence network of themes in abstracts of 2011-2015 scientific publications

Term frequencies in number of occurrences per thousand words.

Word	1991-1995	2001-2005	2011-2015	ALL
(co-)author(ship)	5.0	6.3	7.5	5.8
Career	0.4	0.5	0.6	0.5
Credib(-le / - ility)	0.4	0.4	0.6	0.5
Data				0.6
Definition + define	2.2	1.4	3.7	2.2
Education + educate	3.2	2.1	1.9	2.9
Environment(al)	0.8	3.0	1.6	1.6
Fabrica(te / tion)	0.6	1.1	2.0	1.3
Falsify / falsification	0.2	0.5	1.4	1.0
Finan(-ce / -cial)	0.4	0.4	1.5	0.9
Fraud(-ster / -ulent)	3.0	0.5	3.6	2.3
Fund(-ed / -ing / -er)	1.4	2.6	3.1	2.3
Good	1.2	1.2	1.0	1.0
Human	0.8	2.5	1.4	1.5
Institution(-al)	5.9	3.8	5.2	4.8
Integrity	8.1	14.0	13.2	9.6
Misconduct	17.2	8.6	19.6	13.2
Plagiarism	0.8	0.7	3.8	2.3
Policy	2.6	5.5	5.6	4.0
Public(ly)	3.4	3.2	2.4	2.6
Reputation	0.2	0.0	0.4	0.3
Responsib(le / - ility)	3.0	3.6	4.0	3.3
Sanction	1.4	0.5	0.1	0.4
Society	1.8	2.9	1.2	1.1
Training	2.8	1.6	2.5	1.7
Trust(-ing / -worthy)	0.6	0.7	1.6	1.0

Table A.1 – List of important terms co-occurring with the term 'integrity' Term frequencies in number of occurrence per

thousand words, abstracts of scientific publications

Total number of words:

1991-1995 : 4951

2001-2005 : 7590

2011-2015 : 21522

ALL : 59449



Figure A.4 – Co-occurrence network of 'integrity' in the abstracts of 1991-1995 scientific publications



Figure A.5 – Co-occurrence network of 'integrity' in the abstracts of 2001-2005 scientific publications



Figure A.6– Co-occurrence network of 'integrity' in the abstracts of 2011-2015 scientific publications



Figure A.7– Co-occurrence network of 'integrity' in the abstracts of all scientific publications

Science and Nature publications



Figure A.8 – Co-occurrence network of themes in Science and Nature publication, OLD phase



Figure A.9– Co-occurrence network of themes in Science and Nature publications, MIDDLE phase



Figure A.10 - Co-occurrence network of 'integrity' in Science and Nature publication, OLD phase



Figure A.11 - Co-occurrence network of 'integrity' in Science and Nature publication, MIDDLE phase



Figure A.12 - Co-occurrence network of 'integrity' in Science and Nature publication, NEW phase

Policy documents

Temporal division



Figure A.13 - Co-occurrence network of 'integrity' in policy documents, OLD phase



Figure A.14 - Co-occurrence network of 'misconduct' in policy documents, OLD phase



Figure A.15 - Co-occurrence network of 'misconduct' in policy documents, NEW phase

Geographical division



Figure A.16- Co-occurrence network of themes in British policy documents



Figure A.17 – Co-occurrence network of themes in Dutch policy documents

int<mark>egr</mark>ity

society



Figure 18 - Co-occurrence network of themes in German policy documents


Figure A.19 - Co-occurrence network of themes in Italian policy documents



Figure A.20 - Co-occurrence network of themes in Norwegian policy documents



Figure A.21 – Co-occurrence network of 'integrity' in British policy documents



Figure A.22 - Co-occurrence network of 'integrity' in Dutch policy documents



Figure A.23 – Co-occurrence network of 'integrity' in German policy documents



Figure A.24 - Co-occurrence network of 'integrity' in Italian policy documents



Figure A.25– Co-occurrence network of 'integrity' in Norwegian policy documents

Newspaper articles



Figure A.26 – Co-occurrence network of themes in newspaper articles, OLD phase



Figure A.27 – Co-occurrence network of themes in newspaper articles, MIDDLE phase



Figure A.28– Co-occurrence network of themes in newspaper articles, NEW phase



Figure A.29 – Co-occurrence network of 'integrity' in newspaper articles, MIDDLE phase



Figure A.120 - Co-occurrence network of 'integrity' in newspaper articles, NEW phase

Appendix B: Classification of theme analysis

The following coding was used for the theme analyses. Words in bold, proceeded by *, indicate the name of the theme. The phrases below, separated by |, indicate the words classified under the theme.

*integrity

integrity | ethic | ethical

*misconduct

misconduct | fraud | plagiarism | plagiarize | fabrication | falsification | fraudster | fraudulent |

fraudulently | fabricate | falsify

*science

science | scientific | scientist | research | researcher | academic | university

*finance

fund | funding | funder | funded | grant | tax | taxpayer | money | cost | costs | costly | financially | finance | financial | business | budget

*education

educate | training | train | education

*society

society | societal | human | environment | animal | environmental | environmentally | public | publicly | health | patient

*authorship

author | coauthor | co-author | authorship | journal | publication | publish | published | article | publisher | publishing | publish-or-perish | manuscript | editor

*virtues

trust | trustworthy | trusting | responsible | responsibility | dignity | respect | faith | confidence | honest | honesty

*institution

institution | institutional | community | university | committee | agency | national | european | federal | federally | government | department

*repression

sanction | corrective | retract | retraction | allegation | punish | punishment | accuse

*promote

promote | promotion | promoting | protect | protection | develop | development | improve | good | (highest & standard) | (best & practice) | strengthen

*policy

policy | guideline | recommendation | report | procedure | statement | code