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Study Shows: How Statistics Are Used to Articulate and Shape Discourses of Science in the Newsroom.

By:

Renata Faria Brandão

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"All our science, measured against reality, is primitive and childlike – and yet it is the most precious things we have."

ALBERT EINSTEIN

"We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology."

CARL SAGAN

To my parents.

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Abstract

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Renata Faria Brandão, Department of Journalism Studies

The University of Sheffield, UK

This thesis examines the use of peer-reviewed data and statistics in news communication of science through a content analysis and close reading analysis of statistical data in the United Kingdom science news and in-depth interviews with science journalists. The content analysis yields three key insights into the use of science data in the United Kingdom and Brazilian press: (1) statistics are used overwhelmingly to treat science as hard news, (2) there is an immense lack of fundamental background information about how the reported data are produced and (3) science journalists tend to use peer-reviewed data in a unique fashion: their stories include either too few or too many statistics from original sources. The in-depth interviews attempt to explain this content pattern, examining how journalists access and interpret quantitative data when producing stories about science, the nature of statistical news sources that they regularly use, and how they evaluate and treat such sources in articulating science news stories. Overall, this research finds that journalists tend to see and use statistics mainly to maintain the strategic ritual of objectivity in their social construction of science. The findings will be discussed in relation to a comprehensive body of literature on the use and abuse of statistical information as a key tool in the construction of journalistic objectivity.

Declaration

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The author, Renata Faria Brandão, does not work, consult, own, share or receive funding from any company or organisation that would benefit from this research, and has disclosed no relevant affiliations beyond the academic appointment abovementioned.

Preface

This dissertation is an original intellectual product of the author, R. F. Brandão.

The author conducted all of the work presented henceforth. The University of Sheffield's Department of Journalism Studies approved all projects and associated methods.

A version of Chapters XI, XII and XIII has been published in "Driving STEM Learning with Educational Technologies" as "The Uses of Science Statistics in the News Media and on Daily Life". The author was the lead investigator, responsible for all major areas of concept formation, data collection and analysis, as well as chapter composition.

Another account of the data will be published in "News, Numbers and Public Opinion" as "Newsmeracy: The Uses of Statistics in Science News and its Media Representations across British Media Outlets". Again, the author was the sole investigator, responsible for all major areas of concept formation, data collection and analysis, as well as chapter composition.

Lastly, as a continuation of this research, further data has been proposed for publication in the Journal of Science and Popular Culture in the next few years.

The author has also co-authored the following paper: "Stabbing News: Articulating Crime Statistics in the Newsroom", published in the Journal of Journalism Practice v.9. Dr. Jairo Lugo-Ocando was the lead investigator, responsible for all major areas of concept formation, data collection and analysis, in addition to the majority of manuscript composition. I was second author and assisted in data collection and analysis, as well as manuscript composition.

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CHAPTER I

1. Introduction

1.1. Overview

This dissertation shows that statistics are used primarily to maintain the necessary ritual of objectivity in the articulation and shaping of discourses of science in the newsroom. Statistical argumentation is regarded as one of the most powerful rhetorical instruments in the construction of discourses (Battersby, 2010; Gigenrenzer, 2002; Kahneman, 1982). The use of quantified information is often associated with the idea of objectivity. In actuality, Gödel (1986) and Frege (1977) claim mathematics to be the only language that could explain the universe objectively, and that the language of mathematics implies to allude to and measure over theoretical objects. This, in turn, has created a general compulsion to understanding the world through mathematical and scientific goggles. In point of fact, one could suggest that our current society is largely ruled by numeric and scientific knowledge. Thus, it is important to understand not only the meaning of statistics and science, but also how news discourses, based in numbers, legitimate and construct social reality in the media. This is the context of the present research.

Indeed, this project aims at discussing the uses of statistical information across media outlets. It explores the practical use and media representation of numbers as a rhetorical tool within the construction of science news discourses and coverage. In addition, it looks at how journalists manage quantitative data when gathering, examining and publishing science news stories. In this sense, it further examines how statistics are used to articulate narratives and shape discourses of science in the newsroom and how science journalists articulate, validate and legitimate news articles

using statistics. That is, this research proposes to build an innovative body of knowledge on how numbers are used in news communication of science through a mixed methods analysis of statistical data in the United Kingdom and Brazilian science news and in-depth interviews with science journalists. In the process of looking into these questions this research looks at key notions such as objectivity and legitimacy, the mathematization of society, science communication, in addition to the social construction of reality.

The methodology of this study is based on quantitative and qualitative research methods. It adopts a mixed methods strategy while scrutinizing existing literature in the area of study, especially looking at the philosophy of objectivity, science, and mathematics. Initially, it conducts a content analysis, using SPSS Statistics to scrutinize news articles from different newspapers –namely *The Time, The Guardian, Folha de S. Paulo* and *O Globo*. After that, it examines the construction of news discourses within the articulation of science news rhetoric. Lastly, it investigates how science journalists understand, articulate and legitimate their stories through means of statistical information. To delimit the scope, this analysis looked at science news reported by the United Kingdom and Brazilian media. Following this, it investigated news articles that cited any statistical information in the news item. This gave a total of 1,089 (n=1,089) sampled articles and a further five interviews. Overall, this approach allowed for a better integration of the quantitative and qualitative data analysis as it overcomes limitations that often arise from the use of single datasets.

The content analysis presents key insights into the use of science data in the press, including the observation that statistics are used overwhelmingly to treat science as hard news; that there is a great lack of fundamental background information about how the reported data are produced; that visual data are often neglected; and that

science journalists tend to use peer-reviewed data in a unique fashion, meaning, their stories include either too few or too many statistics from original sources. The close reading suggests a reliance on statistical information, frequently by means of overstatements and exaggerations, in spite of evidence of some illiteracy in the uses and representation of statistical information in the news. To conclude, the in-depth interviews explain this content pattern, examining how journalists access and understand quantitative data when producing science news stories. Moreover, it looks at the nature of statistical news sources, as well as how they handle and evaluate such sources in articulating stories of science. Largely, this project finds that science journalists have a habit of seeing and using numbers mainly as a means to maintain the strategic ritual of objectivity in their social construction of science. The findings of this research are discussed in relation to a comprehensive body of literature on the use and abuse of statistical information as a key instrument in the construction of journalistic rhetoric and objectivity. It accords with the research that the world of experiences and facts is represented as if it can only be validated by science. Therefore, this notion idealises scientific knowledge as accurate and legitimate knowledge, having the property of establishing unambiguous statements and most importantly having universal validity, and a unique, independent and external interpretation.

This research concludes by asserting that statistics are at the highest level of rhetorical implementation within the construction of media discourses, especially in the structuring of science news. The framing of numbers in the media has an important impact on the construction of science. Nonetheless, it often misrepresents its statistical information. As a result, this research proposes that a more inclusive understanding of numbers is imperative. When science journalists, regardless whether

due to lack of training or time, misconstrue statistical information, the audience consumes erroneous information. This misconstruction will in turn be further relayed on to other members of society. This research further argues that this vicious cycle of misinterpretation causes a contradictory response from the public towards the use of statistics in the news. On the one hand, numbers are seen as an important rhetorical tool that contributes to journalistic objectivity; on the other hand, numbers also construct mistrust towards the selection and uses of statistical data in the news. Generally, this study discusses the need for a better understanding of numerical argumentations. Furthermore, it presents a general deficiency in the training of journalists in the manipulation and interpretation of mathematical information. News media outlets need to provide practical training for journalists who write about science. The contemporary accelerated news cycle, which often rewards fast response rather than accuracy is not always ideal for making news about science. The verification of statistical information, for example, is crucial in this process. The training of journalists in data handling should be a top priority for the press.

But how do science journalists handle statistical information? This chapter outlines the background of this approach, the statement of problem and research rationale. It also presents the research's aims and objectives, as well as the primary research question, hypothesis and research design. It ends by offering the definition of principal terms used in the study and an encompassing summary of subsequent chapters.

1.2. Background to Research

1.2.1 Historical Background

There are indications that Babylonians, Chinese and Egyptians used statistics as a means to collect census information dating as far back as 4,000 B.C (Office for

National Statistics, 2011). Nevertheless, it is in the 18th Century that the contemporary history of statistics is said to have properly begun. Gottfried Achenwall coined the current concept of statistics as a tool for data analysis of the State. Following his footsteps, among other scholars of the German school, is Herman Conrig who continued Achenwall's studies, and A. L. Von Scholzer who eventually brought it to maturity. Ultimately, the original purpose of statistical information was to provide data to be used by the government. By the end of the century, the term *statistics* would comprise the systematic gathering of demographic and economic data by the State. As a matter of fact, its etymology substantively reflects this origin, as the basis of the word *statistics* is associated with the Latin *status* – meaning State. Initially, these data consisted mainly of human as well as material resources. However, by the early 19th Century this collection had broadened and intensified. It would now include the entire discipline of collecting, summarising and analysing data. With the advent of computers, the aggregation and analysis of data have augmented. As an autonomous discipline, the establishment of statistics is significantly integrated into the history of science itself. The term *statistics* is widely accepted as "numerical data relating to an aggregate of individuals; the science of collecting, analysing and interpreting such data" (Dodge, 2003, p. 388). One in which numerical data is often presented by means of graphs and charts published by agencies referring to various facts – demographic, scientific, economic, financial, etc. In spite of this, it is regarded as important not only when it comes to the collection of data but also in terms of the available methodological actions used to convert numerical data into statistical information. These methods may include probability tests, mean, medium, mode and range calculations, frequencies, variance, etc.

The construction of statistics begins with its application, as no other discipline has ever interacted with another science as much as statistics. Particularly, with regard to it being intrinsic to nature, the science of meaning, and the use of information. In contrast to the qualitative nature of the aforementioned German school of thought, the notion of statistics as a political division developed in England. Among its main scholars are John Graut and William Perry. The first attempt to create meaning from statistical data for public use dates back to 1662 when a merchant called John Graunt published a booklet entitled: *Natural and Political Observations Mentioned in a Following Index and Made upon the Bills of Mortality* (Graunt, 1665). The booklet focused on reasoning and quantitative data on vital signs, in which he observed a large dataset with statistical regularity (Graunt, 1665). Elected *Fellow of the Royal Society*, his data suggested that there was a greater birth rate amongst children of the male sex but an even distribution between the sexes in the general population; a high mortality rate within the first years of life; and higher mortality within the urban areas in comparison with the countryside (Graunt, 1665). It was William Petty who coined the term *political arithmetic* as the new art of reasoning through statistical information related to the State. In 1685 he published *Essays on Mankind and Political Arithmetic* that suggested the division of statistical records and contributed to the momentum of statistics (Petty, 2014). This notion is crucial to this research and will further be developed when subjecting Dorling and Simpson's (1999) *the arithmetic of politics* to analysis.

Continuing along these lines, at this point, it is important to understand the development of national and public accountability as a method to quantify economic activity, improve bureaucratic planning and map its evolution over time. In England, William Petty was also the pioneer in the development of the notion of national

accountability. William Petty (2014) and Gregory King were first to attempt to calculate economic statistics by introducing concepts such as income and national wealth (Laslett, 1973). In France, this concept was designed and developed by Pierre Boisguilbert. Both works followed the contributions of the French physiocrats, especially that of François Quesnay. Amongst the most famous names in the understanding of statistics as a means of public accountability and governmental planning is Pierre Samuel du Pont de Nemours, Quesnay's protégée. In 1802 Pierre held a high post, engaging in informal diplomacy between the United States and France under Napoleon's reign. It was also during the reign of Napoleon that the bureaucratic-planning system started in Europe (Jackson, 1977, p. 39). Among proposed civil reforms, Napoleon instituted the "Code Napoleon" in 1804 and strengthened French bureaucracy by establishing a political network of prefects, sub-prefects and mayors. The development of a public accountability method to government and the improvement of bureaucratic planning are crucial to understanding why statistics became so relevant to journalism studies later on. This is because one of the first newspapers published consisted primarily of accounts of numerical information (Infelise, 2002, p. 212). Namely Notizie Scritte, the first handwritten monthly newspaper that used to inform on the political, military and economic data. These newsletters regularly served as premises whereupon European representatives would write dispatches, as well as interpret and manage particular diplomatic circumstances (Infelise, 2002, p. 212).

The production of statistical information in the news started with the printing of trade and stock market figures and numbers. The story of business journalism, and thus the use of statistics in the news, is said to have started in the Middle Ages (Roush, 2011, pp. 1-13). However, it was only in 1889 that the first business newspaper was

published by the hands of Charles Dow, Edward Jones and Charles Bergstresser. It was the first time numerical data were officially printed and distributed in a journal as hard news. *The Wall Street Journal* and its business coverage gained prominence in the 1990s, due to extensive and broader investments in the stock market. Today, business journalism is one of the most prominent types of journalism.

If, in developed countries, the use of statistics in news started with the printing of statistical accounts of stock markets, in Brazil it started with football. Within the Brazilian context, *Folha de S. Paulo* was the first to use statistical information in its articles. In 1985 Datafolha, a research institute belonging to Grupo Folha, put together Brazil's first department of statistics to study the numbers supplied by football. It initially aimed to create a vast database to publish statistical material surrounding the World Cup in 1986. According to Datafolha, the department comprised around 100 professionals and six journalists that attended the games to gather data. Records show that in their first article, a simulation of FIFA's U-20 World Cup final, a misreading of statistical information caused an unwary editor to misprint the results. It was the first time that a Brazilian newsroom dealt with the misuse of statistics and understood the significance of correctly printing statistics. Since then, Datafolha became an independent company that accommodates Grupo Folha and external customers alike. It currently conducts statistical and marketing surveys, as well as election and opinion polling. Nowadays every major newspaper in Brazil follows this method.

1.2.3 Rhetorical Background

Indeed a lot has changed since Graunt's use of annual parochial records to generate the first societal statistical conclusions. Today, due to the mathematization of society and the growing influence and deployment of computers, the use of statistics has

skyrocketed. The mathematization of society is of great importance to the understanding of human history and civilization. It is also critical to the study of science and thus key to this research. Frege (1960) first noticed it in 1884 when statistical evidence gradually became more important in the construction of knowledge –especially in the development of scientific knowledge (p. 21). The understanding of society through mathematical perspectives comprised an elaborate view of reality that originated when society started using numbers as the way science is progressively constructed as truth (Frege, 1960, p. 21). This notion will be revised more comprehensively later on. For the time being, it will suffice to recognise that contemporary society is structured within a ubiquitous presence of modern technology. Most of our reasoning and argumentation comes from the information consumed through technological objects. In fact, this growth in automated technology is based on mathematics as intrinsic to modern society. Mathematical information governs most aspects of day-to-day life, establishing conditions and orientating societal development. This augmentation of the production of statistical data information has led to a situation where most academics, and even statisticians, experience difficulties understanding all figures and even reading articles due to their high levels of mathematical sophistication. This condition creates a mathematical social filter because of which only a few people fully understand the decision-making processes.

Numbers have a distinctive power in modern society in reference to shaping public perception. Consequently the uses of statistics are fundamental to the construction of society and social reality. Indeed, throughout the history of social structures and since the beginning of social arrangements, numbers have been crucial to civilisation as they quantify commerce, demographics and most aspects of everyday life. Nowadays,

they have become even more important to global development. From crime to finance, numbers are everywhere. On any given day, numbers will be carried on the front pages of newspapers and readers embraced by statistics, predictions and mathematical speculations on the basis of salient numbers (Rose, 1991, p. 673). As a matter of fact, studies conducted over the past decade indicate that society (at both a micro, individual and macro, social, level) needs science to make effective decisions (Fischhoff & Scheufele, 2013). Indeed, the applicability of scientific knowledge in the process of decision-making is crucial to this research, as it is to the understanding of the scientific discovery processes. The reality is that the epistemological, statistical and systematic methods of its discoveries provide science with the persuasive power of rhetoric. It provides the intellectual foundation for making decisions in the face of uncertainties.

Historically, since the early days of modern civilisation, scientific knowledge has been key to making practical arrangements. One fundamental representative of this notion of science as an authoritative tool is agriculture (Bock, Furtado, & Teixeira, 1999, p. 41). The history of agriculture began concurrently in different parts of the world, yet one would know the right time for sowing and harvesting, the need for suitable fertilises, soil and crop rotation, along with others. Throughout the ages, this position can be seen with certain recurrence: scientific knowledge being used as a means to make sense of an otherwise unknown world. Later, the modern scientific revolution, as designed by Galileo Galilei, would introduce mathematics as a language of science, and experimental quantitative inquiry as a means to attain the so-called scientific truth (Seeger, 1966, p. 50). Galileo viewed the world as a geometric, deterministic and quantitative universe (Seeger, 1966, p. 51). Following this line of thought, he established a scientific dialogue between man and nature, according to

which, society should build through reason, theorised methodologies, and mathematical interpretations of reality and nature (Seeger, 1966, pp. 52-62).

Much in the same way, Isaac Newton would later argue that theories and laws should be drawn from facts. Independently formed from the interferences of hypothetical speculations, his method suggested it should be submitted to test the scientific hypothesis (Newton, 1999, p. 25). This scientific methodological design is called inductive. Contrary to other approaches, Newton holds an inductive strategy to scientific inquiry. It consists of the following format: (1) observation of phenomenon; (2) analysis of existing quantitative information regarding the elements of the event; (3) introduction of such assumptions; (4) experimental testing of as a hypothesis; and (5) generalisation of the results of law. Every scientific inquiry would thus use this systematic, scientific method towards the development of valid and true knowledge. Furthermore, it would help scientists make decisions and detect possible errors.

Conversely, the successful application of Newton's inductive design over the past centuries has developed a blind reliability test in this type of science. The upsurge of scientific information as an effective tool for decision-making also led to an increasing level of ignorance towards numbers and science (Tal & Wansink, 1991, p. 124). In fact, Lakatos and Marconi (1996) argue that scientific knowledge is not a means to access truth. At the macro level, successful communication of science is essential to the construction of social reality as through science society perceives and uncovers the world (Fischhoff & Scheufele, 2013). At a micro level, it encompasses a rather more individual dynamic: subject to one's belief, science communication either fills gaps in knowledge or is widely used to "overcome misconceptions" (Fischhoff & Scheufele, 2013, p. 14031). Tal and Wansink (1991) recruited 61 participants to determine the importance of numbers and graphs, and their manipulation, in the

perception of scientific research. This study also supports that any information presented in scientific terms, such as chemical notations, augmented the message's persuasive power (Tal & Wansink, 1991, pp. 123-124). Similarly, Sumner, et al's (2014) research suggests that over 75 per cent of exaggerations communicated in health-related science news originated in Associated Press releases. Overall, the understanding of science, as well as its communication to the public, has been widely researched (Barata, 2011; Bauer & Bucchi, 2007; Brossard, 2013; Gregory & Miller, 1998; Holliman, 2009; Nelkin, 1987; Nisbet, 2014; Scheufele, Nisbet, Brossard, & Nisbet, 2004; Weingart, 2000). There are comparable studies analysing online communication on climate change using big data (Flottum, 2010; O'Neill, et al., 2014; Pearce, Holmberg, Hellsten, & Nerlich, 2014; Williams, Mcmurray, Kurz, & Hugo Lambert, 2015). Similar studies on the use and representation of statistics in news of science as a more extensive term were not found in the literature review.

The following quotation elucidates the importance of high-quality scientific communication:

> *We all need science for making effective decisions in our lives. Are the expected benefits of a medical procedure worth its risks? Does it make sense to rebuild homes along the seashore after a hurricane? How good are the predictions for storm surges? Should we sign a lease for hydrofracking on our property? What are the risks to our drinking water? Science is, potentially, the best source for the evidence needed to answer these questions. Realizing that potential will require effective two-way communication with those whom science hopes to serve –so that it produces relevant information and conveys it in a credible, comprehensible form (Fischhoff & Scheufele, 2013, p. 14031).*

The portrayal of science in the news has an ever-present potential to influence science-related behaviour, from Wakefield's MMR vaccine controversy to more general misunderstandings of scientific information (Boyce, 2007). Indeed, studies have shown "that even trivial elements can increase public persuasion even when they

do not indicate scientific expertise or objective support" (Tal & Wansink, 1991, p. 117). Similarly, it has been argued that the prestige of science offers a persuasive power to arguments. In point of fact, even trivial elements such as graphics seem more credible as scientific information and argumentation. It is this sense of credibility that provides science communication with its empowering function of the bearer of knowledge. By the same token, it often provides citizen with the authority to make rational decisions. This authoritative power of science, and even scientific-like information, can be seen through the agency of journalism, so much so that science communication in the news is now a popular property within modern society. Scientific judgments are widely communicated by the news media – as well as universities, companies, and public relations agencies – through the uses of graphs, statistics, and general mathematical narratives (Dahlstrom, 2010; Gastel, 1983; Haard, Slater, & Long, 2004; Tufte, 2013). These elements often play a decisive role in the legitimacy of the findings (Abelson, 1995; Fahnestock, 1998; Gross A. , 1990). Given its pivotal role in society, the credibility of a source has authoritative influence on its persuasiveness (Wu & Schaffer, 1987). By that token, the mere implication of scientific legitimacy augments this influence (Miller S. , 2001; Weisberg, Keil, Goodstein, Rawson, & Gray, 2008). Accordingly, this enhanced credibility of scientific sources is crucial to science journalists.

In summary, in terms of its uses in this process, there is a comprehensive body of scholarly work that suggests statistics are regarded as one of the most prominent validating tools in the construction of an objective reality (Boyle, 2000; Davis & Hersh, 1988; Desrosieres, 1998; Eberstadt, 1995; Goldacre, 2009; Hacking, 1965; Koch, 1990; Livingston & Voakes, 2005; Zuberi, 2001). Journalism plays an important role as an intermediary of sense-making and meanings. It influences the

public's understanding of reality as a socially shared phenomenon (Tuchman, 1978), as well as of science, environment, entertainment, etc. Like this, news is constantly defining, redefining, constituting and reconstituting social phenomena. Furthermore, statistics are widely used in newsrooms as a means to achieve journalistic objectivity. They aim to deliver information without fear of subjective statements, misunderstandings or fallacies. This study questions this use of statistics as an objectifying tool while writing about science. The persuasive power of statistical data can be seen in newsrooms as they supports and validates arguments. This thesis goes further by stating that statistics are the ultimate journalistic source; that objectivity and use of statistical information in journalism provides audiences with information most conducive to decision-making, and supposedly unthreatened by fallacies. This study considers, however, that in spite of quantitative data being used as certainties or objectifying tools, they cannot be taken as absolute truths.

Positively, statistics help us make these decisions in an informed way. An important part of understanding statistics and the role they play is the recognition of how they help one to interpret information in everyday life. For example, if you have a quick look at one's daily routine, you would probably notice the huge amount of statistical data that are routinely presented in newspapers, television and Internet and that newspapers, for instance, offer a significant number of headlines that use statistical information on a daily basis. Correspondingly, television and the Internet often use statistics as a means to attract the attention of their audiences. Often these attractive features and headlines are concerned with variability: the extent to which temperatures have varied, how much airfares have varied etc. Statistics are about explaining this variability. They are a crucial concept to this study. So much so that

this notion and perception of statistics as objective assets will be further developed in Chapter IV.

This concept of statistical objectivity is closely connected to the application of statistics in daily life. In terms of consumption and uses of numbers, most scholars agree that our current society, as a mass society, was formed at the end of the 19th Century through its processes of mathematization, modernization, and industrialization of our civilization (Wells & Hakanen, 1997). In turn, the media play a unique function in how this society chooses to use these processes. Thus, the media's relationship with this mass society is both reflective and varied – with the former concerning their simultaneous influence and the influence that is projected back by society. In terms of news media, there is substantial scholarship studying the relationship of their agency and objectivity. A comprehensive review of such scholarship is presented in Chapter II.

In regards to scientific information, this dependence on statistical data turns out to be even more evident. There is an ample body of scholarly work concerning the accuracy of news media's reporting of science (Blastland & Dilnot, 2008; Goldacre, 2009; Fjæstad, 2007; Nelkin, 1987; Signorielli, 1993). Scholars have emphasized the importance of how scientific claims have also been used as a tool to achieve this most pursued "journalistic truth" (Battersby, 2010). In fact, most social scientists would argue that our current society is governed by scientific knowledge (Dahlstrom, 2010; Fahnestock, 1998; Gastel, 1983; Gross A. , 1990; Prelli, 1989). In the understanding of society, and its imaginary collective, science is often perceived as a certainty or absolute truth. Within this framework, two thinkers are crucial to this conception of scientific knowledge: Thomas Kuhn and Karl Popper. Both contributed widely to the notion of scientific knowledge and discussed it thoroughly. The latter proposes that

science is constructed within the grounds of falsifiability; that every proposition in order to be scientific needs to be falsifiable. Conversely, Kuhn (1962) argues that science develops through means of what he calls scientific revolutions that happen with particular frequency. A more in-depth analysis of their body of work is presented in Chapter III.

Covering both angles, Williams (1965) queries how one can know what is science if it is not strategically planned (p. 49). Still in accordance to him, most research is done independently and in doing so is only shared after publishing (Williams, 1965, p. 49-50). Thus, it was difficult to understand what constitutes science and how science is created. To him, science is built through the lenses of the scientist. It is the scientists who decide what science is. As a result, the conditions that simultaneously associate and separate common knowledge or common sense from scientific knowledge also seem to be changing due to new attitudes among the scientific community, especially in the scientific dissemination.

This apparent transformation directly affects society and its scientific culture. As it is expected to derive far away from classic scientism in almost all instances (that is, the processes, procedures and scientific products) it is, in this sense, made available to the specialised public (such as scientific researchers and peers) as well as the lay public. In this context, a field of knowledge may not be enough by itself and does not seem to build knowledge without an association with its opposite. This means that science needs common sense as much as rational thought needs the myth that principles emerge from rigorous scientific methods. Therefore, true settings, and perhaps especially scientific ones, express the most reliable evidence and clearest examples of fear, anguish, love, faith, philosophical joy and contemplation, the highest levels of

rigor, methodological and scientific scepticism, precisely because the scientific spirit is metaphorical.

As aforementioned, in questions of their interconnectivity, statistical aspects of science stories are considerably more apparent. Indeed, most science articles reproduced in the media announce new studies without offering further perspective (Paulos, 1995, p. 79) or making any reference to the experiment's basic information – like sample sizes, number of replications, among others. This omission can be misleading. Similarly, Paulos (1995) observe that the subjective manipulation of data by the media (e.g. through means of using big numbers) is often used as a tool by agencies such as governments, and advertisers to give people the confidence to change their minds in a particular way, and to tell particular stories (p. 79).

In terms of the presentation of statistical information, there is a need for a certain manipulation of data as a means to present it to the public in a simpler and more comprehensive way. As a consequence, however, there is a requisite for a more comprehensive understanding of the theories behind statistical information and how they relate to their research methodologies (Zuberi, 2001, p. 176). This underlines the fact that for many journalists 'quantitative data can be overwhelming, both due to their nature and their proliferation' (Lindgren, 2008, p. 93). Indeed, the persuasive power of statistical data can be seen in newsrooms as it supports and validates arguments. Nonetheless, there are few studies that examine the origins of statistics as a rhetorical instrument and objectifying tool when writing news items about science.

As a means to fill this gap in the knowledge, this work seeks to analyse the use of statistics in science news by focusing on media representations of statistics across media outlets. Within this framework, this research is about how journalists make use of statistics to read, analyse and construct news stories. It explores and analyses how

journalists use statistics as a research technique and as a critical and reflective way to gather knowledge and information. The aim, therefore, is to explore, analyse and explain these techniques in light of the process of newsgathering and news dissemination of scientific information. This research aims to offer some grounding in theory associated with statistics and the use of numbers in the news, while offering some insight into the way journalists use and represent numerical data as a means to create imaginative stories, investigate science and science policy as well as to substantiate their pieces. In so doing, this research wants to engage with the wide set of possibilities that statistics and maths provide to create news stories and to enhance the role of journalism as a public service in our societies.

As already established, statistics are present in a significant portion of our daily life and news (Randall, 2000, p. 72). On any given day, several stories will be carried on the front pages of newspapers such as *The Australian*, *The New York Times* or *The Guardian*. Many of these stories will be based entirely on statistical information while others will use it as a mere background reference. In any case, they are heavily presented in daily newspapers and used in the newsroom. This is also the case with broadcast and online media. Almost without exception, the daily headlines for radio bulletins, television news, magazines, news articles or main news websites will make use of statistical information or be validated statistically. One can find statistical data in sports, business, politics, science, etc. Statistics can be seen in almost every main area of news coverage.

This tradition and practice of using statistical information in the news, however, varies according to the area of journalism. Many sports journalists in the United States, as an example, are highly familiar with the use of statistics. Over there, no serious sports reporter can get away without understanding what the average in

baseball means and be capable of explaining to others how it is calculated. In many of these cases, journalists will keep a close record of each player's statistics for their home team. The media outlets for which they work will also carry a significant database on many sports and will keep a historical record of former players from the teams supported by their audiences. In similar fashion, financial journalists are avid consumers and users of statistics as an argumentative tool. Commonly, financial journalists and news services produce a huge volume of statistics every minute of the day. Avid users of statistics include the *Financial Times, Wall Street Journal,* Reuters, Bloomberg, and the AP/Dow Jones among others. More generally, however, journalists who can understand and use statistics to produce good news stories are better able to secure a job because it gives them a better understanding of the world and issues they cover. Improving thus, their employability and skills.

Most importantly, this study wants to place emphasis on the uses of statistical information when reporting news about science. The purpose of this project is, therefore, to research the uses and representations of statistics across media outlets, specifically examining the usage of statistical data in science news media coverage. In other words, what this project wants to achieve is to generate an innovative body of knowledge that produces one of the first comprehensive accounts of how statistics are used to articulate narratives and develop discourses of science in the news media. To do so, it will look at the representations of statistics and maths in science reporting in two different countries: the United Kingdom and Brazil. In looking at these cases, the research will explore commonalities and distinctiveness in the reporting of science.

1.3. Statement of the Problem

Within the professional norms and contexts of news, editors, journalists and reporters, how are statistics and maths used and represented in the articulation of news and the construction of science discourses in the United Kingdom and Brazilian media? There seems to be a gap in the body of knowledge concerning the understanding of statistical information as a tool for argumentation, influence, persuasiveness, and finally credibility. In the same way, there is a lack of knowledge of the importance of its representation in science news. The representation of numerical information to the public and its possible misunderstanding by them is problematic in several ways. In 2012, the Programme for International Student Assessment (PISA) looked at the mathematical ability of fifteen-year-olds. This study listed the United Kingdom in 26th position in mathematical performance (out of 65 OECD nations). Still according to it, the United Kingdom spends more on education than the average among these 65 countries. Nevertheless, its higher GDP and spend does not show a clear correlation with its educational outcomes. While analysing this study, Grossman (2015) argues that nearly eight million adults of working age have the same mathematical skills as a nine-year-old child. To her, that presents itself as a problem as it not only prevents people from fulfilling their potential but also causes the economy a loss of approximately £8 million. This study will be further scrutinised in Chapter VIII.

In spite of being the country with the largest mean performance improvement since 2003, with a rise from 356 to 391 points, the same assessment found that Brazil performs below the OECD average – which often ranks between 57 and 60 points. It also performs below average in reading (between 54 and 56 points) and science (between 57 and 60 points). Furthermore, Brazil is identified as experiencing habitual grade repetition often negatively linked to its mathematical performance and more

prominent among disadvantaged students. Comparatively, the country performs at the same level as Albania, Jordan and Tunisia; and lower than Latin American neighbours such as Uruguay and Chile. Figures show that 61 per cent of students in Brazil perform below the standard level of proficiency. That means, "at best, they can present scientific explanations that are obvious and follow explicitly from given evidence" (PISA, 2012, p. 3). Around seven per cent of Brazilian students perform above the baseline and less than one per cent is a top performer in science. Nonetheless, figures also showed that performance improvements can be explained by improvements in the economic, social and cultural status of disadvantaged students. According to the study, "over the last decade, Brazil has greatly expanded enrolment in primary and secondary schools" (PISA, 2012, p. 4). This increase in the number of scientifically and mathematically literate students in primary and secondary schools results in a better understanding of mathematical and scientific information, and thus better ways to make an informed decision. Still, Brazil had little or no participation in international conversations on the need for the modernization and improvement of the teaching of mathematics. What happened in the country was mostly assimilation, uncritically, towards global trends that enabled any change within the axiomatic teaching of mathematics. Most unfortunately it did not reinvent or improve the transmission of mathematical knowledge to the students. But what do those numbers mean to the articulation of news and the construction of science discourses through statistics in the UK and Brazilian media?

In terms of the articulation of news, it is important to understand that, among scholars of media, there is a line of thought that seeks to study the internal structures and professional standards of the manufacturing and articulation of news through the systematic study of people and cultures. One central scholar of this school of thought

is Schlesinger (1978). His empirical evidence concluded that journalists do articulate the news as to manipulate views of reality (Schlesinger, 1978, p. 132). According to him, journalism is not neutral. Not only because of its political and ideological interferences but also due to external factors such as professional routines (Schlesinger, 1978, p. 121). It is this articulation of news that is instrumental to this study and the understanding of the uses of statistical information in the construction of science in the news. Responding to the question on the meaning of numbers in the articulation of news, the understanding of mathematical language is imperative to understanding the world and making informed decisions. An appropriate communication of this language, however, is dependent on numerous factors and needs to be considered thoroughly. In terms of news media communication, as seen from PISA's 2012 results, journalists need to bear in mind the general lack of knowledge of their readers, making it crucial then to create a suitable means of articulating and constructing science and mathematics discourses.

There is a small body of research that has been done on this issue (Nelkin, 1987). The perception of the media in terms of understanding and representing statistical information in the articulation of news of science is critical to better understand both as legitimising and objectifying tools of social construction. This study is designed to consider the perceptions of news outlets and journalists in the United Kingdom and Brazil regarding this construction of science discourses in newspapers through mathematical terms.

1.4. Research Rationale

Quantitative information is pivotal in today's society, its construction and development, daily seen in newspapers everywhere. In fact, when constructing

themselves as a “mirror of reality”, the media developed a powerful tool for public opinion (Mindich, 1998; Kaplan, 2009) and used this to incorporate scientific information as a product to be offered and presented back to society. It is also particularly relevant in the current context whereby the process of public policy design and implementation seems to be influenced by both public opinion and all-important media representations that help construct that opinion.

Journalistic objectivity must be understood as the relationship between social reality and media reality, and as the search for and approximation of reality through journalism. Objectivity is, therefore, a discussion on the possibility of knowing reality and thus understanding the characteristics of reality, or better yet as the existing knowledge of reality that is practically indistinguishable from reality itself (Amaral, 1996). From this perspective, there is an existing gap in the body of knowledge and consequently a need to analyse how statistical information is used as rhetoric in the production of news stories.

This research aims to close this gap. As to examine the ways in which journalists use statistical information as a means to legitimately communicate news of science, this study represents context from four daily broadsheet newspapers in the United Kingdom and Brazil. The need to understand how statistics are used as an influential, objective source was supported by 1,089 (n=1,089) articles and five interviews. In addition, this research also presents and considers an analysis of a wide range of previous studies and a review of the literature.

It looks at this implied connection between scientific sources and numbers to enhance claims of credibility and persuasion while aiming to produce exploratory research on how journalists in the newsrooms manage quantitative data when gathering and disseminating news stories concerning statistics. Adopting a mixed methodological

approach, it carries out both a revision of existing literature in the area of media, especially looking at the previous existing body of work on how media reports statistics and maths, as well as a review of a number of journal articles that have been dedicated to this theme up to this point. The research thus provides greater insight into the ways in which quantitative data is processed by journalists and news editors, by assessing statistics-related methodologies used in the newsrooms when it comes to representing numbers, with an emphasis on science reporting.

This project looks at the uses and representations of statistical data in news media coverage while explaining its methodological issues, describing main findings and making general suggestion for further research. It aims to produce exploratory research on how journalists in the newsrooms manage quantitative data when gathering and disseminating news stories. In so doing it offers a comprehensive assessment of numerical and analytical skills in the newsroom together with modes of presentation across media outlets regarding statistical information. The research will thus offer an initial assessment of how journalists in the newsrooms manage quantitative data when gathering and disseminating stories concerning statistics. Furthermore, it will explore how journalists access these sources within the newsgathering dynamics in the newsroom, looking at how statistical data is processed and managed in the newsroom and how it is disseminated among the audiences and publics of different media outlets. No information regarding this subject of study was found in the literature reviewed.

Therefore the significance of this study can potentially change the ways in which science news and science-related statistics are communicated in the news. Results of this study will be used to make recommendations for addressing the uses and

representations of statistics in science news in support of enhancing the means in which they are communicated in the UK and Brazilian media.

1.5. Aims and Objectives

The overall aim of this research project has been to analyse the uses and representations of statistics in news media coverage. It seeks to produce an innovative body of knowledge on the presentation of data in the reporting of science stories and how numbers are used to articulate journalistic narratives and shape news discourses of science. Here, the aim has *not* been to determine any comparison or causal relationship between specialist science journalists versus non-specialist ones and their levels of numerical literacy. This research did not account for or discuss the personal dissension within the journalistic spectrum. It did not analyse the possible variances of understanding, uses and representations of statistical information by specialist science journalists in opposition to non-specialist journalists that write about science. In addition, it was not the aim of this study to look at how journalists read and understand press releases and scientific journal articles. Instead, it has examined the means in which statistics have been used across news media outlets, focusing on the uses of statistics when reporting science news. Since the literature on the uses of statistics in news of science is scarce, the proposed methodology design was used as a means to tackle the study with the objective of considering multiple data perspectives and analytical methods.

Furthermore, the five main objectives of this study were to (1) identify and describe the ways in which statistics are used to articulate news and content in science news; (2) explore and describe how numbers are used to create discourses of science in science news; (3) scrutinise how statistics are understood and communicated by

science journalists; as well as (4) provide suitable background to the subject of study; and (5) make recommendations for enabling a better communication of science and statistics in the media.

In terms of recognising the ways in which statistics are used to articulate news and content in science news, the data was analysed through a triangulated approach combining content and discourse analysis with in-depth interviews. This choice aims to give a more detailed picture of circumstances. It was also used as a means to overcome possible weaknesses and biases by increasing accuracy and methodological richness. The methodology to guide the data collection will be discussed in Chapter V, while the findings from the collection of data will be presented in Chapters VI, VII, and VIII.

A quantitative analysis of statistical data in science news will be presented in Chapter VI. It aims to assess the uses of statistics regarding newspapers, byline, sources quoted, main emphasis and statistical uses, among others. The design includes a political affiliation and nation-state multilevel correspondence analysis. With regard to exploring and describing how statistical information is used to create discourses of science in science articles, the analysis of discourses will meet this objective. The findings from this analysis will be presented in Chapter VII. In the matter of scrutinising how statistics are understood and conveyed to the public by science journalists, in-depth interviews were conducted with distinguished science journalists from the newspapers mentioned above –namely *The Times, The Guardian, Folha de S. Paulo* and *O Globo.* The findings from the collected data will be put forward in Chapter VIII.

So as to provide a suitable background to the subject of statistical representations in public culture collected works on the uses and representations of statistics and

construction of science discourses were assessed thoroughly. The analysis is crucial to understanding the findings and how the work intends to answer the research questions. This objective will be met by means of an extensive review of existing literature, provided in Chapters II, III, and IV.

Lastly, with regards to making recommendations for future research and better communication of science and statistics in the media, this study culminated in a comprehensive analysis of literature, methodologies, and findings. It aimed to find gaps of knowledge, which this existing research was not able to answer. This objective will be met by the elucidation of final conclusions and statements, presented in Chapter IX.

1.5.1 Primary Research Question

As aforementioned, the purpose of this study was to examine the ways in which quantitative data is used in science news. This research represented the assessment of content and discourse analysis while triangulating it with semi-structured interviews, from four daily newspapers. The primary question in this study was: how are statistics used and represented in the articulation of news and the construction of science discourses in the UK and Brazilian media? This question was supported by existing literature and identified gap in knowledge regarding the usage of numbers in the manufacturing of science information in the news. The research questions addressed in this study were:

1) How are statistics used to articulate narratives and shape discourses of science in the newsroom?
    a) What are some of the significant factors that cause science journalists to use statistical information in the news?

b) What is the purpose of using statistics in science news?

c) Do science news and science journalists emphasize a certain type of statistics?

d) Is there a difference in how statistical information is used to establish narratives and frame discourses of science in the United Kingdom and Brazilian newsrooms?

e) What are the differences in attitude towards uses of statistical information in the news within the United Kingdom and Brazilian newsrooms?

f) Do the bylines or writers of an article determine how statistics are used in the articulation of science news?

g) Is statistical information treated differently in terms of quantity of sources quoted?

h) Does the type of sources engage with the uses of statistics?

i) What nature of sources do science journalists engage in as presenters of statistics?

j) How are visual data used to articulate news of science?

2) How do science journalists articulate and legitimate stories using statistics?

1.5.2 Hypotheses

At this point, this research considers the following hypotheses:

(1) Statistics are heavily used as a means to make news appear objective or match conventions of journalistic objectivity. Similarly, statistics legitimate science news and science information when shaping discourses of science in the newsroom.

(2) Statistics are similarly used within the United Kingdom and Brazilian newsrooms.

(3) Statistical information is often poorly represented in the news.

(4) Science journalists do not have the time or space to check their sources.

(5) Improving the coverage could have positive effects in the process of policy formulation and decision-making by reducing public anxiety and pressures on policy formulation.

1.6. Research Design

This study implements a research design plan that involves a span of decisions with reference to how the study is conducted, including the collection of data, its analysis, and interpretation. The proposed QUALI-quanti methodology is arguably one of the most comprehensive methods for analysing statistical information in the news (Creswell, 2009). To give one example, Atton and Wickenden (2005), Briggs and Hallin (2010) and Seale (2001) all use such a methodological strategy to gather data points and produce their findings. Following their approaches, this research design was constructed to be able to identify the research problem. Furthermore, it aims to review previously published literature, and effectively describe the data and method of analysis of this research. The methodological approach of this study takes on a mixed methods approach. The research strategy is based on the triangulation of quantitative and qualitative research methodologies. These comprise of a content analysis of printed news articles written by science journalists while attempting a close reading analysis of an assortment of said news articles, systematically selected from a theoretic-methodological basis construction, from Brazil and the United Kingdom in 2013. To delimit the scope of the research, the study focuses on two newspapers in the United Kingdom (*The Guardian* and *The Times*) and two in Brazil (*Folha de S. Paulo* and *O Globo*). The in-depth interviews attempt to substantiate the findings, examining how journalists access, gather and interpret statistical information when producing news stories about science, the nature of sources regularly used when using statistics, and how they assess and handle such sources in articulating science

news. Thus, how statistics are gathered, used and disseminated in the newsroom (both as a news item as well as a means to construct news stories) and how does the media report them?

This research highlights two main outcomes: the first one is the type of limitations that journalists face when validating and processing data, and their over-dependence on official sources to do this for them. The second is the problem of legitimisation and entrusting validation, taking into consideration that the statistics come from a variety of sources and that most journalists do not check or understand such sources. Arguably, it appears that science journalists and news editors feel that reporting of statistics feeds the process of social construction of reality and thus policy making; therefore strengthening the initial hypothesis that improving the coverage could have positive effects in the process of decision-making by constructing science and reality through the authoritative lenses of objective. Nevertheless, given the problems of accessing and validating the data, the traditional mechanisms of verification and validation normally used in other areas of journalism are not performed by science journalists and sub-editors. From this angle, the public tends to receive information that is not always up to standard, and is often embellished or erroneous. And therefore has a limited scope to make well–grounded interventions in the process of decision-making and scientific elucidation.

1.7. Definitions of Main Terms

To deal with this research topic it is important to define some of the key concepts the researcher will be dealing with here. The researcher has adopted relevant conventions by looking at each case and the different discussions surrounding these notions. When investigating the subject area of this research, eight principal terms need to be taken

into account: (1) News; (2) Science Communication; (3) Statistics; (4) Objectivity; (5) Legitimation; (6) Mirror Theory; (7) Social Construction of Reality and (8) the Mathematization of Society.

For example, the notion of (1) news is a widely accepted concept and is the essence of this research. There is relative understanding in the literature that the news media enable the space for defining reality. Or as Castells (2007) argues, it is "the social space where power is decided" (p. 238). This is because the contemporary definition of news defines it as "new information about a subject of some public interest that is shared with some portion of the public" (Stephens, 2007, p. 4). Several academics have examined and defined this medium, the latter being best fitted to this research. To the researcher, the news is an arena for constructing social reality. More specifically, this term is here closely linked to that of the printed news media.

The (2) science communication and the divulgation of science information is a contested notion among scholars. McQuail (1983) classifies mass communication into two classes: operational theories and normative theories (p. 23). According to Gregory and Miller (1998), the main problem of understanding science and its communication is the insufficient recognition of these ideas and their differences (p. 106). Still, the understanding of science communication and its role in the public understanding has been widely scrutinised by scholars. There are general disagreements on the importance of improving the public understanding of science; however, "while other areas in media studies have developed via contest or comment, academic discourses of science popularization has been marked by enduring consensus" (Dornan, 1990, p. 49). Thus, most specifically with this research in mind, the researcher proposes to merge the understanding of science communication as a scientific medium where information is specialised and directed to the scientific

community, and science divulgation, which aims at the democratization of public access to scientific knowledge as a means to establish a space for scientific literacy. To the researcher, science-in-the-media (Gregory & Miller, 1998) defines a combination of both: an arena in which the scientific community can publish its findings towards generating social scientific knowledge.

Still in the spectrum of scientific knowledge, (3) statistics is a fundamental concept. According to the Royal Statistical Society, statistics "change numbers into information. Statistics is the art and science of deciding what are the appropriate data to collect, deciding how to collect them efficiently and then using them to answer questions, draw conclusions and identify solutions." This study understands statistics as an informative quantitative datum resulting from the collection of diverse numerical information. In addition, these may be presented by means of visual graphs, formulas or written narratives.

On the one hand statistics is already a well-established concept. On the other, the notion of (4) objectivity is an extensively contested one. However, for the purpose of this research, objectivity assumes that truth or independent reality exists outside of any investigation or observation. Historically, the literature review argues the notion of objectivism as enunciated by Dilthey (1833-1911) at which time he was articulating ideas about the cultural sciences (Geisteswissenschaften). According to these, objectivity presumes an independent reality that can be grasped. As such, it is the exposition of information without the influence of opinions or personal beliefs. The concept of objectivity is key to journalism (Dahlgren & Sparks, 1991; 1992; Koch, 1990; Kovach & Rosenstiel, 2001; Mindich, 1998), as well as to this study, as it is intrinsically based on the understanding and theory that sees journalism as a form of knowledge that is based in reality, in truth. Accordingly, this study was bases on a

construct of three means of objectivities: (1) Journalistic Objectivity; (2) Scientific Objectivity; and (3) Statistical Objectivity.

Firstly, as an essential branch of objectivity, (4.1) is the concept of journalistic objectivity. The notion of journalistic objectivity rules the agency of journalism and the newsroom. Historically, the concept of objectivity within the study of journalism originates in the positivistic tradition. In its tradition, one can only know something through its senses; consequently, knowledge can only be achieved through the means of our senses. Within this practice, objectivity is a binary; information is either objective or subjective. In regards to journalistic objectivity this means that journalists can only objectively represent something that it is immediately knew via their senses. Overall, there is a wide consensus in the media that objectivity is a guiding doctrine of news agencies and central to the journalism profession (Koch, 1990; Kovach & Rosenstiel, 2001; Mindich, 1998; Sparks & Dahlgren, 1991; 1992). Schudson (1978) believes journalistic objectivity is the cultural bargain through which news agencies assert their political status as a Fourth Estate (pp. 7-9). As an initial standpoint, in this study, journalistic objectivity is "inextricably intertwined with truth, fairness, balance, neutrality, the absence of value judgements – in short, with the most fundamental journalistic values – objectivity is a cornerstone of the professional ideology of journalists in liberal democracies (Lichtenberg, 2000, p. 238).

Similarly, (4.2) scientific objectivity is key to the study of sciences where "external assessments of accuracy have always been important to science. They can provide the only access to the measurement of systematic errors or biases" (Stigler, 1986, p. 6). Moreover, it represents scientists' caution in effectively producing an error-free understanding of a subject. It aspires towards objectivity while trying to overcome subjectivity conditions – in this case, science being a social institution.

Lastly, as a third member of this trinity of objective knowledge, (4.3) statistical objectivity stands as a less contested notion. As a consequence of its exact technical science dimension, statistics have always been linked to the notion of objectivity (Boyle, 2000; Davis & Hersh, 1988; Desrosieres, 1998; Eberstadt, 1995; Goldacre, 2009; Hacking, 1965; Koch, 1990; Livingston & Voakes, 2005; Zuberi, 2001). As an exact science that can be quantified and recreated it is often seen as a 'universal truth'. This secured the existing credibility and legitimacy of statistical information and knowledge.

As far as (5) legitimation is concerned, legitimacy is a term that defines the quality of an object that follows reason. Thus, legitimation is the action of giving legitimacy to an action, process or opinion so that the community accepts it. In the context of political processes, power is habitually legitimated by authoritative figures. To Weber (1964), within this framework, legitimacy is imposed by coercion. For the purpose of this study, legitimacy is understood as a concept of political-legal origin that refers to a recognition by authoritative figures or institutions of power –as seen in the uses of official sources and resources; and is in accordance with the articulation of discourses that these institutions of power have over certain social elements, regardless if it refers to processes or objects.

In terms of newsroom concepts, the (6) mirror theory was one of the first explanations of the agency of journalism. Inspired by Comte's 'positivists' idea, it claims that quality news needs its writers to faithfully describe the situation as if it was being reflected by a mirror in the news.

The (7) social construction of reality is another principle that is central to this study – as well as current society. It is the understanding that people's interaction within a social system creates conceptual representations (Berger & Luckmann, 1966).

Developed by Berger and Luckmann (1966), they further argued that the 'sociology of statistics' makes the practises of social construction of reality possible by way of its uses and dissemination, as symbolic forms. Still, in accordance to them, this furnishes it with ability to mediate the understanding and thus construction of events (Berger & Luckmann, 1966). Berger and Luckmann (1966) tackle the notion of the sociology of knowledge while redefining the understanding of general knowledge. To them, society can present itself as an objective reality (through the means of institutionalization or legitimation) or as a subjective reality (through interiorization or identification). Within the notion of social construction of reality is the understanding of the (7.1) social construction of science. Gross and Levitt (1994) suggest that scientists, rather than using an infallible method to reveal facts of nature, are instead constructing explanatory stories from data produced and interpreted in ways conditioned by and designed to reinforce both the scientists' social and cultural mores and their preconceptions and expectations of the natural world – a world that contributes to only a limited extent to the researchers' reconstruction of it in the laboratory.

Lastly, it is imperative to provide a description of the concept of the (8) mathematization of society. Schuyt and Taverne (2004) argue that the mathematization of society commenced when mathematical knowledge became more influential on the matters of technological scientific qualities of affluence. Porter (1997) further points out that: "mathematics is central to our modern scientific understanding of the natural and social worlds" (p. 9) and that society relies on quantification and mathematics because it is key to decision-making. Furthermore, it helps society understand how it conducts most aspects of our daily lives – from the enforcement of law to the exchange of goods and media communication. Ultimately,

mathematical information is the investigation of ubiquitous structures that are presented to society as a means of rational analysis, which gives a particular domain of reality.

1.8. Summary of Subsequent Chapters

This chapter introduced the study of the uses and representations of statistical information in the news and identified gaps of knowledge in the understanding of how they are used in the articulation and legitimation of science information. The research rationale, questions, and objectives were explained. The importance of science communication was discussed in this chapter. Relevant concepts were defined, and the structure of the research was outlined. In subsequent chapters I will provide a more extensive discussion of the uses of statistics in science news, outline the research methodology, present the general findings, and conclude with quick review of the study and suggestions for further studies while affirming the contribution and significance of research. A short summary of each subsequent chapter is provided below.

Chapters II, III, and IV present the literature review relating to sciences, statistics and journalism's influence on credibility and its means of creating a social reality. Chapter II looks at objectivity as a quality concept in journalism studies. It looks at the portrayal of media as a mirror of reality while redefining the social mirror theory (SMT) as a tentative explanation of journalistic practice and its meaning in contemporary society. According to this theory, its means of knowledge production is through the methods of impartiality and objectivity. In fact, this objectivity condition is what allows journalists to legitimate their work as it gives them and their work a stamp of validity. Chapter III analyses science communication as a means of scientific

explanation. It examines the divulgation of science as a means of publicising science and the role of journalism agencies in the propagation and publicising of science information. It seeks to understand the relationship between science, its communication, and the public while analysing it under the scope of objective science. Chapter IV scrutinises the meaning of statistics as an objective source. It analyses established theories on the objectivity of numbers and their representations in the public domain. Furthermore, it seeks to analyse how society is constructed from mathematical discourse, and how its discourse is extensively present in today's society. Chapter V describes and rationalises the chosen research methodology. It looks at the most suitable methodological approach while accounting for its respective target population, sampling, coding and data coding and analysis. Chapters VI, VII, and VIII present an analysis of the data collected. Chapter VI analyses the content. It looks at the content of 1,089 (n=1,089) articles, from *The Times, The Guardian, Folha de S. Paulo* and *O Globo,* in search of patterns in the ways in which statistics is used in science news articles published in the UK and Brazil daily press. Chapter VII looks at discourses as a multimodal social semiotic means of communication. Looking at the same daily UK and Brazilian newspapers, it analyses four articles (two from each newspaper) in terms of multimodality. It assesses the practices within the newsroom through means of visual statistical information, while also analysing the discourses of science that statistics create within the article. Chapter VIII analyses interviews. It considers the five in-depth interviews as a unique point of view into the uses of numbers in the respective, as well as conjunctive, newsrooms when writing about science. It considers the processes newsrooms engage in when choosing which news and statistical information to use, to the ways in which they use the latter to create news discourses of science. Chapter IX contains a conclusion and

recommendations for further studies. This study ends by summarizing the findings whilst affirming the contribution and significance of research. It also shares its strengths and limitations while offering recommendations for further research.

CHAPTER II

Objectivity in Journalism

2. Literature Review

2.1. Introduction

When investigating the subject area of statistical data usage to articulate discourses of science in the news, broadly three areas need to be taken into account: (1) the agency of journalism, (2) science knowledge, and (3) the mathematization of society. In order to understand the findings, first it needs to make clear the theoretical framework. Accordingly, the literature review been divided into three parts: Chapter II focuses on the understanding of journalism as a means of constructing social reality while looking into its claim to objectivity and mirror theory. The following chapter (Chapter III) looks at the literature on scientific knowledge and its communication in public culture. Lastly, Chapter IV scrutinizes the uses of statistics as a tool for legitimation and argumentation. Thus, how important are statistics and scientific articles in the newsroom as a tool for legitimation and construction of social reality?

They are key. Science knowledge and statistics are fundamental in the construction of social reality through the lenses of journalism. From this angle, looking at central concepts such as legitimacy, credibility and objectivity the research questions their uses. Approximately 50 million journal articles have been published since 1665, when the journal 'Philosophical Transactions of the Royal Society' was first issued (Jinha, 2010). Given the pivotal role of scientific articles and statistical information in the

composition of news articles, in particular science news articles, and the making of lifestyle decisions (Battersby, 2010), it is important to establish whether or not their legitimacy is warranted. With this in mind, the literature reviewed in this chapter is a result of a collaborative process between science, journalism and statistics. Literature particularly significant to this study's findings is reviewed in Chapter VI, VII and VIII and brought into comparison with the empirical findings.

2.2. Objectivity as a quality concept in Journalism

This section presents objectivity as a quality concept within the practice of journalism. The notion of objectivity as a structural concept is key to understanding how statistics are used to articulate and shape discourses of science in the newsroom. As a matter of fact, among main concepts investigated under the discipline of journalism studies, is the belief that objectivity is central to the credibility of journalism (Dahlgren & Sparks, 1991; 1992; Koch, 1990; Kovach & Rosenstiel, 2001; Mindich, 1998). In general terms, objectivity in newsrooms can be seen as comprising two different understandings: journalistic objectivity and more generally understood objectivity. While journalistic objectivity should be understood as a relationship between social reality and the text, and as the search and approximation of reality through the lenses of journalism; objectivity of method, on the other hand, should be perceived as a set of standards and rules for the observation of reality, and aims to produce a structural similarity between the social reality and the text (or media reality). The former refers to the news production phase in which reality has not yet been coded, the phase when journalists are informing themselves in order to inform others. The latter concerns the phase where reality is coded, that is, when journalists write the news articles. In support of this research, objectivity is therefore understood as a discussion on the possibility of knowing reality.

After a brief historical opening, I will look more closely at different dimensions of objectivity as a means of knowing reality. The word “objective” did not begin to be used in the newsroom as a quality concept until the 1920s (Streckfuss, 1990, p. 973). Since then, objectivity as a means to describe journalistic work has grown and become one of the most familiar concepts in the journalistic vocabulary and is present in most newsroom guidelines (Maras, 2013; Schudson, 1978; Ward, 2004). Today the term implies that news articles should be written to present facts and events independently of biases, subjective methods and personal views. The notion of objectivity reasons that news pieces should instead be based on neutral grounds and, when possible, depicts all sides. The origin in point of time or place of objectivity, however, is highly contested. While Schudson (1978) argues, it cannot be determined to one 'magic moment' (p. 167), other authors, such as Mindich (1998, pp. 1-14), dispute that objectivity started with the so-called penny press in the United States. For the purpose of this study, the determination of a point of origin is not necessary. Instead, I will look at its historical development as a cultural discourse within journalism.

As a frame of reference to its beginning, Amaral (1996) addresses how this notion of objectivity came into existence as opposed to the partisan sensationalism of the 19th century, when newspapers were biased and generally critical of political opponents. According to him, the readers’ reactions to this manipulation and newspapers’ large commercial potential compelled the press to change its practices and start using objectivity as a means to show news as an unbiased collection of information, one without prejudices or interpretations (Amaral, 1996, p. 26). Thus, in its beginning objectivity was viewed as something more than being neutral; it was an invitation for intellectually precise methods that had in mind social change (Streckfuss, 1990, p.

973). Indeed, to Streckfuss (1990), objectivity as a quality concept for journalism was not envisioned and was initially established on a naïve idea that journalists could be objective, but rather on the recognition "that they could not" (p. 974). Within this framework, objectivity becomes an ideology in which objectivity is not completely opposed to subjectivity (Schudson, 2001, p. 167). To Schudson, (2001) objectivity in journalism happened precisely due to the inevitability of subjectivity. It is a means of compensating for this inherent weakness; a response that suggested a new journalistic system based on the scientific method (Streckfuss, 1990, p. 974). The journalistic objectivity would be a working method capable of ensuring some scientific rigor to journalism practice (Schudson, 2001, p. 149). Such methodology aimed, thus, to reduce the influence of subjectivity in the account of events. Conclusively, "objectivity was a child of its time and a creature of its culture" (Streckfuss, 1990, p. 975).

Within this timely and cultural context, Amaral (1996) argues there were three instances which strengthened the significance of objectivity in the newsroom: (1) the emergence of news agencies, (2) the industrial development, and (3) the first two World Wars, which culminated in the advent of advertising and public relations (Amaral, 1996, p. 18). Amaral (1996) suggests that news agencies played a key role in the appearance of objectivity in newsroom guidelines. That is because news agencies, as international institutions, had not only a broader audience but were also selling information to a bigger number and diversity of clients, and thus it was necessary to have a more neutral and impartial reproduction of news (Amaral, 1996, p. 18). Conversely, industrial development generated a considerable rise in the quality of education. This rise in the quality of education started a domino effect: the increase in the quality of education produced an increase in the number of literate people. In

turn, it increased the number of newspaper readers and lowered the prices of newspapers, which consequently required reporters to represent reality further, and more accurately to captivate the new audience (Amaral, 1996). On the other hand, the First World War brought the notion of winning "hearts and minds" to the core of the US propaganda war model and journalists were severely questioning the use of propaganda war (Amaral, 1996, p. 26).

Within this changing set of cultural attitudes, objective journalism was created. (Streckfuss, 1990, p. 975). To him, the following forces were key in this process: (1) the distrust of human nature to gather facts before making judgments, backed by Freud's work in psychology highlighting the role of the sub-conscious in decision making; (2) the recognition that propagandists were manipulating the facts released to news outlets, thus clouding public opinion; (3) the awareness that if citizens did not get a reliable source of facts, then democracy as an omnicompetent body was a myth; and lastly, and most important for this research, (4) the idea that the scientific method, applied to journalism "could open the door to human betterment" (Streckfuss, 1990, p. 975). Thus, as pointed out by Amaral (1996), the onset of the World War I saw objective journalism becoming the hope of academics and scientific methodology as a means to find the journalistic truth through the methodology of the scientists (Streckfuss, 1990, p. 975). For example, in 1922, Lippmman (1922) publishes his book *Public Opinion* in which he argues "it is no longer possible, for example, to believe in the original dogma of democracy; that the knowledge needed for management of human affairs comes up spontaneously from the human heart" (1922, p. 248). Without this reliance that democracy is omnicompetent and that the truth would win in the end, Lippmann (1920) argued his defence of objectivity against propaganda. To him, "opinion could be made at once free and enlightening only by

transferring our interest from 'opinion' to the objective realities from which it springs" (Lippmann, 1920, p. 97). To do so, the journalist must undergo professional training in which the model of the objectivity of the method is imperative (Lippmann, 1920, p. 82), the blueprint towards objective reporting. Having claimed that opinions should transpose objective realities, how does this new view of journalistic judgment affect the understanding of objectivity?

This traditional notion of journalistic objectivity, which defines objectivity as a matter that disclosed only the facts and eliminated all interpretations or opinions of the journalist, should be abandoned (Ward, 2004, pp. 13-14). To Ward (2004), it is out-dated and dualistic (p. 13). Journalistic objectivity is not a perfect neutrality or elimination of interpretation. Ward (2004) believes it refers to the desire of a person to use objective methods to test interpretations to identify trends and inaccuracies (pp. 261-316). As a method, objectivity is compatible with journalism as it interprets and represents reality. Still, he argues that the ideal of objectivity, however, should not be abandoned because it supports important journalistic attitudes (Ward, 2004). It should rather be constructed as a method, a professional model that opposes propaganda and aims to free the news from propagandists and publicists (Ward, 2004, p. 319). This view coincides with Lippmann's (1920) interpretation of the ideal of objectivity.

In this context, how is objectivity seen in the newsroom today? In its broader conceptualisation, objectivity can be seen in a number of ways in the newsroom. From this angle, the concept of objectivity in journalism originates in the positivistic tradition (Wien, 2005, pp. 4-6). Although commonly related by some theorists, such as Kovach and Rosenstiel (2001), Meikle (2009), and Mindich (1998), to the structure of journalistic texts, objectivity is most commonly linked to context. Furthermore, it exerts a close relationship with "accuracy" and "truthfulness", resulting in a dictated

fairness that became synonymous to objectivity (in the news) as seen today. Kovach and Rosenstiel (2001) defend the practice of journalistic objectivity as objectivity of method; similar to the one that occurs in science that constructs itself as an impartial representation of information. Furthermore, it presents evidence that can be replicated. From this perspective, according to them, this objectivity of method provides the audience with the appropriate tools to replicate and better understand how journalists discovered something and why they believe it to be true (Kovach & Rosenstiel, 2001, p. 79). Following on Lippmann's definition, Kovach and Rosenstiel (2001) further argue that there is only one way to unity and being objective, that is, through method **"**based on exact record, measurement, analysis and comparison" (Lippmann, 1922, p. 138). In other words, the original definition of objectivity in journalism would point to the fact that it should aspire to a set of default rules and (consensual) methods of observation, such as the ones seen in natural sciences and law. Furthermore, in accordance to Kovach and Rosenstiel (2001), these methods could even possibly generate different results depending on the assumptions and resources of the chosen journalist; but even if it were a consensual method of observation, it would still allow the results to be checked, verified and reproducible by others (p. 79). Then, if this consensual process is repeated and the same results are verified, it would be corroborated journalistically, as well as scientifically (Kovach & Rosenstiel, 2001; Lippmann, 1922).

The objectivity of method is therefore considered one of the main virtues of journalism and the fundamental principle that guides a journalistic text itself (Meikle, 2009, p. 98). Indeed, the appropriation of such a concept and the understanding of reality as elaborate versions of objectivity have long been part of this area of study (Chomsky, 1989; 1997; Chomsky & Herman, 1994; Kaplan, 2009; Koch, 1990)

(Mindich, 1998). This process, thus, uses the discourses of objectivity of method as a means of legitimation, one that gives the 'journalistic sphere' the basis to support and reflect a sense of veracity towards the institution, as well as the understanding of news as truthful, singular and universal.

The discourse of objectivity as an ideology in any professional activity favours two opposing poles: it can either demote the profession or promote it (Schudson, 1978). In the case of journalism, these two poles collide and coexist as in few others. Critics of the notion of objectivity as a quality concept argue that objectivity is a frame, in which the profession inserts its strategy ritual as a means to fend off any objections or complaints. According to Tuchman (1978) this journalistic ritual aims to reinforce its status quo. Core to this ritual is the concept of "factual presentation"; the name assigned to the set of rules that journalists must undergo to create seemingly objective reporting (Tuchman, 1978, p. 232). Others view objectivity as a naïve concept that legitimises journalists' status as neutral observers, compiling the conditions to create a *sensu stricto* design that sees journalism as a mirror of reality (Broersma, 2010a; Mindich, 1998). Schudson (1978) conceptualises the term to the detriment of moral values: "It is, moreover, a political commitment, for it provides a guide to what groups one should acknowledge as relevant audiences for judging one's own thoughts and acts" (Schudson, 1978, p. 8).

For that reason, objectivity is also a dubious and "slippery notion" (Mindich, 1998). Mindich (1998) refutes the idea that journalism reflects reality. To him, journalism does not merely reflect reality, but it also produces and reproduces it – meaning that it also copies the journalists' ideas, beliefs, and paradigms. In this sense, "the practice of 'objectivity' has also come under scrutiny from those who point out (correctly) that it too often reflects a world dominated by white men, that it often serves the status quo"

(Mindich, 1998, p. 4). In the same way, Davies (2009) argues, "the great blockbuster myth of modern journalism is objectivity, the idea that a good newspaper or broadcaster simply collects and reproduces the objective truth" (p. 111). That is because news stories need to view reality from a specific perspective and point of view; news stories "can't be everywhere at once" (Davies, 2009, p. 111). Good, sound news organisations judge stories and put forward these judgments by case –selecting stories, angles, languages, sources, and presentation which uncover what is most essential. Furthermore, "they do it without restricting those judgments to the demands of any ideology or owner or advertiser or government or any other overarching influence. They do it knowing that other opinions are always available. They do it 'honestly'" (Davies, 2009, pp. 111-112). Kovach and Rosenstiel (2001) believe that the reason why the discussion regarding objectivity in the newsroom has become a large deception is because "rather than defend our techniques and methods for finding truth, journalists have tended to deny they exist" (p. 41). To them, "whether it is secrecy or inability, the failure by journalists to articulate what they do leaves citizens all the more suspicious that the press is either deluding itself or hiding something" (p. 41). Kovach and Rosenstiel (2001) thus, propose that journalists seek a more practical and functional way of telling the truth and not what they consider to be "truth in the absolute and philosophical sense" (p. 42). To them, "the truth here, in other words, is a complicated and sometimes contradictory phenomenon, but seen as a process over time, journalism can get at it" (Kovach & Rosenstiel, 2001, p. 45). Kovach and Rosenstiel (2001) further argue that, according to philosophers, there are two tests of truth: one is correspondence, the other consistency. In journalistic terms, this means in order to establish the right facts and make sense of them, coherence should be the ultimate test of journalistic truth (Kovach & Rosenstiel, 2001). It is worth bearing in

mind however that, in epistemology, there are more than these two criteria of truth (or "tests of truth"). The three most widely accepted are, indeed, correspondence and consistency, but also pragmatism. The first one is the correspondence of certain statements with the fact (the correlation is between language and reality); the second argues that truth consists of coherence between a set of statements or beliefs (it relates to a "logic plan"); the third, pragmatism, believes that truth is usefulness. The former, thus, seems to become comparably more important as this view of truth as correspondence appears to be much more appropriate to both the study of journalism and science. That is because it tends to claims that a statement or proposition is true if it corresponds to the facts; in fact, this inclusion with respect to scientists, researchers and intellectuals in the "the practical problems of governing their country is a characteristic of British society" (Desrosieres A. , 1998, p. 173). To Desrosieres (1998) English intellectuals invented this systems and method of objectifying scientific facts that could be separated from the observer, that could be communicated and replicated, and protected from conflict of interest (Desrosieres A. , 1998, p. 173).

As a consequence, Amaral (1996) believes the history of journalism shows that since the mid-nineteenth century, when journalism starts to be defined as "news" and "objective" and, at the same time, as a particular profession, it begins to focus, instead of on a formative-oriented news that it relevant to the community and public at large, on more informative-oriented news presentation on more or less ephemeral events that are designed to feed readers and are essentially aimed towards their amusement and pleasure. According to researchers, this has reached its ultimate stage with the widespread transformation of journalistic information into spectacle and entertainment (Koch, 1990; Mindich, 1998). And it is this notion that news is

presently more informative-oriented that rules the uses and representations of statistical information in the news.

In the end, due to these complex perceptions, Tuchman (1978) believes objectivity to be a most difficult term to conceptualise. Therefore, the first thing this research must do is to develop systematically a concept of objectivity in journalism. To do so, the theory of objective reporting is employed. Mindich (1998) lays down five components of "objective reporting" (p. 8): (1) detachment, (2) non-partisanship, (3) inverted pyramid, (4) naïve empiricism, and (5) balance. Concisely, in terms of (1) detachment, objectivity means the separation of having knowledge of the subject from the object of information. This way, objectivity depends on a clear-cut division between the self and reality. In this context, the principle of detachment is seen as a virtue; an ethical tool of communication that calls for facts to be communicated without designed interventions, and for journalists to limit themselves to reproducing reality. This notion invokes the same modern epistemologies that men should merely read the world instead of creating explanatory hypotheses – such as Newton's hypothesis *non-fingo* (Newton, 1999). That assumption, however, will later be discussed and rejected by epistemological theories like Popper (1959), Kuhn (1962) and Feyerabend (1975) that argue that social paradigms are similarly essential to reality, science and everything in between. Therefore, the message is also conditioned by its mediums. The idea of detachment thus resides in the opportunity and capacity to look at events and notice aspects that one would probably not see if standing too close to the case. It means journalists should have no association with political parties or any party-political preferences. Likewise, the ethical approach of (2) non-partisanship claims to be detached of partisan biases. To Mindich (1998), when reporting a political debate, for example, a journalist should avoid any form of

affiliation to a political party. He further argues that, historically, it was not possible before the 1830s when newspapers formally separated themselves of party ties (Mindich, 1998, p. 39). In the long run, non-partisanship in journalism means, in principle, favouring all political parties. In terms of the (3) inverted pyramid, Meikle (2009) considers it a means to mask official perspectives behind a thin veil of objectivity (p. 54). Still within this context, Mindich (1998) considers the (3) inverted pyramid technique essential to the portrayal of objective reportages. Its method consists of narrating fact decreasingly from its importance, hence becoming a functional arrangement. Thus, the technique is not only convenient to publishers to avoid unnecessary typographic elements, but also it creates the opportunity to attract the reader's attention. The notion of (4) naïve empiricism is particularly interesting, as Mindich (1998) points out, due to the relationship between its understanding and the authority spectrum of science in the news. To him, the growth in the scope of both was only due to the coincidental "spread of journalism and cholera in New York in 1832" (Mindich, 1998, p. 112). And lastly, (5) balance. Balance in terms of objectivity in journalism means the absence of bias. It is the basic moral of journalists to communicate news in an impartial and fair-minded way, in which news writers try to balance accounts when recounting stories.

As a final point, it is worth bearing in mind that the concept of objectivity, although central to this research, it is not exclusive of others. Therefore, the next section will further look at journalism, its components and news values as a continuation of this study on the notions of objectivity as a quality concept in the newsroom.

2.3. Journalism and its News Values

As noted above, it has already been observed that objectivity is one of the most enduring concepts within the conditioning of liberal journalism (Schudson, 2001, pp.

149-153). That previous research has been conducted on its importance to the construction of media reality indicates that it is key to the shaping of science discourse in the news. In terms of journalism and news values, it is worth remembering that notions such as 'truth' and 'reality' cannot be detached from the concept of objectivity (Wien, 2005, p. 3). That because journalism determines its authenticity from the proposition that it presents an accurate representation of reality. According to her, there would be no use for news and news coverage if the writers themselves attested that the dissemination of news comprised of misleading pictures of falsity (Wien, 2005, p. 3). News values act as complementary means of selecting and gathering information to be turned into news. The significance of these criteria regards the different combinations that occur between different news values in the selection of facts and production of news. Therefore, Galtung and Ruge (1965) reason that the typology of news values included:

- *In terms of impact* – amplitude, frequency, negativity, unexpectedness, and unambiguity.
- *In terms of audience empathy* – personalization, meaningfulness, reference to elite nations, and reference to elite persons.
- *In terms of pragmatism coverage* – consonance, continuity, and composition.

Further values include co-optation, prefabrication, predictability, time constrains, logistics and data. The latter being a keyword and indeed object of this research. Indeed, bearing in mind the importance of data to this study, it is imperative to note that the understanding of such news values is concurrently essential to the development of this research's results.

Indeed, news values are quality parameters that embody or characterize events through institutionalised methods (Wolf M. , 2003), for example, notoriety, death,

proximity, relevance, novelty, time, notability, unexpectedness, conflict, controversy, scandal, availability, accessibility, balance, visuals, among others. Lippmann (1922) refers to variables such as clarity, surprise, geographical proximity, impact and personal conflict. Gans (1979) suggests importance, interest, newness, quality and balance. Ultimately, regardless of the list of quality parameters, most authors agree that news values are primary and fundamental to the articulation of news. Newsworthiness and news values do not constitute an ordinary externality. Rather, they are the very process of the construction of events as news. After all, news values are the criteria that determine what is news and what is not, and that is an essential part of a journalistic practice, which decides which stories are worth being given special attention. Thus, news agendas are constructed by occasions that are extensively encoded by the media. That is, by a limited group of people.

Indeed, since Galtung and Ruge's (1965) publication, the media's ecosystem has changed a fair amount. In order to create a connected public stage, today's media arrangements comprise of a series of opinion leaders that utilise old and new means of communication technologies to create stories (Graeff, Stempeck, & Zuckerman, 2014). Within this networked public arena (Benkler, 2006, p. 10) opinion leaders act as gatekeepers, connecting information and audiences. Thus, to reach the audience, potential news stories ought to pass through the opinion leaders' media lenses. In that regards, due to limitations, journalists have to select which events will be reported and which ones will not. To make such a selection, Lippmann (1922) argues that writers must choose the news according to particular values. There is a news value system gained through an acculturation that guides this story assortment (Harrison, 2006). The understanding of such guidance is essential to analysing how data are gathered, interpreted and used in the newsroom.

Accordingly, while the conceptual definition of news values fails to define how news is chosen, news values offer an explanation of how such criteria are used and how certain events are turned into news. Following Galtung and Ruge (1965) elaboration, Traquina (2008) defines the concept of news values as a set of principles and operations that provide the ability to enable journalistic approaches, and to give news its values. To him, news requires a set of value that determines whether an event is likely to become news (Traquina, 2008); if it is "deemed worthy of being transformed into a reportable matter, and therefore having 'news values'" (Traquina, 2008, p. 63). Amongst those that contributed to the understanding of this process, is Charaudeau (2002), who exemplifies the symbolic exchanges embedded in a social communicative conception of discourses. To him, there are two primary theoretical systems: the connection between language and situational plans, and between macro and micro social plans (Charaudeau, 2002). In this framework, he aims to understand social discourse as an intimate, bidirectional enunciation between the social and linguistic planes (Charaudeau, 2002). Consequently, Charaudeau (2002) defends the media as institutional supporters; ones that make use of different concepts and logics –namely economic, technologic and symbolic– and therefore need clear guidelines (p. 302). Therefore, which are the media's guidelines?

Wolf (2003) argues that news values concern the sum of elements that are used to transform news and the means through which the informative media controls and generates the reporting of events (pp. 195-199). Wolf (2003) further concludes that news values are a key component of news itself, as they constitute the answer to how events are considered relevant, attractive and significant enough to transform into news articles (pp. 195-199). Within the spectrum of news and its news values, some theories offer particular descriptions to the agency of journalism. Notable

philosophies include the notion that journalism follows the theory of gatekeepers, the organisational theory, the theory of agenda setting, the instrumentalist theory, the news-making theory, the mirror of reality theory, and the theory of multifaceted news. Against this background, this research will continue with an account of news as a means of articulating and reflecting the mirroring and construction of reality. That because, to determine the limits and boundaries of news values, separate from the concept of the selection of news, a reference to the construction of social reality is essential to the reflection and study of how statistical information is used in the newsroom as a means to articulate narrative and shape discourses of science. In support of this study, the construction of reality is therefore understood as a result of the notion of objectivity as a quality concept in journalism.

2.4. Mirroring and construction of reality

As a complex and shifting field, journalism has played different roles throughout the years. Edmund Burke (1826) and later Thomas Carlyle (1840) first developed the concept of this institution as a fourth power in democratic society. To them, the press works as an influential power; one that can influence the other three branches – the legislative, executive and judicial – and has a unique power that has survived thus far (Burke, 1826; Carlyle, 1840). For the purpose of this research, in terms of journalism as a mirroring and constructor of reality, it argues journalism obtains its legitimacy from the understanding that it mirrors reality (Broersma, 2010a; Mindich, 1998) by presenting a true depiction of reality. The mirroring theory is one of the oldest principles of journalism. Historically, in the mid-19th Century, journalism grounded itself on the beliefs of informative journalism, where opinion was separated from information (Kaplan, 2009; Mindich, 1998). In the early 20th Century, reporting appears mostly associated with objectivity, understood here as a careful research of

methods and checking of facts (Kaplan, 2009). Given the background, from the 1920s on, facts start being presented as consensually approved articulations of the world; and therefore its construction as a shared reality get hold of a focal position in social studies, supporting a more complex notion of objectivity across media outlets (Schudson, 1978, pp. 5-7). The theory of Mirror of Reality was developed in the United States in the 1920s when facts started substituting comments, and articles began to make and claim to represent reality (Pena, 2010). The metaphorical nature of this approach is self-explanatory. It was one of the first theoretical explanations of the agency of reporting. The theory of journalism as a mirror of reality exists in the positivist ideas of Comte (1973), which defend the notion of objective journalism and reality. This school of thought sees journalists as unbiased, detached and truthful writers of facts. It claims that quality news needed its writers to describe the situation faithfully as if a mirror in the news was reflecting it. Consequently, in agreement with this philosophy, journalism represents reality objectively. Furthermore, as a positivist theory, it favours rationality.

In this context, the facts replace comments because the word reflects an observed reality as it presents itself. In the 1920s, the American press and newsroom developed narrative practices and a method they had to follow – the lead format – to avoid subjectivity; a journalist should be neutral and objective and have the power of synthesis when observing. Acting as a mirror of society, journalists do not need to have a self-critical approach. They function merely as a connecting tool within reality that the press, in general, observes. To date, the journalistic community continues to advocate the Mirror Theory, annulling all possible different opinions reflected in the newsroom, as this theory brings credibility and legitimacy to the journalist who

submits to the limited professional procedures, reporting the facts as they present themselves.

In respect of journalism studies, the Mirror Theory argues that journalists must then observe reality and reproduce a balanced report of the event. It mimics reality as it sees it, without interpretation or bias. This theory sees writers as disinterested mediators of information. Their responsibility relies on the information and communication of truth. To Lippmann (1922) it would bring scientific methodological rigour to the agency of journalism, thus avoiding subjectivity. According to this theory, the function of the agency of journalism is profoundly linked to the notions of objectivity and legitimacy, and thus crucial to the understanding of statistical data in the news, especially regarding the communication of scientific information in the news and is, therefore, vital to this research.

With reference to this mirroring of reality, it is imperative to remember "that is what journalism is after – a practical or functional form of truth. It is not the truth in the absolute or philosophical sense. It is not the truth of a chemical equation. But journalism can – and must – pursue truth in the sense by which we can operate day to day" (Kovach & Rosenstiel, 2001, p. 42). Similarly, Meikle (2009) would argue, "the media enable an arena for the defining reality" (p. 3) one which James Carey (1989, p. 87) claims to be a "fundamental form of power." In a parallel manner, objectivity has thus been entrenched in and linked to this power of defining reality. From this angle,

> *"the capacity to achieve distance from one's perspective and interests, conceiving the movement toward truth as the result of a continuously enacted impartiality on the part of the individual. This approach involves, however, a complex dialectic of detachment and engagement: ethical and epistemological progress is achieved through the flexible agency of sympathetic understanding" (Anderson, 2001, p. 17).*

In this context, journalism defines reality as it has the ability "to intervene in the course of events, to influence the actions of others and indeed to create events, with the help of the production and transmission of symbolic forms" (Thompson, 1995, p. 17). Furthermore, to Meikle (2009), the power of news does not differ from other forms of authority (p. 3). On the contrary, it converges with them as "political power generates resources of symbolic power; economic power can be expressed as symbolic power; coercive power can be demonstrated through the exercise of symbolic power" (Meikle, 2009, p. 3). Ultimately, "contemporary journalism presents itself as offering a record of reality that is as unbiased and as complete as possible" (Koch, 1990, p. 15) and is often taken as absolute truth through a false premise of objectivity and the bearing of truth. In a similar way, Chomsky and Herman (1994) argue that the functioning of the media today is seen as lacking in the representation of reality as it is deformed and regularly omits relevant facts. Reflecting upon strategies used in the newsroom to control meaning, construct and establish 'truth', Chomsky and Herman (1994) agree that journalistic discourse is highly persuasive and often used to create realities that serve particular interests within specific social contexts. Indeed, Chomsky (1989; 1997) and Chomsky and Herman (1994) are fierce critics of this complicity between media and power. To them, power represents to media what political repression means to a totalitarian state (Chomsky, 1989; 1997; Chomsky & Herman, 1994). There is a systemic bias in the media today focused on economic and structural causes. Furthermore, in democratic societies, the news media has a particular role to make the public absorb values, opinions, ways of thinking and a general worldview that is consistent with the interest of the elites (Chomsky, 1989; 1997; Chomsky & Herman, 1994). In terms of producing and establishing values, and

constructing 'truth', this research suggests upon the uses of statistical information as a key strategy in the construction of discourses in the news.

The following section will explore this suggestion in more detail, while looking at statistics as a tool towards this assertion on the representation of reality and legitimation of facts. Certainly, statistical information as a discursive tool in journalism has all the necessary qualities to conclude this analysis on the existing literature on the specific aspects of journalism for this research.

2.5. Statistics as a rhetorical tool in journalism

Statistics as a source within newsrooms is seen as an issue of primary importance in journalism studies. As a matter of fact, statistics are widely considered one of the most prominent legitimising tools in the construction of social reality. Similarly, the false and distorted use of statistics damages the endorsement of the alleged journalistic credibility (Hacking, 1965; 2001), as newsrooms tend to use or value different pieces of statistical data in ways that distort their meanings to produce effects that suit them. Statistics "are inscribed in routinized practices that, by providing a stable and widely accepted language to give voice to the debate, help establish the reality of the picture described" (Desrosieres, 1998, p. 1). Moreover, the persuasive power of numbers can be seen in newsrooms as it reinforces and validates arguments. That is because more than a legitimising tool, statistics, and quantitative data represent a positivist discourse that is highly regarded and as such is incorporated in journalism studies; the practice of using statistics, however, varies in accordance with each particular area of journalism. Although the current literature addresses some theories regarding this correlation between objectivity, truth, and news, little has

been studied regarding the role of statistics in science newsrooms as a means of articulation and legitimation.

This understanding, however, is essential to this research as the primary function of statistics is the rationalisation of argumentation. More than a fact, statistical data are facts that are enveloped by numbers. In that sense, "it does not matter that the news is not susceptible of mathematical statement. In fact, just because news is complex and slippery, good reporting requires the exercise of the highest of the scientific virtues" (Lippmann, 1920, p. 82). Thus, within its exercise of scientific virtues, journalism relies on quantitative data –due to the credibility that its information confers on argumentation. By doing so, journalists develop the habit "of scribing no more credibility to a statement than it warrants, a nice sense of the probabilities, and a keen understanding of the quantitative importance of particular facts" (Lippmann, 1920, pp. 82-83). Indeed, the use of statistical information as a rhetorical tool in the construction of journalistic discourses is so prominent in the newsroom.

CHAPTER III

Science Journalism and Communication

3. Literature Review

3.1. Introduction

Subsequent to the thorough analysis of the agency of journalism, this chapter targets the exploration of scientific knowledge as a means of public communication, argumentation and legitimation. This section presents an essential technical background to the agency of science in order to provide an understanding of its role in society and the newsroom. Within its framework, five concepts need particular scrutiny: (1) the philosophy of science, (2) objectivity as a scientific attitude, (3)

science as a social construction and its accountability, (4) the communication of science, and (5) its mathematization. Accordingly, this chapter subdivides into five parts. The chapter starts by presenting a historical perspective of the philosophy of science, most specifically looking at logical positivism. Furthermore it looks at falsificationism as an inductivist approach to knowledge. It then looks at objectivity as a strategic tool indicative of a scientific attitude towards the construction of scientific knowledge. Similarly, it looks at science as an objective tool in general knowledge. Then, it analyses the social construction of science and its communication to the public. It finishes by analysing the relationship between mathematic and scientific knowledge. The literature looked at in this chapter is the result of this understanding of science as a rational accessory within society and some literature especially pertinent to the findings from this research will be revisited in chapters VI, VII, and VIII.

3.2. The Philosophy of Science

The traditional understanding of science consists of a regular activity that gathers knowledge of the natural world through empirical study. This almost mythical scientific process means science makes progress due to its systematic method of analysis. According to it, the scientific method presents to society a consistent form of creating and accumulating knowledge. The philosophy of science in its turn is embedded in the study of science. It is defined as the study of its concepts, methods, and general implications within its discipline. Historically, this philosophical quest towards the understanding of science can be traced to Ancient Greece when Aristotle first suggested a distinction between the species. Since then, the study of the natural world and science have flourish. Amid leading researchers are Kuhn (1962), Popper (1959), Quine (1992), Feyerabend (1975), Bloor (1991), Barnes (1974), among others.

Concisely, these represent the history of the philosophy of science. The philosophy of science broadly encompasses three areas of research: (1) the study of methods, (2) the classification of its concepts, and (3) the study of its limitations. For the purpose of this research, particularly the domain of the study of methods and its limitations is relevant. In this traditional understanding of science and the scientific method, the basis and starting point for scientists and science researchers is the collection of empirical data –or observable data. Following it, collected data would, through experiments and repeated observations, becomes a hypothesis – which, once verified, would become a scientific law. Induction is, thus, what guides scientific findings. In this framework, if different scientists carry out experiments of the same kind, using similar methodologies, they should consider the same evidence and thus come up with comparable hypotheses. In fact, Stigler (1986) believes that only through this means of accuracy assessment, can one access knowledge: "external assessments of accuracy have always been critical to science. They can provide the only access to the measurement of systematic errors or biases" (p. 6). Within this assessment of accuracy, the philosophy of science can be classified into six perspectives: (1) logical positivism, (2) coherentist approach, (3) axiomatic assumptions, (4) epistemological anarchism, (5) sociology of scientific knowledge, and (6) continental philosophy. The understanding of science as an exact and precise knowledge explains it importance in the daily life and the newsroom. Within this framework, science helps construct the modern world and shape society. Arguably science is recognised as the largest source of knowledge in the world, habitually assisting the decision making process and rhetorical appeals. As a consequence of its importance, grasping the history and philosophical approach to the philosophy and study of science is critical to looking at the uses of statistics in the articulation of science discourses in the news media.

Within the scope of this research, the larger philosophical approach to science knowledge is of logical positivism. According to the scientific conception of logical positivism, the production of knowledge is based on empirical research. This approach is significant for this research as its inductive method establishes that scientific assumptions should aim to avoid the introduction of judgement. From this angle, the intent of depicting science as objective information is essential to this research.

3.2.1. Logical Positivism

The first perspective, proposed in the early 1930's during the Vienna Circle, aims at the expansion of the understanding of science through the means of social sciences. The Vienna Circle, as a cultural and scientific movement, profoundly alters the western scientific way of thinking. For logical positivists, the scientific method is exhausted by empirical deliberations. Logical positivism discusses that (1) science must be cohesive in its language, through methods of verificationism and tautological character of inference; (2) the study of philosophy must be understood as the philosophy of science and address the positivistic aspect of human knowledge, towards the direction of an effective objectivity; which, ultimately, (3) ends the understanding of metaphysics as science, seeing that every question now is interpreted in a unified language that provides sense. (Carnap, Hahn, & Neurath, 1973).

The Vienna Circle's primary intent is to free the Philosophy of Science from the idealist and irrational philosophy. It aims to formulate a new criterion that would distinguish between scientific significant and non-significant propositions, and works toward the design of a new philosophy of science, which through a logical language,

methods and scientific rigour would logically explain this formal-empirical science of nature. Accordingly, the Vienna Circle takes on a scientific view of logic. From this basis, logical positivists consider empirical science as a role model and propose that only scientific statements that offer observations that can be manipulated and described to be permissible empirical verification. Verificationism is the doctrine that proposes to exclude from the epistemological and scientific discipline any proposition that basis itself on concepts that cannot be verified empirically. Therefore, the principle of verificationism affirms that a proposition only has meaning if its terms can be written in observational concepts avoiding thus the introduction of judgements. Only through this set of conditions, knowledge can be accepted as empirically significant. This general principle leads to the attempt to disassociate applied scientific research theory to abstract predicaments.

In doing so, Ayer (1946) and Carnap (1952) claim that the logical manipulation of observations creates scientific knowledge. To them, knowledge is constructed by the consideration of datum in general avowals. According to them and this philosophy, science aims to check such statements. This distinguishable characteristic is the hallmark of empirical science and the meaning of scientific propositions. The philosophy of science, from this positivist aspect, directs itself towards an effective objective knowledge. Ayer (1946) argues that the main feature "which enables us to test whether a sentence expresses genuine proposition about a matter of fact" (pp. 15-16) is the process of verifiability. Ayer (1946) further stresses the importance of understanding this fact and proposes a distinction between practical verifiability and verifiability of principle. To him, the latter comprehends those assertions that cannot be verified practically –as is the case of the statement "there are mountains on the farther side of the moon" (Ayer, 1946, p. 17). Ultimately, Ayer (1946) and Carnap

(1952) argue that each scientific proposition based on factual information has an empirical hypothesis. And every empirical hypothesis must be relevant to any current experience.

For the purpose of this research, the understanding of this philosophy of science and ways in which it came to be is crucial. It is only through the means of understanding how scientific knowledge is verified that one can assert how its discourses are constructed in the news media. As the scientific method is the set of ground rules that must be followed for the production of knowledge. The way in which the scientific method is checked is significate for the understanding of science as information. In this context, it is this set of rules that determine the objective and legitimate aspect of the scientific knowledge. Its interpretation is thus essential to the ways in which statistics are used in the newsroom, especially regarding its application as a tool for constructing reliable information and official narratives.

3.2.2. Popper's Falsificationism

Popper (1959) believes this philosophical approach left more space for scientific knowledge in the sense that the best theories are those which cannot be proven wrong in the long run. Popper, whose spectrum of influence propagates after the aforementioned Vienna Circle, believes in the development of a philosophy of science based on a logical language and created through logical procedures with high scientific rigour (1959, p. 40). His principle of falsificationism proposes that axioms must be established as true or false; not according to their verificability but their refutability. To him, scientific propositions cannot be proven right, only proven wrong. According to Popper (1959), scientific observations are first oriented by a theory to be proven.

> *"The criterion of demarcation inherent in inductive logic – that is, the positivistic dogma of meaning – is equivalent to the requirement that all the statements of empirical science (or all 'meaningful' statements) must be capable of being finally decided, with respect to their truth and falsity"* (Popper, 1959, p. 40).

Thus, science that is based on an inductive logic method selects the phenomena to be studied through the establishment of evidence that is already assumed. As a consequence, the previously used verification criterion is not always valid. To him, there is no logical inference in singular statements.

In view of that, Popper (1959) states the logic of scientific discovery has as its primary task the logical analysis of the methods of the empirical sciences. To him,

> *"a theory is to be called 'empirical' or 'falsifiable' if it divides the class of all possible basic statements unambiguously into the following two nonempty subclasses. First, the class of all those basic statements with which it is inconsistent (or which it rules out, or prohibits): we call this the class of the potential falsifiers of the theory; and secondly, the class of those basic statements which it does not contradict (or which it 'permits'). We can put this more briefly by saying: a theory is falsifiable if the class of its potential falsifiers is not empty"* (Popper, 1959, p. 86).

Furthermore, to justify inductive inferences, one must first establish the principle of induction that seeks to order scientific assumptions in a logical way. To him, the principle of induction is not analytic but synthetic. Within this framework, it should be considered that Kant (1781) previously postulates that in the analytical, the predicate is contained in the subject and the synthetic is not – even though, still in accordance to him, the predicate and subject are connected. According to Popper (1959) only the synthetic adds knowledge.

The logic of scientific knowledge examines the justification of validity, not the question of factuality. Popper (1959) believes that one can never know that a scientific theory is valid; all one can assume is that – up until the present moment – it has not been proven wrong. This notion, also known as critical rationalism, adopts a

critical attitude that subjects theories to testing, which might result in its refutation – in other words, tries to detect mistakes in proposed principles. Popper (1959), thus, identifies four different ways to submit theories to the test. They regard the comparison of findings; the investigation of logical theory; the comparison with other theories; and the confirmation by experiments.

Taking into account the logical result of theory, other results are derivable from it. Moreover, one can say that this deductible outcome can also put the theory to the test, as it needs to be logical. This process 'escapes' inductive logic. Popper (1959) refutes this idea as it does not provide adequate 'demarcation criterion'. According to him, this principle distinguishes the empirical sciences from the 'apriori' ones (i.e. geometry, algebra, and physics). For epistemologists, empiricism tends to go to induction – and, thus, this also applies to positivism (Popper, 1959). Positivists, Popper (1959) says, have engaged themselves to show that metaphysics, because it is not empirical, is empty of meaning, or as Hume states pure "sophistry and illusion" (Popper, 1959, p. 35)**.**

> *"The positivists tried to say more clearly what 'meaningful' meant, the attempt led to the same result – to a definition of 'meaningful sentence' (in contradistinction to 'meaningless pseudo-sentence') that simply reiterated the criterion of demarcation of their inductive logic"* (Popper, 1959, p. 36).

Similarly, Wittgenstein, also in accordance with Popper (1959)**,** did this because, for him, the meaningful propositions can be reduced to elementary propositions. Wittgenstein's significance criterion suggests that it is irrelevant to natural laws (p. 35). Wittgenstein developed the theory of meaning and language. His philosophy is essentially that the meaning of proposition and language, which he believes to be the limit of man, to be its method of verification as it specifies its truth-conditions. Popper (1959) says that the positivists failed in his demarcation criterion, as they

reached the conclusion that both have no meaning. Furthermore, it can be argued that Popper's demarcation criterion seeks a convention. To him, the task of the logic of knowledge is to develop a concept of empirical science (Popper, 1959). Building on the critique of logical positivism and idea of verifiability, it understands reality as something socially constructed. It recognises science as falsifiable knowledge (Popper, 1959) and a shifting paradigm (Kuhn, 1962). In addition, it places it within a meta-theoretical instance, which criticizes positivism and views knowledge as inevitably hypothetical. Contained by this idea, whole knowledge must be shifted when encountering new evidence. Science adjusts its views based on evidence, and what is observed.

Thus, empirical science is the world of experience. Indeed, Popper (1959) believes the theoretical system seeks to be synthetic, non-contradictory and aims to meet this criterion of demarcation and strive to be different from similar systems, by submitting it to the production of evidence and deductive method. As Popper (1959) rejects the deduction, he claims the places that theories are never empirically verifiable. But despite this, Popper considers a system valid only if experience confirms it. The defying criteria should not use verifiability but ‘falsifiability’ to analyse a system. Thus, Popper's (1959) explanation of falsifiability and the scientific progress is not only closely associated with the conception of the scientific method, but also as its understanding of objective truth. Again, this is relevant to how science is presented in the news. Its characteristic as an objective information is essential to the way in which its knowledge is presented, how science discourses are constructed and narratives shaped in the newsroom.

3.3. Scientific Objectivity

In bried, the scientific method is essential for the understanding of science as information. Within this framework, the interpretation of science is crucial to how statistics are used in the newsroom, as a tool for constructing objective narratives. The reason behind its importance, and therefore the need to understand science, is due to science aspires to objectivity as a means to try overcoming subjective conditions. To Stigler (1986) "external assessments of accuracy have always been important to science. They can provide the only access to the measurement of systematic errors or biases" (p. 6). The assumption is that scientific knowledge has been successful in its explanation of reality due to it being rational and objective. The process in which this information is created is therefore essential to the construction of science. With this in mind, how is this process developed?

According to the traditional conception of science and scientific discovery, the starting point for scientists and science researchers is the collection of empirical data –or observable data. That means that collected data would, through experiments and repeated observations, becomes a hypothesis – which, once verified, would become a scientific law.

> *"Only by such repetitions can we convince ourselves that we are not dealing with a mere isolated 'coincidence' but with events which, on account of their regularity and reproducibility, are in principle inter-subjectivity testable"* (Popper, 1959, p. 45).

Within this context, Kant (1781) believes knowledge should be justifiable, as the only way a proposition can, in principle, be objectified is through tests and if it is understood by everybody. To him, a proposition is only valid when understood by everybody in possession of reason and logical thought, and then its lines of reasoning are objective and sufficient. Furthermore, Kant (1781) argues that the construction of

scientific theories – using scientific premises, principles, and universal statements – is closely connected with the objectivity of scientific reports.

> *"Critical reason is, of course, itself to be distinguished from conceptions of objectivity: the former subjects customs and habit to reflexive interrogation; the latter seeks to identify empirically verifiable facts and laws, relying on a fundamental conception of the objective status of the external world"* (Anderson, 2001, p. 92).

Similarly, Cournot (1843) argues that

> *"Our belief in certain truths is not, therefore, founded solely on the repetition of the same judgements, nor on unanimous or almost unanimous assent: it rests mainly on the perception of a rational order according to which these truths are linked together, and on the belief that the causes of error are abnormal, irregular, and subjective, and could not engender so regular and objective a coordination" (Cournot, 1843, p. 421).*

As previously mentioned, Popper (1959) believes that "in demanding objectivity for basic statements as well as for scientific reports, we deprive ourselves of any logical means by which we might have hoped to reduce the truth of scientific statements to our experiences" (p. 25). He argues that Kant was not successful in validating these 'synthetic judgments' *a priori* – as the latter claimed that these judgments were based solely on sciences such as mathematics and physics. Popper (1959) goes on to cite Reichenbach (1969), who speaks favourably of the inductive method: "the principle of induction as the means whereby science decides upon probability. For it is not given to science to reach either truth or falsity…but scientific statements can only attain continuous degrees of probability whose unattainable upper and lower limits are truth and falsity" (Reichenbach, 1969, p. 64). Thus, *a priori* premise comes from the process of induction, which in accordance to Popper (1959) commits a redundancy – despite being valid and necessary. He further argues against this idea – the deductive method of proof – that only empirical scientific hypnotises and premises admit the empirical evidence.

Conversely, while Popper (1959) defends that scientific knowledge is objective and that its evolution is rational, Kuhn (1962) presents a different perspective, which rejects objectivity and its claims to rationality. Kuhn (1962) believes that scientific paradigms must define and regulate all scientific knowledge and work in a particular research area. His paradigm, thus, is based on a theory of high explanatory strength, which serves as a model for investigations and determining the problems that the research will focus on. Its elements include (1) fundamental laws and theoretical assumptions; (2) rules to implement these requirements to reality; (3) rules for using scientific instruments; and (4) metaphysical and philosophical principles. According to him, "scientific methods are simply the ones illustrated by the manipulative techniques used in gathering textbook data, together with the logical operations employed when relating those data to the textbook's theoretical generalisation. The result has been a concept of science with profound implications about its nature and development" (Kuhn, 1962, p. 2)**.** The evolution of science is not an entirely rational process of eliminating of false theories in the light of criteria, but a succession of paradigms selected by a combination of objective standard and subjective factors (Kuhn, 1962)**.** Differently from reality, which is a complicated matter as it is subjective, scientific truth "is that which has evolved to the point where it is the currently accepted basis of application and of further research and speculation" (Davis & Hersh, 1988, p. 273)**.**

3.3.1. In Journalism

Additionally, science is also an area in which one can clearly notice how it has been used as a tool of achieving the "journalistic truth" (Battersby, 2010). That is because, science is considered to be the pursuit of knowledge and, therefore, it (all scientific

knowledge and study) must be founded upon the belief that there is a universal, unbiased, objective reality that is precisely the one that is going to be analysed and represented. Goldacre (2009) argues that "there is an attack implicit in all media coverage of science: in their choices of stories, and the way they cover them, the media create a parody of science. According to this template, science is portrayed as a series of groundless, incomprehensible, didactic truth statements from scientists, who themselves are socially powerful, arbitrary, unelected, authority figures" (2009, p. 225). Correspondingly Blastland and Dilnot (2008) believe that "food and health scares are a paranoia – laced anomaly, often reported and, presumably, often read with no sense of proportion whatsoever" (p. 25). Scientific claims, unlike casual claims, create a believable fallacy due to the processes they have been exposed to – peer reviews, numerous experiments, replication, etc. For peer reviews and news, convergence is crucial to asserting the plausibility and credibility of a claim – the outcomes that emerge from news studies – particularly in terms of "preliminary" studies. Those are seldom worthy of any concrete confidence (Franklin, 2008: 143 as in Bauer and Bucchi, 2008).

This approach is somehow similar to Goldacre (2009) that critically passes judgment on the inconsistency and irrelevance of ways in which scientific studies are portrayed in the news. In a similar manner, Fjæstad (2007) argues that the reporting of science news (especially natural science) is inadequate due to its "non- or underreporting of important scientific progress; sensationalism and negativity in choice of science topics; sensationalism and negativity in wording and in presentation; inaccurate reporting; reluctance to publish rejoinders and corrections" (p. 123)**.**

Similarly to Goldacre (2009), Fjæstad (2007) thus believes that the media do not appreciate the importance of science and scientific histories, as, according to him,

journalists tend to obstruct rather than facilitate the communication with the public as a whole, as journalism "distorts science in its own idiosyncratic way" (Goldacre, 2009, p. 225), and "they play on the public's view of science as irrelevant, peripheral boffinry" (Goldacre, 2009, p. 226). Ultimately, this often makes scientific stories fall into the following three categories: (1) the 'wacky' stories", (2) the 'breakthrough' stories, and (3) the 'scare' stories. And ultimately it is the "way science is perceived, and the repetitive, structural patterns in how we have been mislead" (Goldacre, 2009, p. 224). Rooted in its textual structure, Koch (1990) argues, that at the core of contemporary news lies innate, regulated inclinations, biases and fundamental flaws. He criticises the institutional myth touted as journalism, which "brands" its practitioners as spokesmen and women (of the general public) in disseminating information without any interest or influence.

For the epistemology of science, what is at stake is the opposition between objectivity and objectification, between the ideal of science and the possible and 'real science'. In a more traditional sense, objectivity is understood as the characteristic of reality, better even than the existing knowledge of reality that is practically indistinguishable from reality itself. From this perspective, the world of experiences and facts is and can only be relevant and validated by science. This notion, thus, idealises scientific knowledge as accurate and real knowledge, one that has the property to establish unambiguous statements and most importantly have universal validity, as a unique, independent, and external interpretation of the subject and researcher. In other words, scientific knowledge is said to be the collection of justifications and explanations about reality – objective reality – which is based on observed phenomena; one that can and must be verified repeatedly to confirm its validity. Modern science, or rather, modern sciences, the science of nature – all that is natural, including human nature –

are based on this premise. Conversely, the concept of objectification in its place tends to dismantle the notion of absolute truth and nature. To it, there are no simple phenomena that can be simply observed and predicted. Rather, it believes that the 'phenomenal world' is configured as a product of some diverse relationship. The identification of the scientific object and experiment – which is no longer freely shaped by immediate experiences, but rather from a constructivist point of view (meaning it is now constructed) – implies an inconclusive and provisional knowledge, which is incompatible with the so-called established certainties that promised the paradigm and illusion of objectivity. Knowledge, in turn, can only be constituted through continuous 'guesstimates', which are viable simultaneously by both the theoretical model and the practice of the scientific technique. Accordingly, "if all sciences require measurement –and statistics [are] the logical of measurement– it follows that the history of statistics can encompass the history of all science" (Stigler, 1986, p. 2). The objectivity becomes thus the maker, the conceding of science. In this framework, science reporting is the ideal of objectivity. When writing about science, journalists present information that is verifiable, replicable and generally widely accepted. As a result science validates the journalistic objectivity.

3.4. Social Construction of Science

Following on the understanding that science is essential to the construction of journalistic discourses, this research suggests its importance as tool towards the social and the construction of social reality. Firstly, in terms of science in the service of the social, Sagan (1995) believes that in spite of numerous opportunities for abuse, scientific knowledge may be the "golden road" away from ignorance and poverty (p. 37). It informs society of the dangers of its world-altering advances, educates us about the most profound issues of origin, life and prospects, and shares the same values as

democracy itself (p. 38). To him, science and civilized democracy are concordant and "in many cases indistinguishable" (Sagan, 1995, p. 38). This notion that science complements society, that the history of knowledge is linked to the history of humanity and social development itself, is crucial to understanding how science discourses are articulated in the media and its importance to society.

From this angle, according to the theory of social constructivism, scientific knowledge is constructed by diverse arrays of scientific communities that act subjectively, as the understanding of science to one community varies according to its social, historical, cultural and political background. Collins and Pinch (1993) compare science to the Golem, a creature of Jewish mythology made of clay that was animated by having the word Truth written on its forehead. To them, science is clumsy, dangerous and "does not mean it understands the truth" (Collins & Pinch, 1993, p. 2). In their study, they analyse a series of incidences in which the means through which science is validated and its methodological and logical processes are portrayed to the public are completely altered. As an example, Collins and Pinch mention the "edible memory" episode in which psychologists and biochemists claimed memories could be passed on by feeding pieces of one animal to another (Collins & Pinch, 1993). Goldacre (2008) in the same way remembers the media's MMR news story when doctor Andrew Wakefield linked the MMR triple jab to autism. Examples are numerous, for example the "cold fusion" claim in which nuclear energy could be released by an electrochemical reaction in tube tests; fish oil pills that solve complex social problems. Ultimately, Collins and Pinch (1993) argue that only by presenting an open explanation of how science really works, can one truly understand science and its complexity. To them, it is the uncertainties and disagreements that matter most to the public at large.

In this context, Cole (1992) believes scientific knowledge is socially constructed both within the highly specific scientific community, as well as in the general community. To him, however, this social construction is limited to a variety of empirical senses. That means nature, *per se*, does not affect science's cognitive essence. It does not determine scientific knowledge. Rather, it does not "not influence" it (Cole, 1992, p. 5). The core principle of the social construction of science is in the means in which we socially conceive our knowledge from culture and other pieces of information that often depend on political agreements between all parties (Bird, 2000, p. 137). Additionally, Merton (1938) agrees that socio-historical studies of science can help us understand the means in which the development of science is influenced. However, he believes it has little to do with how scientific content is produced. This dichotomy therefore proposes two variants of the social construction of science: (1) the relativist social construction of science, which denies any outer influence on scientific knowledge; and (2) the realist social construction of science that does not deny such influence, but believes it does not define scientific content. The relativist social construction argues that scientific knowledge is relative to each culture. This knowledge is only valid if socially approved by a specific culture. Furthermore, according to this conception, scientific processes and principles are social conventions that must be based on norms determined by society.

One of the greatest minds behind this concept is Kuhn (1962). According to Kuhn (1962), scientific knowledge is not entirely dependent on social factors in order to progress as it depends on the interaction between the scientific community, the paradigm, and nature. Within this framework, Kuhn (1962) explores three kinds of relativism: epistemic, ontological and linguistic. Indeed, academic studies into science communication and the construction of science in the media have widely been placed

within the boundaries of two models of scientific research: relativism and positivism. One of the most common misconceptions of paradigms is the understanding that this notion of paradigm shifts as well as the evolution and nature of science itself are an example of relativism. Kuhn (1962) denies this interpretation. He claims that science does not progress in a linear and continuous way. Conversely he argues that the understanding of scientific truth cannot be founded uniquely by objective criteria. Instead, it is defined by a consensus created by the scientific community – or rather a social construction. With regards to this social construction of science, Lopes (2007) argued that this so-called modern scientific revolution brought the notion of a mathematical rationality, which mainly consisted of the objectification of areas beyond the notions of science. The understanding of this social reality happened through this scientific consensus, an organised and logical thought. The key aspects of human knowledge are traditionally apportioned into categories such as ethics, science, etc. In this perspective, the construction of knowledge of the object is accepted as obtained in the subject-object relationship, mediated by technology, as they the "modern" scientists thought, led by the paradigm of consciousness that further reinforces this way of thinking.

3.5. Science Communication in Public Culture

In terms of the communication of science in public culture, more specifically in the news, the relationship between journalists and scientists is crucial for making scientific knowledge accessible to the public at large. Over the past decades, science communication has been a prime area of journalism (Bauer & Bucchi, 2007; Bucchi & Mazzolini, 2003; Bucchi & Trench, 2014; Feyerabend, 2011; Fjæstad, 2007). The social demand to understand the world through scientific lenses has led to the necessity to communicate their findings among the general public. Within this

framework, the communication of scientific knowledge to the public at large is broadly seen as a tool of social inclusion where news agencies are seen as a means of scientific culture formation, rather than merely an instrument of news dissemination.

In theoretical terms, Bueno (1985) defines science communication as the processes, strategies and mechanisms for the diffusion of facts that are related to the fields of science, technology and environment. Furthermore, Bueno (1985) considers science journalism as a social process that is articulated through the relationship between formal organizations (research institutions, government agencies, broadcasters) and the collective (general public), through channels of information dissemination. More than that, it is understood as a means of social construction of science and common scientific elucidation. Correspondingly, Perreira, Serra e Peiriço (2003) argue that the purpose of science communication is – aside from the amusement and enlightenment of the public – the exposition of eventual discoveries that may change society and the way it exists. Examples of this intersection between science, communication and society have increased in number and intensity on a global scale (Bauer & Bucchi, 2007; Bucchi & Mazzolini, 2003; Bucchi & Trench, 2014). In this context, the communication of science in public culture acts as an arena for discussion of assumptions, values, attitudes, language and general implementation of science knowledge (Valerio & Bazzo, 2006). Furthermore, it positions itself as a means of theoretical-formative content edification and a vehicle for social inclusion.

Given the background, science communication can be divided into the following models: the deficit model of science communication (Gregory & Miller, 1998; Levy-Leblond, 1992; Myers, 2003) and the contextualist model (Durant, 1996). For that reason "public engagement and outreach activities have now become a routine, or even prominent, feature for several research institutions in Europe and elsewhere"

(Bucchi, 2013, p. 905). For these research institutions the dissemination of scientific research and information is crucial to the institution's exposure and thus the attraction of new grants and endowments. For the public it is important to have the opportunity to acquire basic knowledge on science as a means to understand the world around it (Bucchi, 2013; Bucchi & Mazzolini, 2003; Bucchi & Trench, 2014; Goldacre, 2009; Popper, 1959). Nonetheless, that is not always the case. The public's knowledge of scientific topics is still very limited, especially among the lower socio-economic classes. In Brazil, for example, a national public opinion poll conducted in 2003 by IBOPE [1] indicated that out of the 2,000 people interviewed, 49 per cent of interviewees from class E[2] has never heard of GMOs. That number rises to 57 per cent of those who earn less than the minimum wage.

3.5.1. The Deficit Model

As regards the promotion of the scientific culture and communication, the diversity in the modern modalities in the coverage of scientific information to the non-specialised public also presents a variety of possible options in the gathering, interpretation and communication of scientific data. This multiplicity did not arise without questioning. The debate between the legitimacy and efficiency of these multiple modalities has been vocal (Bauer, Allum, & Miller, 2007; Dierkes & Von Grote, 2000; Gregory & Miller, 1998). One pattern in particular that has been increasingly discussed among researchers is that of the 'deficits'. Succinctly, in this model, scientists are seen as specialists who possess knowledge, while the general public is seen as deprived (deficit) of proficiency in the area of science and technology (Durant, 1996; Gregory & Miller, 1998; Levy-Leblond, 1992; Myers, 2003). Additionally, it attributes public

[1] http://www.ibope.com.br/pt-br/Paginas/home.aspx
[2] Social Class division in Brazil ranges from A1 to H. Class A includes households with a monthly income higher than R$ 14,000 and H R$97 per month. Class E includes households with a monthly income between R$950 and R$1,400.

hostility to science to a fundamental lack of understanding of scientific knowledge, derived from a deficiency of information. It is often seen as an “us versus them” (or in-groups and out-groups) sociological mentality where on the one hand scientists hold expert knowledge and on the other hand non-experts lack it. According to Sturgis and Allum (2004) this model implies that the processes behind science communication follow a one-way road where scientists produce information and the public merely, passively receives it. Further to the aspect mentioned above, this model holds a second aspect that relates to the notion that general public opinion will change once this knowledge deficit is countered by reliable and accurate information.

Over the past ten years of research in the field of scientific communication, it was demonstrated that the "deficit model" could explain only part of the complexity of the understanding and perception of the public on issues of science and technology (Gregory & Miller, 1998), for various reasons. First, treating the audience as passive and analysing knowledge more in terms of failures (or deficits) instead of content, does not give appropriate weight to dynamic aspects of informational sense construction, of trading messages, motivation and emotional connotations that lead citizens to build their own social representation of science and technology. Secondly, the model does not address the scientific culture as a dynamic, collective, and social attribute, but rather as an individual one, ignoring the understanding of science that crucially depends on the social environment in which knowledge becomes operative (Irwin, Wynne, & Jasanoff, 1996). A third point worth mentioning relates to the fact that an understanding of the communication of science, as pieces of information flowing from an external institution to society, does not consider the broad and dynamic exchanges between the so-called contemporary science (that some sociologists called post-academic) and other social institutions (Ziman, 2000).

Following academic discussions, Non Governmental Organisations and PR organisations have also questioned the deficit model. As new critiques towards this assertion of science and its uncertainties are raised, claiming more democratic public participation and a more positive view of scientific information and knowledge, a new view of this model is created. According to this view, the role of the public in society needs to be reconsidered, as does its relationship between science and society. In this context, the general public must not be seen as an ignorant audience that merely receives information and must be educated on the values of scientific knowledge, but as an intelligent partner that can actively engage in the processes of debate and diffusion of knowledge. This new understanding of deficit, thus, argues the existence of an inadequate understanding of the public by the scientific community and its communicators due to a lack of means for open bidirectional dialogue.

To Nelkin (1987) and Durant (2005), the reason for this deficit in knowledge and understanding of scientific information is the way a non-realistic image of its activities and an almost sanctification of its methods and professionals has been created. They argue in favour of a representation of science as it is: a knowledge that is often controversial, sometimes wrong and seldom certain. To Shapin (1992) this option would better serve the public's understanding of science, which according to Miller (2001) stands today at a point of convergence. Moreover, it would create a more reasonable imagine of science than its current portrayal, going beyond the mere satisfaction of the interest of citizens, instead providing them with competencies that they certainly need in contemporary society (Shapin, 1992). For Sturgis and Allum (2004) this scientifically literate citizen is important as it enables public participation in scientific debates and often holds governments accountable for their decisions and their direction of science policies. At this point, it is important to mention that Brazil

adopts this deficit model (Fares, Navas, & Marandino, 2007). Regarding culture, it lacks a didactical and discursive communication of scientific knowledge to an uninformed public.

3.5.2. The Contextualist Model

Opposing the unidirectional deficit model of science communication is the contextualist model, which bases itself in the democratization of scientific knowledge. In this multidirectional model, scientific information is widely communicated through public arenas. In this model, public and scholastic participation in forums on scientific subjects happens in spheres open for communication (Durant, 1996). Durant (1996) further argues the need for open and valued dialogue between scientists and non-scientists, which values both groups of participants.

Alternative models include: (1) The model of lay knowledge or expertise lay model, which emphasises the role of local cultural knowledge (based on the lives and experiences of communities), interpretation and social use of advances in Science & Technology (Burns, O'Connor, & Stocklmayer, 2003); (2) the so-called democratic or public participation model (Hamlett, 2002; Miller S. , 2001; Wachelder, 2003), which instead of allocating disagreements relating to science to the general public prefers to seek a deeper understanding of the cultural and institutional causes of these differences; trying not only to inform society, but also form and develop a critical spirit that would enable not only the understanding but also the evaluation of the facts and scientific events, not to mention, their risks and social relevance; and (3) the web model (Lewenstein, 1995), which examines how internal communication, technical, science, and the public disclosure, interact in complex ways and relate to each other.

According to this model, there is no longer a new God. No scientific public with blindly accept scientific authority on its own terms. The policy is too often poorly informed by science and driven by other criteria. The direction of publicly funded science research is politicised. In this framework there are two strands: (1) utilitarianism as a theory of science and morality and (2) ethical relativism. The former concerns a philosophical theory on how one should understand the foundations of scientific ethics – and therefore its authority. The latter, implies that one should choose its own moral grounds in accordance to what society approves and understands as socially ethical. As every other ethical doctrine, utilitarianism is a theory on the foundations of moral conduct and the criterion that ultimately allows us to evaluate and judge the actions we take, the behaviours we must follow and the rules that we must adopt in the course of our lives. Therefore, the fundamental thesis of utilitarianism is a recommended procedure for assessments within the processes of decision-making or determined judgments. Its general guideline proposes assessments based on the calculation of the consequences of our action – both as an individual and a collective. Ethical relativism on the other hand argues that morals and ethics are not objective notions. In accordance to it, attitudes vary in terms of space and time. What is understood and implied today might not be tomorrow. In this context, our moral and ethics are rules learned within a society. Different societies have different morals. According to it, morality is also a social construction. And if ethics can be constructed, how can the communication of science detach itself from this relativism?

Within these terms, a new beneficial boundary mechanism to communicate science is necessary (Bucchi & Mazzolini, 2003). The subsequent section will help further develop this understanding of science as an objective authority and its importance to the social world, as well as the construction of a social reality.

3.6. Mathematization of Science

The use of mathematical techniques is increasing in most disciplines within the social sciences, especially in Economics, and supporters of this trend towards mathematization usually try to legitimise this process from the supposedly axiological neutrality of Mathematics, arguing, under the positivist influence, that mathematical language should be the very language of science. This research stands in opposition to this conception, rejecting the possibility of statistical neutrality and demonstrating that Mathematics can help comprehend historical processes in only a very limited way. We maintain that mathematical models are unable to describe the origin, development or decline of social relations, being useful, only as a description of quantitative patterns of events when social relations remain stable. It follows that mathematically formulated social theories have the objective of developing a collection of models, one for each circumstance. Social changes, even the smallest, are outside the focus of the theories developed in such a way. Finally, we argue that the contemporary philosophical and cultural environments, due to the abundance of relativist and pragmatic approaches, favour mathematization, even against the wishes of many supporters of such philosophical conceptions. The mathematization of society, however, has a long and intrinsic history. Galileo (1564-1642) stated that the book of nature was written in mathematical characters namely that the laws of science should be written through mathematical formulas (Seeger, 1966, p. 50). Galileo, when applying a resolving method and mathematical research, performed movements and developed the idea that the object of cognition of nature is the insusceptible phenomena of a mathematical interpretation and quantifier (Seeger, 1966, p. 51). In short, philosophy became aware of the motion of bodies of knowledge. For Galileo, nature was mathematized; an abstract construct (Seeger, 1966, p. 51). At the end of

the nineteenth century and early twentieth century, the exacerbated psychologism that insistently denied philosophy and, in its way, wanted to become the theoretical basis of all sciences, led Husserl (1994) to return philosophy to its scientific status. Amid an avalanche of discussıon between innatism and Empiricists about the origin of logic, Husserl appears to show a new vision: the possibility of extracting the absolute sensitive forms. In that sense, he was the first to present numbers as an absolute form of certainty. Since then, the knowledge of science has been connected to the methodology of numerical information, and thus, mathematics became the tool for the construction of science, the only one that can be truthful. Why should science be mathematized?

There are a number of reasons that validates the mathematization of science. While Husserl (1994) argues that mathematization does not mean a clear and unequivocal improvement of existing theories. Its implementation is stimulated and encouraged by a shift in the focus of science. In fact, it is frequently less interested in historical process and increasingly more focused on the description of mechanisms restricted to specific contexts. As a matter of fact, this account is legitimised by its ability to provide instrumental agents for their practices. However, of course, not every advocate of formalisation adopts the criterion of instrumentalism.

In fact, there is a clash of mathematical philosophical assumptions. In conjunction with intuitionism (Brouwer, 1976) and logicism (Frege, 1977; Russell, 1993; Whitehead, 1962)**,** mathematical formalism (Hilbert, 1950) goes against mathematical Platonism. Mathematical Platonism is the metaphysical notion that mathematical information exists independently from language, thought or practices (Frege, 1960). They can be said to be true or false by numbers that have perfectly objective properties. Thus, mathematical truths are always discovered – never invented. My

epistemological view is that whilst the representation of statistical science is socially constructed (Davis & Hersh, 1988; Ernest, 1991, 1998; Lakatos, 1976;), the philosophical assumption, foundation, and implication of mathematics are not. Mathematical information is discovered, not constructed.

In terms of mathematical knowledge, Comte's view of mathematics as being the highest hierarchical level of information source (1973) continues to be cultivated in scientific and academic circles. Thus, numbers are not only considered a fundamental tool for human progress (Boyle, 2000, p. 57) but also widely used in the newsroom as a means of ensuring objectivity in news articles. Lastly, in the general areas of science, although the philosophies have and are often shifting paradigms (Kuhn, 1962), scientific information is still regarded as a powerful tool towards rational thought. Moreover, it is seen as the greatest tool for societal development and thus must be duly understood as well as used.

CHAPTER IV

Mathematization of Reality

4. Literature Review

4.1. Introduction

This chapter reviews existing research on the mathematization of society, as well as, its uses in the social construction of reality that is relevant to this study. The aim of this chapter is to provide a clearer understanding of the phenomena and processes in which statistics are used as a rhetorical tool in society, and in shaping discourses of science in the news. Therefore, this chapter is divided into two parts: (1) the statistical construction of reality and (2) the mathematization of society. The review of literature analysed in this chapter is the conclusion to arguments, which claim statistical information as a means to socially construct reality. Some literature especially

relevant to the findings from this study will be revised in Chapters VI, VII, and VIII and conveyed in relation to the empirical finding.

4.2. Statistical Construction of Social Reality

It has been argued that as a consequence of their technical-scientific dimension, statistics have always been associated with the idea of objectivity and legitimacy (Boyle, 2000; Davis & Hersh, 1988; Desrosieres, 1998; Eberstadt, 1995; Goldacre, 2009; Hacking, 1965; Koch, 1990; Livingston & Voakes, 2005). Because statistics are understood as part of the natural science paradigm, which assumes that the object of study can be quantified and technically retraceable, they are generally considered to be 'universally objective'. Moreover, the fact that official statistical institutions and disciplines produce them, secures their credibility and legitimacy. In other words, in the common imagination, statistics are seen as a natural object almost devoid of human intervention. They are perceived by the public to both summarise and represent natural truth.

Because of this, statistics have become a means of constructing social reality and therefore exercising a very particular power over society and the interpretation of reality (Davis and Hersh, 1981, 1986; Ernest, 1997). The fundamental notion is that within statistical knowledge there is a perception of "truth" that is dependable on social construction processes. According to Henning (2010), this relationship developed because of "all scientific reasoning involving mathematics" (Henning, 2010, p. 30). Indeed, Ernest (1997) has suggested social constructivism as a philosophy of mathematics. To him, statistics, as a social construction, imply social perspectives and are, therefore, permissible of meaning.

Stigler (1986) points out that mathematical and statistical methods were developed amidst a special combination of science, technology and logic as a means to solve and investigate problems in the various areas of human knowledge,

> *Modern statistics provides a quantitative technology for empirical science; it is a logic and methodology for measurement of uncertainty and for an examination of the consequences of that uncertainty in the planning and interpretation of experimentation and observation (Stigler, 1986, p. 1).*

Meanwhile, according to Davis and Hersh (1986), anyone who is familiar with mathematical terms consents to their truth (p. 57). Indeed, to Comte (1973), mathematical language is necessary, if not essential, to rational positivism –both to individuals as well as to the species. In fact, he argues that statistics constitute itself as a positivistic discipline (Comte, 1973). Moreover, statistics are, to Comte (1973), an instrument to all sciences –more than simply a particular science. Still, they believe them to be as dangerous as they are fascinating (Comte, 1973). To Comte (1973), statistics are the basis of his knowledge, which he judges necessary and inevitable, although, he also suspects this to be a form of mathematical imperialism. This understanding of statistical information as a constructor of social reality has experienced a change of paradigm in which according to Porter (1997) statistical data have shifted from being seen as objective to an objectification and the generality of objectifying characteristics. Indeed, already back in the 19th century, Cournot (1843) believed that the aggregation of statistical data would profoundly change the scale and nature of knowledge of the so-called social world,

> *"the fundamental distinction between probabilities that have an objective existence, that give the measure of possibility of things, and subjective probabilities, which are partly relative to our knowledge, and partly to our ignorance, and which vary from one intellect to another, depending on their abilities and data provided them" (Cournot, 1843, p. 421).*

Henning (2010) goes one step further claiming that this relationship between statistics and society has been crucial to science and the development of society. Within its communication to the public, the media are constantly presenting the general public with a variety of statistics, indices, and comprehensive quantitative data. For that reason, statistical institutions have continuously been required and forced into producing statistical information for almost every report (Higgs, 2013) – regardless whether it is on violence, poverty, hunger, development or science. "Hardly a subject is mentioned these days without measurements, quantification, forecasts…" (Blastland & Dilnot, 2008, p. 2). That is because, they are not only useful to governments but also because the larger public frequently uses them to, not only dictate their choices but also, as a means of having broader and more significant influence and control over social reality –and therefore retains power over governments, their institutions and authorities. Thus, it is argued that everything today is or has been quantified, and consequently statistics have been used as expressions of reality (Desrosieres A. , 1998, p. 3), and as imperative figures within a gradually fragmented society, that glue together this fragmented world. Ultimately, the understanding of statistical information as an expression of reality has to do with the notion that statistics have always been seen as an element of power (Simpson & Dorling, 1999). Simpson and Dorling (1999) have extensively criticised and questioned the production of accurate statistical information. According to them, statistics have the purpose of exposing the ways in which they reflect power relations. Meaning that through the understanding of factual statistical information society can make accurate decisions. Examples of this connection are aplenty. For example, NATO has a military spending target, for its member states', of a minimum of 2% of the respective member state GDP on defence. Is that reasonable? Is that too much or

too little? Is 2% of the United Kingdom's GDP a big number? These questions can only be understood and therefore answered if one understands its statistical information. This ability gives citizen a unique power affront the government, and daily news decisions. In the same way, Foucault and Gordon (1980), among others, have demonstrated that statistics are pervaded by elements of power as opposed to being mirrors of reality, and thus society often needs to analyse statistical information.

In addition to this, statistics allow one to isolate particular fields or areas of the world and society. Therefore, it is the 'sociology of statistics' that makes these processes of social construction of reality possible (Berger & Luckmann, 1966). As a matter of fact, the understanding of statistics is dependent on their social context. This kind of context is crucial in understanding statistics. These express the intention, values, interests and ideologies of certain groups or individuals with the purpose of exposing the ways in which they reflect power relations (Simpson & Dorling, 1999). This notion will be developed in the next section when analysing the role of statistics in the mathematization of society. For the time being, it is important to see it as a means of constructing social reality, of shaping the social world. That because statistics are key to making rational decisions and to the general development of society.

Indeed, statistical information as a philosophy of mathematics is thus likely to affirm that reality is not a given thing but a constructed social mechanism. Furthermore, in accordance with Davis and Hersh (1988), "the way to arrive at objectivity in the real world is to travel mathematical roads – if the subject can be mathematized, this automatically guarantees objectivity" (p. 276). This notion is essential to the understanding of the importance of statistics in the production of news –and its significance in the newsroom. Why is this notion essential? This study bases itself on

this premise. For the purpose of this research, the conception of statistical information as the mathematical road towards objectivity is inherent to the construction of scientific discourses in the news. In this journalistic framework, statistics are pre-eminent to the development of science information and the communication of its values to the public. Moreover, they provide the basis for the construction of a scientific discourse, and therefore apparently open the door for an objective and rational conversation. In view of looking at statistics as a science, in their logical and systematic nature, it is important to highlight their importance as a mathematical method to better understand and communicate science. For this research, the understanding of it as a tool for social construction is crucial to looking at how it is used to articulate news of science and construct its discourses in the news.

However, before we explore this, we need to understand the role of journalism in creating social reality. When constructing itself as a mirror of reality –where institutions are reflected and legitimised, and objectivity is considered as its main key element– journalism plays the role of an intermediary of meanings. In opposition, Tuchman (1978) claims that news does not mirror reality. To her, news helps construct reality as a shared social phenomenon, since the process of defining an event and the definition of the news gives way to the event itself. The story is constantly defining and redefining, constituting and reconstituting social phenomena. The ways in which news is formulated, and journalistic statements are structured from codes and an open reading of reality, builds a common and public communication system (Meikle, 2009, p. 68). The experience one has of the world today cannot be thought of without the influence of media representations and constructions –built not only from its process of integration and socialisation but also from the contradictions and tensions of the different fields of knowledge. With regards to that, it is worth

bearing in mind that symbolic universes are liable to solidification by processes of objectification, sedimentation and accumulation of knowledge. Inevitably, "the media's use of such concepts as "impartiality" and "objectivity" inevitably leads them to privilege certain kind of sources" (Koch, 1990). Following that line of thought, Tuchman (1978) proposes that news sources are crucial in the process of choosing content and giving news credibility.

What journalists seek to find in reliable sources is this sense of neutrality, impartiality and objectivity, because the news itself has already been positioned. News sources are also incredibly important in the manufacturing of news stories, and are in their own way a conveyor of legitimacy. Traditional news sources of information are regularly too short and concise, often making it impossible to contain all the critical pieces of information and points of interest necessary to deliver entirely objective assessment of events. Therefore, often "leaving out information such as the duration of study or number of people studied" (Battersby, 2010, p. 5). Another known way in which a news article can be legitimised is through the use of statistics, as for news to be 'objective' it needs to draw on an accurate statement –such as statistics. As a matter of fact, the dependence on official sources and particularly on statistical data is intrinsic to the doctrine of objectivity (Goldacre, 2009) given the general aim of news is to objectify reality and make it measurable and tangible. In this sense, Zuberi (2001) believes that statistical findings, as a legitimising scientific method of quantitative data collection and scrutiny, can be considered to be politically neutral and objective. Because statistics and qualitative data, in general, are considered by most journalists and news editors as a news source in and of themselves, which act both as a source and legitimating tool (Koch, 1990; Zuberi, 2001). The use of statistics as a means of validation has been used across media outlets in a variety of

ways and a considerable amount of literature has been published on the uses of statistics in the news as a means of legitimisation (Boyle, 2000; Eberstadt, 1995; Goldacre, 2009; Hacking, 1965; Livingston & Voakes, 2005). Statistics often "look and sound scientific and are usually promulgated by reputable scholars, great weight is accorded them, even if their import is in fact distorted by subjective predisposition" (Zuberi, 2001, p. x). Precisely for that reason, Battersby (2010) argues that critical knowledge and awareness is essential not only to understand the data given but also, and perhaps most importantly, to distinguish useful information from deceptive information. On that point, Blastland and Dilnot (2008) argue that "numbers, pure and precise in abstract, lose precision in the real world" (p. 11), and that "if it has been counted, it has been defined, and that will almost always have meant using force to squeeze reality into boxes that don't fit" (p. 15). Thus, statistical data, so as not to present unreasonable expectations, must first and foremost be defined. That is because, each time statistical data is created, something is counted, one defines it; "we say the things we count are sufficiently the same to be lumped together" (Blastland & Dilnot, 2008, p. 12). Therefore, according to Battersby (2010), "once we know what questions to ask, we will reduce our chances of being deceived, and will be free to make intelligent use of credible statistical information" (p. 5). That being said, statistical information is still present in a significant portion of our daily news (Randal, 2000) and "numbers are still an absolute vital tool for human progress" (Boyle, 2000, p. 57).

Hacking (1965), in particular, focused on critically assessing the use of probability and probability theory in contemporary statistics. He scrutinised how the idea of probability theory as seen today first took shape in the late 17th Century, with academics such as Blaise Pascal and Pierre de Fermat, and how it shifted in the late

18th to 19th Century when states started to collect and publish statistics, which in accordance to Hacking (1965), led social scientists to use probabilistic notions and concepts as a means of understanding social life. Overall, Hacking (1965) also made a substantial contribution to our understanding of the emergence of probability as a fundamental and core concept in the modern world both theoretically and in more practical situations.

Similarly, Desrosieres (1998) indicates that the 'birth of statistics' is enough to show this existing link between statistical approaches and methods and the social condition of its development. To Desrosieres (1998), like most other fields of study, statistics had to acquire legitimacy in the eyes of its supporters and establish itself as a reliable scientific discipline. That happens because social facts have become 'things' for everyone who uses statistical techniques, and these methods are proposed to back up logical, scientific and political contentions (Desrosieres A. , 1998, p. 2). Thus, once this necessity of being recognised as an objective discipline, as outlined previously, was conceived by the scientific discipline of statistics, it meant that

> *"we can begin to test new therapies, judge schools, hospitals and cities. They seek out the fraudulent or inefficient. They still give us some control over our unpredictable world. They can take us by surprise (...). It's just that they are not objective, nor the final answer, and we rely on them too much"* (Boyle, 2000, p. 57).

Indeed, all mathematical language facilitates and reinforces the myths of transparency, neutrality and independence of journalistic discourse primarily because "mathematics is a system of statements that are accepted as truth" (Zuberi, 2001, p. xvi). One key example of this acceptance as undeniable truth involves polls, as censuses no longer offer or represent the journalist speaking 'the truth' but rather it is the journalist reporting the truth as perceived by the audience (as reflected in poll numbers, the opinion of the majority). Journalistic discourse seeks a mythical

objectivity, ideological and impossible to achieve fully (Koch, 1990). Given its aim to appear objective, many news media outlets tend to conceal or dissimulate any explicit opinions in their hard news reporting (Hearns-Branaman, 2016). In reality, however, each news item is gathered, selected and constructed on the basis of individual and collective preconceptions, values and worldviews. In this context, journalists themselves are the vehicles for these opinions, and as subjective actors cannot be truly neutral. However, given the deontological requirements of their profession they need to appear to be neutral and try constantly to make a clear-cut distinction between facts and opinions. In this sense, statistical data helps them construct a narrative that ensures credibility. After all, these numbers are seen as neutral entities that underpin journalistic 'truth'. The quantification of reality by the media corroborates and amplifies this alienation of the individual, who trusts these mathematical discourses almost blindly. Hence, when statistics say that crime, unemployment and poverty are down, the public engaging in the debates in the public arena tend to accept this as truth despite personal and individual experiences or political interventions that make these statistics implausible. These numbers are seen in the news as the representation of an unquestionable truth. This manufacturing of news, however, is only a representation of reality (Chomsky, 1997). "The picture of the world that's represented to the public has only the remotest relation to reality. The truth of the matter is that buried under edifice after edifice of lies upon lies" (Chomsky, 1997, p. 37). As Kovach and Rosenstiel (2001) point out, writers that select sources to communicate what is truly their own perspective only to afterwards "use the neutral voice to make it seem objective, are engaged in a form of deception" (p. 74).

Notwithstanding these limitations, Lippmann (1922) has suggested that it makes no difference that news is not responsive to mathematical explanations. According to

him, in light of the fact that, "news is complex and slippery, good reporting requires the exercise of the highest scientific virtues" (Lippmann, 1922, p. 49), all the more because, "'knowledge' precedes 'values' in the legitimation of institutions" (Berger & Luckmann, 1966, p. 110). As a matter of fact, what matters is its perceived notion as a legitimising tool for objective construction of social and media reality. What is more, statistical statements are of importance in the shaping of scientific discourses in the newsroom.

Ultimately, due to the aforesaid importance of statistical information in the construction of social reality and legitimation of media reality, journalists should use statistics responsibly. When articulating news and using statistics journalists need to be more socially responsible and have stronger professional rigour. Firstly, by not making the mistake of not questioning the given data, limiting the news, and merely reproducing the data provided by interested sources; secondly, and more problematically, by not entering the dangerous zone of manipulation and data handling –either through incompetence, dishonesty or simply through the misrepresentation and interpretation of the data (Callon, 1986). When this misinterpretation and distortion happens, the false or distorted statistical information and use of statistics adds a fake 'endorsement' (or veracity) to the alleged journalistic credibility and neutrality (Hacking, 1965; 2001). Newsrooms therefore sometimes tend to use or value pieces of statistical data and distort its meaning, to produce effects that suit them. One studied cause for this misinterpretation is that, from the moment qualitative data is gathered to when statistical information is developed there is a funnelling of data to present it in a simpler form for the public to understanding it better (Koch, 1990; Zuberi, 2001). Because of that, Zuberi (2001) further argues that

there is a need for better comprehension of the theories behind the data and how they relate to their research methodology (p. 176).

4.3. Mathematization of Society

The notion of the mathematization of society started when mathematical information became more important for the understanding and production of scientific knowledge, especially in terms of science as a quality of influence (Schuyt & Taverne, 2004). For this research, it is important to view statistics not as created in a historical vacuum but within an area existent within social boundaries. Within this context, Porter (1997) calls attention to the notion that statistics are an integral part of our present society and essential to the understanding of our social and shared realities. Most importantly, that society has depended on numbers since its early stages, as it is critical to the processes of decision-making. Among philosophers, especially Plato, Aristotle and Descartes, there is an understanding that mathematics and quantitative data contain a productivity discourse that constitutes a core representation of the modern western man, of validation and legitimation, and of modes of regulation. Plato also, subsequent to this notion that the world and society must be understood mathematically, argues that all knowledge rests on the mathematical idea. That means that, according to him, mathematics, statistics and quantitative data hold and are the true essence of things, values, concepts, etc.

At this point, as far as mathematics and society are concerned, their relationship is a subtle but noticeable one.

> *"Numbers saturate the news, politics, life. For good or ill, they are today's pre-eminent public language – and those who speak it rule. Quick and cool, numbers often seem to have conquered fact. But they are also hated, often for the same reasons. They can bamboozle not enlighten, terrorise not guide, and all too easily end up abused and distrusted. Potent but*

> *shifty, the role of numbers is frighteningly ambiguous"* (Blastland & Dilnot, 2008, p. 1).

Devlin (1998) argues that the mathematization of society "has become more and more hidden from view, forming an invisible universe that supports much of our lives" (p. 12). In the same way, Porter (1997) points out that mathematical knowledge is key to our current scientific comprehension of the natural and social worlds. Furthermore, according to him, society relies on quantification and mathematics not merely because of their apparent objectivity validity but because they are an essential element to comprehending how we conduct most aspects of our daily lives – from the enforcement of the law to the exchange of goods and media communication (Porter, 1997, p. 9). In the same way, Schuyt and Taverne (2004) state that the mathematization of society started once mathematicians, especially statisticians, became more influential on the matters of "technological aspects of affluence" (p. 49); was manifested in such a way that consistently more areas of private and public life were "literally and figuratively shaped" by statistical definitions, and calculations by specialists such as politicians, and economists, among others (Schuyt & Taverne, 2004, p. 49).

One of the foremost reasons for this ubiquitous presence of mathematics in society, regards its applicability. For example, 'the laws of nature' and science can be described with exactitude and precision, although in quite abstract and not intuitive, mathematical terms. Our contemporary society recognises that there is an enormous difference between opinion and science; furthermore, it is argued (Chafetz, 2005; Zuberi, 2001) that the West (and Western societies) has achieved much of its knowledge and progress due to the preponderance of science over other areas. The assimilation of science in the fields of society, culture and, most importantly, politics

and policy-making became increasingly common in Europe after Voltaire's 1738 publication "Élements de la philosophie de Newton" – or Elements of the Philosophy of Newton – in which he rationalises and even tries to popularise Newton's theories and line of thought in France. It is worth remembering that Newton's laws and principles, in addition to elucidating the particularities of inanimate matter, were reflected and thought about its 'order', applying itself to the study of society, nature, life, and human and social organisations. Also, the importance and suitability of his theories towards all observed nature not only left an impression on the mathematicians of that time, but also on almost all areas of academia. As a matter of fact, it provoked immense interest and reach in the field of philosophy – especially in Kant's work and line of thought – compelling every academic from then on to justify (mathematically) the possibility of nature's rational knowledge that is visible every day (1781).

Taking into account that, amidst all those who previously sought truth in the study of sciences, only mathematics was able to find some of these 'demonstrations' in certain and evident reasons; which, in accordance to Descartes, do not create any doubt in proving that repeated results are the same as they examined (Davis & Hersh, 1988). According to them, "mathematization is upheld as the only way for a field of study to attain the rank of a science' (Davis & Hersh, 1988, p. 57). In fact, another point worth understanding is the idea of mathematical certainty, as it is perceived as an objective truth precisely because of this certainty.

> *"Mathematical certainty is a byword for a level of certainty to which other subjects can only aspire. As a consequence, the level of advancement of science has come to be judged by the extent to which it is mathematical"* (Davis & Hersh, 1988, p. 57).

The idea that mathematics, statistics and its variants are on a pedestal above all other knowledge and sciences, however, has long been the subject of scrutiny of the theorists, academics and philosophers. Leonardo da Vinci, for example, arduously believed that "no human investigation can be called real science if it cannot be demonstrated mathematically" (Da Vinci, c.1490). Similarly, White (2013) argues, mathematics is the science of exactitude, the necessary language of knowledgeable individuals; it is the dialect of definiteness, the fundamental language of those who know, hence the special connection between science and statistical information. Ultimately, it is understood that the emergence of the modern scientific method initiated the process, which led to the formulation of this new term "mathematization of nature" – and therefore also the mathematization of society. Following this framework nowadays, in order to understand the world, it is imperative to think mathematically as "there is no modern society that can exist without doing mathematics, the majority of people in it can survive with understanding some Mathematics" (Nikolakaki, n.d.; Gellert and Jablonka, 2009).

For the study of social sciences, for example, statistics are important in light of the fact that through them, it is conceivable to conduct particular analysis for the development and implementation of social policies. Afterwards, it is still possible to analyse the outcomes of its policies in society. Ultimately, statistical information can help in the study of reality. Schwartzman (1991) further argues that normally, humanities and social sciences make use of systematic observations, scientific and mathematical modelling, statistical analysis and research to address social phenomena – such as population movements, behaviours, and preferences, among others. Therefore, it can be noticed that by using the objectivity of mathematical language in their methods, statistics will often walk side-by-side with social sciences. Indeed, to

Comte (1973), "the father of positivism", it was possible to arrange the development of society and individuals with the definitiveness of an exact science like statistics.

So much so that Zuberi (2001) states that we currently live in a rational society dominated by calculations, logical-mathematical thought and statistics.

> *"Social statistics used in social sciences took a new meaning with the availability of large-scale data at the beginning of the nineteenth century. These data were made possible by the expansion of census enumeration activities undertaken by various government agencies in Europe and the Americas. A data revolution accompanied the social transformations that culminated in emancipation of the formerly enslaved Africans; the expanded colonial activities in Asia, Africa, and the Americas; and social unrest in Europe. These new data gathering gave statistics a new area of study – society"* (Zuberi, 2001, p. 35).

This 'rationalisation movement' affects most institutions, and gives rise to a range of other information that sediment the practices of individuals that belong to the public stage and its social spaces. Furthermore, this process also has a significantly direct influence on every technology, computer knowledge, the Internet, and a number of other things that are commonly found in our contemporary society (Stigler, 1986). That is because there is a harmony to the methodology of statistical knowledge; for example "an economist, a chemist, a sociologist, a psychologist, or a political scientist might use tomorrow the same computer program that analyses the data of a geophysical scientist today" (Stigler, 1986, p. 2). What is more, this harmony does not lack intellectual depth: "even if the interpretations given these analyses differ subtly with the field, the concepts employed in those interpretations and their logical consequences and limitations are much the same" (Stigler, 1986, p. 2).

Following the above-mentioned reasoning of Descartes, David and Hersh (1988) argue that there is an overwhelming amount of digits in society today. Society is drowning in the multitude of numbers through the computerization and mechanisation of all communication mediums (p. 16). The communication of information and

media, in general, is only one 'environment' in which mathematics affects the way it we perceive and understand the world. Even the formations of modern states are in the present day hit by this flow of quantified information in the form of numbers. As a matter of fact, statistics today have developed as the science of the nation (Desrosieres A. , 1998). This movement towards the digitalisation of the processes of current social interaction, which has statistics as a key element and core basis, also reaches a number of other different social environments. From science and scientific knowledge to health and nature, the quantification of data is now a prominent characteristic. Nonetheless, the consequences to this over-mathematization it is still not known.

Still, mathematical language has become virtually a condition of scientific theory (Davis & Hersh, 1988, p. 10). In this sense, "numbers can make sense of a world otherwise too vast and intricate to get into proportion. They have their limitations, no doubt, but are sometimes, for some tasks, unbeatable" (Blastland and Dilnot, 2008, p. 1).

Mathematical discourse has become, over the years, not only a logical discussion but also an objective one. According to Descartes, mathematics is a thing of the mind (Davis & Hersh, 1988). Its statements (or 'truths' in Descartes), derive from 'safe hypothesis' and, therefore, are considered to be real, fair and objective (Davis & Hersh, 1988). Still according to Davis and Hersh (1988), the origins of mathematics fit into three 'activities' or categories: (1) to count, (2) to measure, and (3) to make it visual – a similar notion can be seen in Descartes' theory where it is comprised of a theory of numbers (i.e. geometry, algebra and analysis), applied mathematics (i.e. weather reports, etc.), and rhetorical mathematics. Furthermore, of these three categories, the first two have been receiving greater attention. Following the

Complexity Theory, however, Davis and Hersh (1988) argue that most, if not all, things can be mathematized. “Certainly in the physical world we do not believe there is anything un-mathematizable” (Davis & Hersh, 1988, p. 13). Equally, “there is occurring today a mathematization of our intellectual and emotional lives” (Davis & Hersh, 1988, p. 16). Underlying this notion that everything is mathematizable is the idea that, as the world gradually becomes more mathematized, society tends to exclude things that cannot be understood from this perspective.

That being said, following a similar line of thought, Foucault believes in the idea of discontinuity in which discourses emerge and are socially constructed at the same time to disrupt the ‘order of knowledge’ (Foucault & Gordon, 1980) and, therefore, statistical data guides the analysis of all other possibilities of expression, and its variations, as a means of attempting to assimilate the struggles in search of this imposition of meaning. Therefore, Foucault’s notion of discontinuity facilitates the revealing of this impartiality myth; the essential element of both current scientific knowledge and mathematics (Foucault & Gordon, 1980). Similarly, to mathematics and statistics, science is perceived as objective knowledge. Davis and Hersh (1988), for instance, believe that mathematics does not have the power of persuasion, but rather that it does not need any further empowerment to exercise persuasion. “Mathematization does not persuade, but rather because it seemingly needs no art to perform its persuasion. The matter does it all; the manner need only let the matter speak for itself” (Davis & Hersh, 1988, p. 57). An explanation of that understanding of mathematics as the ultimate persuasive power derives from, as previously mentioned, Kuhn’s (1962) notion that certain processes repeat themselves (are repeated) intermittently throughout history and as a consequence always create new ways of thinking, and perceiving life, thus breaking old paradigms.

Mathematics and statistical data become a formality, a necessary means, which "cast the field of study into axiomatic mode and thereby, it is supposed, purging it of the taint of rhetoric" (Davis & Hersh, 1988, p. 57). Still in accordance with Kuhn (1962), Alexandre Koyré coined the expression 'mathematization of nature" from the Platonic to Pythagoras' line of thought (passing through Plato, Aristotle and others), as well as for the Galilean 'scientific revolution'; altering only the argumentation of rationality promoted and supported by this mathematization. Both are very different historical and philosophical moments (or movements) wherein mankind began to see nature and science as a sort of a written law, a book, entirely explainable by mathematics and statistics (Kuhn, 1962). Furthermore, the process of naturalisation of scientific knowledge as true knowledge –meaning that reason infers humanity, civilisation and society– has become ingrained in modern society and therefore has validated mathematics as the means towards a correct way of thinking. Arguably, the structure of our society would be unthinkable without reference to mathematics (Desrosieres A. , 1998). Within this framework, "mathematics, the indispensable tool of the sciences, defying the senses to follow its splendid flights, is demonstrating today, as it never has been demonstrated before, the supremacy of the pure reason" (Butler, 1898, p. 45). In a remarkably similar way, journalism has also the power of constructing social reality (Hacking, 2001).

Subsequently to the transition from traditional or medieval to modern society, with its rationalisation process, theocentric thought was abandoned and the socialisation of individuals went on to accomplish itself through the learning process of theoretical, practical-moral and esthetical problems, experienced in a decentralising way and in accordance with its own internal 'legalities' of these spheres of values. In addition to the consolidation of these two systems widely identified intrinsically with the new

society, the society and the market, one cannot ignore the role of journalism and this generalised system of exchange of (valuable) information that it played in this process. That said, its expressions does not have the "legitimacy scope" restricted to certain institutions, and across the set of all areas of modern experience, which guarantees a unique character. This is the capacity to mediate in the course of events, to impact upon others' activities and even "to create events, by means of the production and transmission of symbolic forms" (Berger & Luckmann, 1966). Social construction is arguably set up by intersubjectivity and one's experiences. Tuchman (1978) makes a case that –bearing in mind the sociological conception of social actors– journalism and the media helps, on the one side, to develop conscience and, on the other, through an intentional apprehension of the phenomena of a shared social world, men and women are building social phenomena collectively. Tuchman (1978) also believes that the notion of news as the mirror of reality defends "objectivity" as a key element of journalistic activity. As suggested by Meikle (2009), these actions are also an indicator of a broader cultural phenomenon that is spreading global modes of civil society organization through communication networks (p. 153).

Berger and Luckmann (1966) further argue that the processes of legitimation seen in social construction are composed of four levels. The first tier is pre-theoretical and regards a "simple traditional affirmation" (Berger & Luckmann, 1966, p. 112). That is, it is the basis of all other evidence and subsequent premise, as it represents self-evident knowledge. The second level "contains theoretical positions in rudimentary form" (Berger & Luckmann, 1966, p. 112). This premise is pragmatic, and openly related to concrete engagements (Berger & Luckmann, 1966, p. 112) and mostly concerned with moral maxims and proverbs. "The third level of legitimation contains explicit theories by which an institutional sector is legitimated in terms of a

differentiated body of knowledge" (Berger & Luckmann, 1966, p. 112). At this stage, the process of legitimation starts to "provide fairly comprehensive frames of reference for the respective sector of instutionalized conduct" (Berger & Luckmann, 1966, p. 112). The fourth and final level is where symbolic universes are imposed. "These are bodies of theoretical tradition that integrate different provinces of meaning and encompasses the institutional order in a symbolic totality" (Berger & Luckmann, 1966, p. 113).

Berger and Luckmann (1966) believe that this four-step process of legitimation justifies the institutional order by attributing cognitive validity (and legitimacy) to its 'objectivated meanings'. To them, "legitimation as a process is best described as a 'second-order' objectivation of meaning" (p. 110). Also, "the function of legitimation is to make objectively available and subjectively plausible the 'first-order' objectivations that have been institutionalized" (Berger and Luckmann, 1966, p. 110).

In this sense, journalism is one of the most significant means of influence and a highly useful tool; thus, "marketing 'scientists' go to a lot of trouble learning what is most likely to have impact upon the viewer" (Chafetz, 2005, p. 20). Chafetz (2005) continues to reason that, much like statistics, science is not a reliable – or as secure as portrayed – source of information either. According to him, science is not a truthful source as habitually portrayed for four main reasons: (1) scientists are not incorruptible; (2) scientific findings have limitations; (3) its experiments are affected by the impossibility of controlling all possible variables; and (4) ultimately it is not as omniscient as we believed it was "in the optimistic 1950s and 60s'" (Chafetz, 2005, pp. 20-21).

A considerable number of modern, cutting-edge scientific discoveries from innovative research happened by accident when the issue that was resolved was not the one for

which an answer was being pursued. By the same token, Goldacre (2009) believes that because commercial interests play – or better yet are allowed to play such a crucial role in the dissemination of science news and information – scientific data and evidence, statistical analysis and the practice of its publication itself are being significantly manipulated. The lack of pressure on the media to provide accurate data, and use research methods, as a means to enable it to confront findings, indicates inadequate evidence, and so forth (Goldacre, 2009). To him, the nature of scientific methods in the current neoliberal society has turned science and scientific data into an untrustworthy form of information (Goldacre, 2009). Furthermore, capitalism and the need to produce profit have turned science into "bad science" (Goldacre, 2009). Still in accordance to Goldacre (2009), one of the reasons why this shift happened is due to the fact that many scientific fields or disciplines are now highly dependent on funding – regardless of its origins. "It is all about the money and power for lawyers. (…) Ah, but surely the media, also mentioned in the First Amendment, serve as a check on the unbridled power of the legal cartel" (Chafetz, 2005, p. 260). Nonetheless, this is not simply a one-way street in which science and scientists manipulate the media; but rather the media, as do scientist and academics, also influence a two-way symbiotic relationship as do medical practices (Goldacre, 2009, p. 324). Goldacre (2009) then goes to argue that: "people read newspapers. Despite everything we think we know, their concepts seep in, we believe them to be true, and we act upon them, which makes it all the more tragic that their contents are so routinely flawed" (Goldacre, 2009, p. 324).

4.4. Conclusion

The review of literature in these last three chapters has concentrated broadly on the empirical observation of the uses of statistical information as a means to articulate

news discourses of science. The multidisciplinary nature of this subject of research, namely the uses of statistical data in the articulation of science discourses in the news, has been addressed by the identification of these three separate stands. Thus, for the purpose of this investigation, three areas were analysed: (1) journalism studies, (2) its representation of science, and (3) its uses of statistics as a means to legitimate information. Firstly, this chapter has focused on reviewing literature on journalism and media studies. Looking at key journalistic concepts, it elucidated old and current research on the understanding of news writing as an objective narrative of social construction. It continued towards the discussion on the representation of scientific information in public culture and society. Furthermore it investigated its communication in the news perceived as an influential, efficient, and widespread means to mediate science. To finish, it provided the research literary basis for understanding statistics as a means of obtaining legitimate argumentation and the construction of society as a mathematical entity.

This critical study leads to an account of the uses of statistical information as a manufacturer of this scientific legitimacy in the newsroom. The apparent, albeit contradictory, objective cloak in which these three themes are shrouded creates the stage for the legitimation of scientific information through statistics. The findings from this review expose a shortage of significant literature on the specifics of the subject of investigation for this study. Media issues in the public understanding of science, analyses of news coverage on science information, studies on the uses of statistics in the construction of social reality, among others have been broadly researched. However, it is apparent that there is still space for studies on the uses of statistical information in the articulation of science and the shaping of science discourses in the news. This study aims to close this gap. By reviewing literature on

the agency of journalism, the communication of science and the mathematization of society, it seeks to produce an innovative body of knowledge on the uses of statistical information in the newsroom.

The communication of science in the news is an internal part of the agency of journalism, and uses of statistics to legitimate information have helped the construction of science in the news. Statistical information may be one of the most powerful tools in the investigation of a wide range of phenomena, and scientific knowledge may require mathematical quantification before being considered fact, but it also must be taken with reservation. It is possible to tell a lot of lies by just telling the truth: "the media can lie to us, without telling any untruths" (Gregory & Miller, 1998, p. 104). Thus, one must be very careful with the information that is communicated, and most importantly, how it is consumed. Inappropriate use of statistics in the news of science may result in the misconstruction or the relentless spin doctoring of scientific information. Both are equally problematic. The misconstruction and communication of science can result in dangerous misinformation, which creates an obstacle in the decision-making process. For example, the MMR scandal resulted in a costly scenario for society, which includes damage to both individual and collective welfare due to outbreaks of otherwise controllable diseases (Gangarosa, et al., 1998). The decrease of uptake of MMR vaccines led to outbreaks of measles in Italy, where more than 5,000 people were hospitalised costing the State circa 22 million Euros; in Ireland, where three people died; as well as several outbreaks in the United states, including Chicago, Nova Scotia, and California. So how can improvements in the communication of science, and statistical uses, help challenge these fallacies, and most importantly, in the construction of effective communication?

The literature review suggests that the mathematization of society has meant making society quantifiable and exact, and statistical information accurate and objective. Indeed, this approach has determined the growth in the belief and conviction of statistical data's effectiveness. However, what does this means for journalism? The news media's potential for literalism is evident in its assumption that reality is something that can be constructed objectively. This need for representing reality as an objective account has developed a dependence on its presentation as quantifiable information. Statistics are presented in the news every day and extensively. It seems that now objective information can be portrayed as accurate without any sort of statistical data. Thus, over the past decades, journalists have tended to use and abuse statistics gradually more and more to legitimise their positions.

In terms of science, this dependence is ever more clear. To start with, scientific information is already a highly quantified area. Most scientists would argue there could be no science without numbers. In fact, it is the numbers that give science meaning legitimacy. Moreover, it is its mathematical language that gives it its apparent objectivity. Thus, what does it means for science journalism? This means that journalists of science have become reliant on data, without necessarily understanding it. Most science journalists would understand its importance, and even its basic information, without fully understanding its properties – and often without any official or formal training in its language. Furthermore, this means that audiences are taking in information that is not fully understood. They are reading news that is often written by someone who does not understand its language, much like if a journalist would write in a foreign language without mastering it. The generalities of the information might pass through, but some things (regardless if crucial or minimal) would undeniably be lost in translation.

This chapter provides context to the subsequent chapter and basis for all subsequent Findings Chapters in which the development of the uses of statistics in the newsroom is outlined, and its uses critically analysed. The next chapter (Chapter V) focuses on the methodological approaches that have been used to collect empirical data in order to explore the uses and representations of quantitative data in the development of scientific discourses in the media.

CHAPTER V

5. Methodology

5.1. Introduction

This chapter introduces the research methodology of this study. Having established the theoretical basis of this research, which is relevant to the way in which the findings will be looked at, it is now important to understand how this explanatory theoretical framework will be examined in the light of empirical evidence. In order to do this, I will explain the different research strategies and how the related data will be gathered, organised and scrutinised in the wider context of methodological approaches. As a result, this section deals with the epistemological and methodological assumptions of this researcher and research while also examining in detail the data gathering technique used throughout the project. The overall objective of this research project is to study the uses of statistical information in the news coverage of science. The aim of this chapter is thus to (1) rationalise the chosen philosophical assumptions, (2) explain the means of data gathering and research methodology, (3) justify the selection of sources and interviewees, and (4) account for the design outline of the proposed research.

5.2. Research Methodology

Let me start by reiterating that the primary purpose of this research is to analyse the uses and representations of statistics across media outlets when reporting science news by asking: (1) How do science journalists articulate and legitimise their news stories; and (2) How are statistics used to articulate narratives and shape the discourse of science within the newsroom when producing news? Additionally, it seeks to present exploratory research on how journalists manage quantitative data when gathering and disseminating news stories and most specifically how statistics are used by science journalists to articulate, validate and legitimate their stories.

A triangulation of quantitative and qualitative research methodology is utilised for this study. The choice of quality press newspapers as the focus of the study was supported by previous studies (Frewer, Raats, & Shepherd, 1993; Meyer, 2005). The scrutiny of the United Kingdom quality newspapers, namely *The Guardian* and *The Times*, has long been identified as a commendable comparison of the United Kingdom news scene in light of science and environmental news (Carvalho, 2007; Lacey & Longman, 1993). In the same way, Guedes (2000) has previously scrutinised Brazilian quality press in her study of environmental news.

To achieve a broader intellectual context (Altrichter, Feldman, Posch, & Somekh, 2008; Cohen & Manion, 2007; O'Donoughue & Punch, 2003) and as a "method of cross-checking data from multiple sources to search for regularities in the research data" (O'Donoughue & Punch, 2003, p. 78) this study triangulates qualitative and quantitative research strategies, following similar research projects (Atton & Wickenden, 2005; Briggs & Hallin, 2010; Seale, 2001). In doing so, it incorporates content analysis of science news items produced by journalists in the United Kingdom

and Brazilian newspapers. To delimit its scope, this study looks at the news stories of science in the United Kingdom and Brazil. This chapter starts with the rationalisation of the practicalities of the research and the basis for the proposed study –in particular the representation of statistics as scientific objectivity. Further to the scrutiny of these primary assumptions, the key elements of the research project – i.e. objectivity, credibility, and legitimation, the construction of social reality (both through the use of statistics as well as science), scientific neutrality, the mathematization of society – are then examined.

5.3. Research Questions

1) How are statistics used to articulate narratives and shape discourses of science in the newsroom?
    a) What are the significant factors that cause science journalists to use statistical information in the news?
    b) What is the purpose of using statistics in science news?
    c) How are statistics used as a means to communicate truth?
    d) Does science news and science journalists emphasize a certain type of statistics?
    e) Is there a difference in how statistical information is used to establish narratives and frame discourses of science in the United Kingdom and Brazilian newsroom?
    f) How are visual data used to articulate news of science?
2) How do science journalists articulate and legitimate stories using statistics?
    a) Do bylines determine how statistics are used in the articulation of news of science?

b) What are the differences in attitude towards uses of statistical information in the news within the United Kingdom and Brazilian newsrooms?
c) Is statistical information treated differently in terms of quantity of sources quoted?
d) Does the type of sources take part in the uses of statistics?
e) What type of sources do science journalists engage with as reporters of statistics?

5.4. Research Design

According to Creswell (2009), research designs are plans for research that involve a series of decisions concerning how the study will be conducted. They include data collection, analysis, and interpretation. The designs include the specific approach to be used and are often associated with the framework of the study. They are the processes of inquiry that provides direction and guides the study (Creswell, 2009, p. 3). Denzin and Lincoln (2011) have called them strategies of research. Overall, it is the blueprint for conducting the study. According to De Vaus (2001), research designs can vary in the length and complexity the researcher imposes on the study. However, they must be able to identify the research problem, review previously published literature, specify any hypotheses, and effectively describe the data and method of analysis. In terms of this adaptability, Creswell (2009) argues quantitative designs are highly structured and invoke post-positivist worldviews while qualitative designs tend to be more flexible. To Newman and Benz (1998) they represent different ends of the research spectrum. The mixed methods design of this study, however, allowed for a better integration of quantitative and qualitative research and data analysis. In fact, the idea to combine mixed methods was chosen to overcome any limitations that come from single datasets. In that sense, it used a quantitative approach in the analysis of

content and a qualitative methodology in the analysis of discourse and in-depth interviews, the former being the primary basis of this research.

A method that is often used to describe written communication through mathematical descriptions is content analysis, in which the researcher systematically reads a body of text and provides a quantitative description. This study helps reinterpret texts, images and symbolic matter to construct a better comprehension of meanings. Furthermore, it practically and theoretically searches for a specific meaning within the field of social sciences investigations. In this study, a content analysis was conducted as a primary method to identify and understand how statistical data are used in articles on science. As a quantitative method, this research strategy aims at answering how statistical data are used to enunciate science information in the news. Additionally they are intended to provide further data on significant aspects that prompt journalists to use statistics, what are their purposes, how they are used, and if Brazil and the United Kingdom use them differently.

A qualitative analysis was used as a more fluid approach to the research. Close reading analysis focuses on meaning and how particular events are represented (Krippendorff, 2004). As a research method, it aims to interrogate the meanings established in the various forms of production, verbal or non-verbal. The subject matter can be a body of text, images or symbolic matter, as long as it produces meanings for interpretation. In this study, data in the analysis of discourse were collected using a qualitative approach. This research strategy seeks to present the essential characteristics of the articulation of statistical information in the news. In order to do so, it explores how journalists articulate news stories of science using statistics. Furthermore, it looks at the different attitudes towards the uses of statistics in the news between Brazil and the United Kingdom. Likewise, it investigates

whether they are treated differently in terms of quantity of sources quoted and what preferences are displayed in the selection and deployment of sources.

5.4.1 Mixed Methods

The methodological approach of this study is based on the triangulation of quantitative and qualitative research methodologies. The need for a triangulation of methods refers to the necessity to improve the reliability of measurement. The quantitative research helps uncover a dimension of factors and an expanded view of the research question from a very specific variable created by the researcher. For this study, this variable was the use of statistical information in science news. The qualitative research, on the other hand, has a methodological nature less concerned with the amplitude of the research variable and more with its understanding. It aims at the perception of meaning and the articulation of information. Thus, by triangulating these two methodologies, it is possible to present a broader response to the research question. Aside from that, it presents a deeper understanding of the phenomena. In this research, this triangulation was essential to analysing how statistics is used as a tool to condition news discourses of science and how science journalists legitimate stories using statistics. Ultimately, it was necessary to triangulate this research because I am far more confident about the validity of my findings as various and complementary types of data support them.

Arguably, this QUALI-quanti analysis is one of the most inclusive methods for analysing data in the news (Creswell, 2009) as seen in the work of Atton and Wickenden (2005), Briggs and Hallin (2010) and Seale (2001). Furthermore, this approach can be viewed in the works of Sayer (2000) and Bryman (2002). It has also been the subject of scrutiny from Herrera and Braumoeller (2004), as well as Hardy,

Lawrance and Grant (2005), and Hardy, Palmer, and Philips (2000). The former, after presenting rather substantial differences between the two methods (quantitative and qualitative), Hardy, Lawrance and Grant (2005), and Hardy, Palmer and Philips (2000) proposed that actually there can be a mixture between the two, and that this triangulation of data is indeed beneficial to research. In the same way that Hardy, Lawrance and Grant (2005), and Hardy, Palmer and Philips (2000) argue in favour of making the case from the start and questioning the assumptions behind content analysis, Lowe (2003) and Sayer (2000) show that doing so is imperative for this kind of research because if assumptions are made explicit they can then easily be modelled to fit each particular research project's circumstances. Consequently, one could apply this principle to the adjustment of content analysis assumptions towards the assumptions of critical discourse analysis as outlined by Hardy, Lawrance and Grant (2005), and Hardy, Palmer and Philips (2000). A marginally different take on the issue of the uses of quantitative and qualitative methods in triangulation, comes from Neuendorf (2002), who argues for the use of qualitative and quantitative methods together, but not necessarily for a hybrid use of critical discourse analysis and content analysis, as she suggests that these can be complementary but not necessary interlinked.

Triangulation means that more than one method is used to collect, analyse and interpret the data. This study was conducted in three phases and methods. These methods include the content analysis of newspaper articles produced by science journalists. The content analysis looks at science news from a quantitative perspective, analysing statistically the frequency of occurrences of the variables. The list of specific variables for this study will be duly presented in the section (6.4.4.) coding. These variables aim at answering broadly how statistics are used to enunciate

science information in the news. The second part of this study consists of a close reading analysis that collected data from news articles on science. The purpose of close reading is a detailed account of all integral aspects of the news article. In this research, the close reading aims at analysing the aspects of the articulation of statistical data in the news of science. Lastly, the in-depth interviews attempt to explain the content and close reading analysis from the perspective of science journalists. The choice to conduct in-depth interview enables a closer and more detailed view of the research subject. Indeed, it is a singular data collection technique as the researcher has direct contact with the person of interest to find out their personal opinions about the topic. For this study, the interview with science journalists was essential in the process of validating my findings.

Within this processes, data were collected from a total of 1,089 (n=1,089) articles that used statistical information in the portrayal of science news, which allowed the compilation of material for analysis. The collection of articles was gathered from daily newspapers. In the United Kingdom-based newspapers, with the help of Lexis Nexis, news articles were searched using *Science* in the indexing within the topic of *Science and Technology* (but not Humanities & Social Sciences, Computer Science, Maths & Education, Science Funding, Science Policy). Subsequently, it looked at the presence of statistical information in its main article. With regard to Brazilian papers, the search was conducted by using the respective company's archives –*O Globo* and *Folha de S. Paulo* private archives. As was done in Lexis Nexis, the search term was *Ciência* (meaning 'science' in Portuguese), which was then examined for quantitative data.

Why the choice of newspapers? The preference for daily newspapers is explained by their essential role in framing science (Petersen, 2001) and the central part they play

in contemporary society (Lester & Hutchins, 2009). Daily newspapers are very effective. Arguably, the majority of research focusing on science in the news has studied daily newspapers. Gregory and Miller (1998) believe that this preference is not due to their influence or large readership but rather because they are the most efficient way to study mass media of communication. To them, quality daily newspapers are even more preferential as they have easier access, are archived, and indexed, among others (Gregory & Miller, 1998, p. 105). In this sense, the continuing reference to mainstream newspapers also relates to this age where newspaper circulation is declining. In spite of the current fall on circulation, quality daily newspapers stands as the mot read form of communication. Furthermore, "journalistic culture of news has been much studied; and newswriting practices have been codified" (Gregory & Miller, 1998, p. 105). In spite of Gregory and Miller's (1998) argument, this study reasons that the chosen newspapers' circulation, as well as news values and political views were crucial to them being chosen for this research. The vast occurrence of studies of science in newspapers, its circulation, key position and the abovementioned practicalities supported the decision towards analysing quality daily newspapers. Thus, as daily newspapers have been crucial to bringing scientific issues to public attention, this study analyses the content of newspapers while driving a multimodal close reading analysis of news articles of science.

With this mixed method design, the research plans to gain a more encompassing body of knowledge through a plurality of methodological approaches. The adopted mixed methods research strategy consists of a content analysis of the United Kingdom and Brazilian newspapers to evaluate journalistic practices in the collection and dissemination of quantitative data. To delimit the scope of the research, it studies the scientific news production of two newspapers in the United Kingdom –*The Guardian*

and *The Times*– and two in Brazil –*Folha de S. Paulo* and *O Globo*– in 2013. The selection of these daily quality newspapers was due to the aforementioned reasons. As defined, the choice of daily newspapers was determined by practical considerations, easier access, among others (Gregory & Miller, 1998, p. 105) as well as their being the largest employers of journalists (Weaver, Beam, Brownlee, Voakes, & Wilhoit, 2007)**.** Newspapers, as quality press (Conboy, 2002, p. 148), hold control and influence (Frewer, Raats, & Shepherd, 1993; Meyer, 2005). Consequently, for the objectives of this study, the analysis of newspapers is fundamental to the understanding of how science is portrayed in the news. The argument behind this fundamental importance concerns that quality newspapers are the biggest purveyor of scientific communication, especially in terms of readership. Newspapers are thus a key science communicator. Likewise, to avoid importing biases into the data collected, analysed and interpreted, the year of 2013 was randomly selected to provide a general understanding of the uses of numbers in the articulation of science news in the United Kingdom and Brazilian press. Finally, bearing in mind the objectives of this research, the application of mixed methods in the analysis of science news article aims to provide a more encompassing analytical tool to evaluate the chosen population, their journalists' and newsrooms' statistical legitimacy strategies.

5.4.2 Target Population

A population is the collection of individual units that have at least one common characteristic (Battersby, 2010, p. 228). The study of a population can examine its entire population or part of it. In scientific research, a target population is collected with defined units of interest from which the research aims to make inferences. As research needs to satisfy a particular audience and address a clear data set, this target needs to be well defined when data is collected and analysed by the principle of

research. For this research, the analysis was performed on a representative population, or target population. Within the context of this study, this target population consists of four newspapers with high circulation and a range of readership profiles. Within the United Kingdom newspaper media environment, *The Guardian* and *The Times* were studied as they represent the country's "quality press" (Conboy, 2002). Similarly, *Folha de S. Paulo* and *O Globo* were analysed in the Brazilian scenario.

The Guardian and *The Times* are both quality newspapers and were systematically chosen, in line with characteristics identified by Oeffner (2003) and Poole (2006), due to their circulation, key position and opposing political, as well as ideological stances. Furthermore, they share key practicalities essential to this research. They are easier to access, have better archiving systems and share a similar coding. *The Times* is a traditionalist, inclined towards right central ideas while *The Guardian* is left-of-centre with a social-liberal orientation. For the same reason, *Folha de S. Paulo,* and *O Globo* were selected in the Brazilian scenario. *Folha de S. Paulo* is a Brazilian quality newspaper edited in the city of São Paulo and the second biggest newspaper in circulation in Brazil, according to the Institute of Verification of Circulation. *O Globo* is a daily newspaper based in Rio de Janeiro. Both quality daily newspapers have been chosen due to their proven research relevance (Guedes, 2000) and their being amongst the most influential newspapers in Brazil. Similarly, *Folha de S. Paulo* has a liberal tradition, whereas *O Globo* has a more conservative, centre-right political affiliation.

The selection of newspapers for data collection is based on the following criteria: (1) circulation, (2) news values, and (3) political views. The primary news media outlets are grounded on these three conditions. Furthermore, they are easier to access, are archived, and coded (Gregory & Miller, 1998, p. 105). As a quality newspaper, their

circulation is important as it establishes the readership and their scope of influence. In proportion, Brazilian daily newspapers have a low rate of circulation (Albuquerque, 2012, p. 78). News values articulate the characteristics of information that create the news stories, be that time, prominence, proximity or unusualness. Their importance is due to news being one way in which society examines itself and individuals as singular units in order to make decisions. Lastly, it is important to recognise the significance of the symbiotic relationship between media and political power as well as understanding political power as a fundamental object of analysis for the press and the contemporary world (Lima, 1996). Amidst this scenario, why the United Kingdom and Brazilian newspapers?

The reasoning behind this choice of countries has a few layers. Firstly, they are the two nations whose media cultures I am most familiar with. Therefore, I am more confident about the soundness of my findings due to the stated confidence in knowing both media environments. Secondly, at a macro level, the analysis of the United Kingdom and Brazilian newspapers produces an interesting dichotomy. By studying the two scenes, it contrasts a developed country with a Newly Industrialised Country (NIC). This difference in development levels can influence media cultures and in spite of this not being the objective of this study, it can produce provocative findings. Thirdly, at a micro level, they have different forms of media regulation. While on the one hand, in the United Kingdom, there are communications regulators like OfCom and the independent, self-regulating Ipso, Brazil has no history of compromise towards the freedom of expression and has no communication regulators. Overall, these differences can produce interesting findings and furthermore, illuminating possibilities that can be seen as a foot in the door for future research. The potential for further studies will be developed in Chapter IX.

In order to follow the principle of objectivity and to produce a more comprehensive understanding of the subject in the newsroom, this research studies the same target populations. As a means to provide an equal understanding and analysis of the collected data, this research used the same target population throughout the research. Correspondingly, the close reading analysis of the target population is the same as the content analysis. Thus, a multimodal close reading analysis is also conducted in *The Guardian*, *The Times*, *Folha de S. Paulo* and *O Globo* amongst the United Kingdom and Brazilian news. Similarly to the content and discourse analyses, the target population of the interviews aimed to be the same: in the United Kingdom, *The Guardian* and *The Times*; and in Brazil*, Folha de S. Paulo* and *O Globo*. That being said, due to scheduling conflicts, no interviews with *The Guardian* science journalists were conducted. Therefore, although I set an equal number of interviews in Brazil and the United Kingdom, many of the journalists in the United Kingdom failed to be interviewed. Due to the high quality of the interviews that were conducted, I believe this did not impair the findings.

5.4.3 Sampling

In terms of sampling, this study analyses *The Guardian, The Times, Folha de S. Paulo* and *O Globo.* Sampling is the limitation of observations to a functional subset of elements that is statistically representative of the total universe (Krippendorff, 2004). An analysis of the representative sample should match the conclusions of the whole population. Thus, the process of drawing a sample should maximise the similarities between the sample and the total universe. As a pre-established procedure to select, analyse and interpret data, sampling is a means to describe the population through the understanding of a smaller subset of individuals.

Accordingly, in terms of the content analysis, it should limit its research to a manageable body of text. As such, it often uses sampling as a means to select data (Bauer & Bas, 2000; Hosti, 1969; Krippendorff, 2004). Statistical sampling provides a rationale to study a smaller amount of data and thus to enable it to analyse and to draw inferences about the whole collective population. Different from statistical sampling theory, the sampling of text needs the plan to ensure the sample population does not transfer any biases into the answers to the research question (Krippendorff, 2004). It needs to be equally informative to generalise points. Furthermore, Krippendorff (2004) distinguishes three sampling techniques: random sampling, systematic sampling, and stratified sampling.

This research uses a systematic sampling methodology while asking how science journalists articulate and legitimate stories using statistics and how these are used to articulate narratives and shape discourses of science in the newsroom. Taking into consideration this variable relies on the scope of the newspaper in terms of quality and national circulation, I will also test other factors that might influence the uses of statistics in science news outlets.

In line with the specific countries selected, a systematic random sampling selection was chosen. Systematic random sampling selects units within a list of pre-randomised possible units (Krippendorff, 2004). Therefore, for the purpose of this investigation, *The Guardian, The Times, Folha de S. Paulo* and *O Globo* were selected among an array of the United Kingdom-based and Brazilian daily quality newspapers. Regarding the choice of time frame, however, a random sampling was conducted. As to avoid biases or the predominance of certain subjects, for example prevalence of environmental news during years of the United Nations Intergovernmental Panel on Climate Change (IPCC) assessment reports, a random sampling was performed. The

year 2013 was chosen as a time frame for analysis. The sample was thus taken over a one-year timeframe from daily newspapers (n=4) in the United Kingdom and Brazil. The sampling frame selected for this general content analysis was from 1 January 2013 to 31 December 2013. However, it was a good range of time as the year 2013 was an interesting year for science, and therefore news of science. The year 2013 saw a number of successful events and science discoveries. For example, in Space related news, it was an extremely important year for space exploration as a number of Earth-like planets were discovered and NASA declared that Voyager 1 had gone interstellar. In Biology, scientists were able to lab-grow parts of organs on test animals. Earlier in the year, researchers had also announced a fast and precise method for editing genetic codes. In Environment, it was the first time since the late 1990s that the Earth's surface temperature increased had slowed due to the warming of deep oceans, instead of the surface. In Medicine, successful new treatments for major known diseases were discovered. All in all, a number of significant developments occurred in every area and range of science, making the year 2013 a productive choice.

Within this stipulated time frame, in terms of qualitative analysis, this research further uses systematic sampling. This process proposes to select subjects from the target population using a criterion, which is applied systematically to a list of the names of the individual units of the population. In the case of this study, from the corpus of *The Guardian*, *The Times*, *Folha de S. Paulo* and *O Globo,* 4 (n=4) science articles were selected. This sample refers to a subset of the population. Lastly, in terms of the conducted in-depth interviews, Gil (1999) argues that interviews must create an environment free of any coercion, intimidation or pressure. Thus, to create a welcoming and open environment, as well as make the interviewee feels comfortable and at ease, the researcher gave them the greatest possible freedom. Richardson

(1999, pp. 216-217) presents some guidelines to help in this process of creating openness. To him, it is important to explain the objective and nature of the conducted research, as well as to explain the logic behind being chosen for such an interview. Secondly, the interviewer must ascertain anonymity of the interviewee and confidentiality of responses. The guidelines also suggest that a few questions might be considered meaningless but that they all have a considered background and research basis to them. Furthermore, it must be indicated that the interviewee should feel free to interrupt and ask for clarification or criticise any questions. Then, the interviewer must inform the interviewee of his or experiences in conducting research and handling data in the area. In terms of ethics, it is worth bearing in mind that I asked permission to record every session and all interviews were anonymised in order to preserve their confidentiality.

5.4.4 Coding

Coding creates a bridge between observations and interpretations (Krippendorff, 2004, p. 84). Researchers use coding as a means to build long-lasting records of short-lived phenomena. Consistent with earlier research (Janis, 1965; Miller G. A., 1951), I used coding to group different elements contained in the news articles and turned this into quantitative data, which drew attention to the most relevant characteristics of media practice and representation of statistics in science news. That is because, "in order to handle larger blocks of verbal material in a statistical way, it seems necessary to reduce the variety of alternatives that must be tabulated" (Miller G. A., 1951, p. 95). Thus, this research uses codes mostly to highlight frequencies, which were, (1) year of publication, (2) newspapers, (3) byline, (4) type of news, (5) total number of sources quoted, (6) number of primary sources quoted, (7) number of secondary sources quoted, (8) nature of main source, (9) type of study, (10) single study, (11)

sample size, (12) main emphasis in headline, (13) who presents the statistics, (14) nature of statistics, (15) number of statistics, (16) nature of data, (17) visual data, (18) use of statistics, as well as (19) political affiliation, and (20) countries designed for the multilevel correspondence analysis.

This coding design and research strategy aimed to facilitate analysis. Towards this objective, I relied on interceding reliability as a general standard of measurement. In terms of conducting a content analysis, interceding reliability is essential. Inter-coding reliability is a widely used term in academic research, which aims to measure the degree to which different individuals reach the same conclusions and "assign exactly the same rating to each object" (Tinsley & Weiss, 2000, p. 98). In this study, the assignment of a standardised form of measurement is important to control coding accuracy and quality of research findings. To that end, I have used Krippendorff's alpha (KALPHA) as a reliable test (Krippendorff, 2004). Using mostly frequencies, calculating KALPHA in SPSS provided no difficulty.

Still in terms of coding, for the close reading analysis, this study uses one to four as codes to describe the samples, each with its citation. Each citation includes, title of article, newspaper, and date of publishing. Furthermore, as a form of coding the interviews, every semi-structured interview was personally transcribed. Due to the purpose of such interviews and the analysis being conducted, the interviews were transcribed directly into the word processor.

5.4.5 Data Collection

Having established the target population, sampling and ways in which the data will be coded, it is equally important to stipulate the ways in which data will be collected and analysed. Data collection is the systematic process of gathering and measuring

information. In that sense, the methodology of data collection is relevant as it influences which data will be collected, analysed and thus interpreted.

In the United Kingdom, using Lexis Nexis, some articles were gathered from *The Guardian* and *The Times* within the time scope. Lexis Nexis is software that scans, collects and manages documents and publications within the legal, accountancy, public and private sector. It has provided full-text accesses to most of the United Kingdom national and international newspapers since the 1980s. Similarly, the archives of *Folha de S. Paulo* and *O Globo* were accessed via their personal archive and file, which collected every news piece on science within the chosen period.

Qualitative data is often collected from a smaller sample that would then be used for quantitative approaches. Therefore, for the close reading analysis, this study used the subset of the first body of information, as quantitative research data collection methodologies require time. Out of the initial corpus, four science news articles were selected on diverse topics. The news articles of science were randomly selected and analysed independently from their quantitative data. Both set of collected data were then used as background for the in-depth interviews. The answers provided by the analysis of content and close reading provoked an interest in exploring certain further queries. Therefore, the semi-structured interview data was collected from a set of 30-minute interviews with science journalists from *The Times, Folha de S. Paulo* and *O Globo.*

5.4.6 Data Analysis

Ultimately, the combination of qualitative and quantitative research methods was chosen for the broad purpose of breadth and depth of understanding and corroboration. The choice for the analysis of the data was the software SPSS. Tests

were conducted with the software SPSS Statistics (v. 22, IBM SPSS). The body of 1,089 (n=1,089) data sets were entered into the software where Multiple Correspondence Analysis and Path Analysis test were conducted. In terms of test designs, I choose simple logic regression to find most frequencies, including but not limited to the type of study, use of single or multiple studies and sample sizes. Moreover, I used multiple correspondence analyses to determine possible relationships between writers and chosen newspapers, as well as whether they depend on the newspapers and vice-versa. Similarly, correlations strategies aimed to uncover associations between, among others, newspaper and type of news; byline and total number of sources quoted; as well as, type of news and total number of sources quoted within news articles of science.

In terms of close reading, this investigation looks at the works of O'Halloran (2011), Carlson, Daniel and Okyrowski (2001), Mann and Thompson (1988), Marcu (2001) and Wolf & Gibson (2004) to analyse discourses. Observing the selected 4 (n=4) science news articles it examines the exploration of both the written language as well as visual journalistic language in this case, mostly statistics and graphs. In terms of the interviews, analytically speaking, this research uses interviews primarily as a means to validate findings and as a tool to legitimate the content and discourse analysis. No direct analysis was conducted in the semi-structured in-depth interviews.

5.5. Content Analysis

This researcher's content analysis looks at the news of science through a quantitative perspective while analysing the frequencies of ranged variables. This research strategy aims to answer how statistics are used to articulate science information in the news, and seeks to provide data on significant characteristics on how science

journalists use statistics in the reporting of science. Furthermore, it looks at how they are used, if there is a difference between how Brazil and the United Kingdom use statistics to shape news discourses, and what are their preferred sources. In terms of content analysis, Berelson (1952) and Krippendorf (2004) offer two of the most widely accepted definitions of content analysis. The former describes content analysis as a versatile technique for social science and media researchers. While Krippendorff (2004) argues the Church was the first to use this systematic analysis of text in the 17th Century. As "quantitative newspaper analysis provides the needed scientific ground for journalistic arguments" (Krippendorff, 2004, p. 5), it gained popularity among social science researchers and communication scholars alike.

Today, content analysis is essential in terms of research technique within the social sciences. With the increase in the mass production of news, as seen at the beginning of the 20th Century, empirical enquiries on print media's ethical standards have emerged. These demands, plus a somewhat simplistic notion of scientific objectivity, were met by what was then called 'quantitative newspaper analysis' (Krippendorff, 2004, p. 5). This way, quantitative analysis seemingly provided scientific ground for argumentation as an interpretive, analytical instrument that seeks to find meanings in a body of text. The authoritative power of quantitative data was considered not only legitimizing but also irrefutable. Since then, quantitative newspaper analysis has changed, but it has also led to the development of many valuable theses. When other news mass media became prominent, researchers extended this approach to the study of other media categories such as radio (Albig, 1938), movies and television.

There is a thin body of knowledge on how journalists in newsrooms access and interpret quantitative data when producing stories related to science. This research strategy looks to redress this lack and provide additional information on how science

journalists use statistics in the reporting of science. Therefore, content analysis was chosen to investigate the nature of statistical news characteristics, emphasis, and the sources regularly used by science journalists in newsrooms. These data were collected by a thorough gathering of news articles, similar to that employed by Atton and Wickenden (2005)**,** on the topic of science in *The Guardian*, *The Times, Folha de S. Paulo* and *O Globo* in the year 2013.

To analyse the content, two techniques were used: multilevel modelling and multiple correspondence analysis. Both required the use of SPSS to examine news articles from the aforementioned different newspapers as well as to crunch the data. Content analysis is used to describe and interpret diverse texts, including media news reports. According to Neuendorf (2002), "content analysis is a summarising, quantitative analysis of messages that relies on the scientific method (including attention to objectivity, intersubjectivity, a priori design, reliability, validity, generalisability, replicability, and hypothesis testing) and is not limited as to the types of variables that may be measured or the context in which the messages are created or presented" (p. 10). Similarly, it is understood that content analysis is a scientific tool that makes replicable and valid inferences, adds new insights, greater understanding and practical actions from texts or data to their concepts. For instance, Bardin (1977) believes that content analysis is "a set of techniques of communications analysis aiming to obtain, by systematic and objective procedures of the description of the contents of the messages of, indicators (quantitative or otherwise) that allow the inference of relative knowledge as to the production/reception conditions (inferred variables) of these messages" (p. 44).

Following a more historical approach Bardin (1977) initially understands hermeneutics, rhetoric, and logic as practices prior to content analysis. She goes on to

explore more in depth the so-called 'second historical moment' of content analysis in which the application of its techniques expanded to a variety of disciplines and understanding of questioning and new answers in the methodological plan. In addition, still according to Bardin (1977), there are some phenomena that are essential to the investigation and practice of content analysis. The three most significant are: (1) the computer, (2) the growth of inherent studies to visual communication, and (3) the unfeasibility of linguistic precision work. As a method, however, Bardin (1977) argues that content analysis is a set of analytic techniques of communication that uses systematic and objective procedures to describe the content of the messages. Thus, within the framework of this study, content analysis was used as a technique to describe and interpret the content of the news media and different media outlets. That is because it is seen as the result of word association (stereotypes and connotations) and ideas/ particular views. To that end, Bardin (1977) recommends that subjects should be associated freely, and quickly disassociated from hearing inductive words (stimuli) and other words (answers). Berelson (1952) goes further than that by arguing that within the range of definitions of content analysis there are six distinguishing characteristics. To him, content analysis can only be applied to social science generalisations, the determination of the effects of communication, the semantic and systematic dimensions of language, characterised as it is as it being objective, systematic and quantitative. This approach relates to the line of inquiry as it allows the understanding of the use of statistical information in science news through a less obvious means of access. It looks at how quantitative data are used in the news, through quantitative information. Furthermore, it provides a solid support for both the analysis of close reading, as well as the in-depth interview. Similarly, it informs my

argument as it constructs a more rigorous and standardized set of results that aims to minimize bias errors; the latter, being essential to this research.

Ultimately, the idea is to use content analysis to understand the association of statistics and their representation with an understanding of them as a vehicle of social construction. The rationale for using this quantitative research method thus was to analyse the uses of statistical data in science news with regards to the ways in which science journalists articulate and legitimate stories using statistics and how they are used to communicate narratives and shape discourses of science. As supported by previous studies (Lester & Hutchins, 2009; Petersen, 2001) a content analysis was the most convenient way to explore its uses and representations. The research design of this quantitative analysis is detailed below.

5.5.1 Multilevel modelling

Multilevel models offer the possibility of looking at this complex world, "to detect patterns buried in complex, interrelated variables, to explore the degrees of influence two or more variables jointly may appear to exert on other variables, or to make predictions of values of outcome variables based on knowledge of the values of selected independent variables" (Kent, 2015, pp. 151-152). Consider, for example, articles within newspapers and the variable political affiliations and country of origin from which one aims to predict their uses of statistics in news reports. The analysis of such data with techniques like standard multiple regression does not acknowledge this replication – nor the fact that the existence of more observational data than it has in reality – which consequently inflates the sample size and leads to underestimates of the variable and underestimated standard errors for these variables.

To Dewey (1948) context is crucial to understanding this complex world. To him, for example, the likelihood of tobacco-smoking habits is influenced by social and cultural contexts – e.g. parents' smoking habits, and age one starts smoking. Teenage pregnancy can vary based on social background, education and access to the health system. Anti-social behaviour is affected by one's social circle. The likelihood of divorced couples is connected to religious and cultural contexts. Such examples can be extended to studies on the effects of organizational downsizing on the employee's health (Kivimäki, Vahtera, Elovainio, Pentti, & Virtanen, 2003); primary (elementary) school children (Aitikin, Anderson, & Hinde, 1981; Bennett, 1976); quality of life of abused women (Bybee & Sullivan, 2002); and, supportive organizational characteristics for rape victim advocates (Wasco, Campbell, & Marcia, 2002).

As a means to provide context for this discussion, it needs to be considered that each article analysed has a byliner (level 1), who works for a newspaper (level 2) –which has distinctive political influences (level 3) and is based on different countries (level 4). As researchers learn more about the importance of bylines in the uses and representations of statistics in science news, one may be able to understand links between them and their particular contexts, newspapers or countries. However, the effect of political influences and cultural backgrounds are overlooked. These fixed effects operate at different levels but still are most commonly measured at the individual level, and often little scrutiny is given to the system these different levels and factors create.

Furthermore, multivariate techniques have the advantage of accounting for the standard of chance, meaning that their correlations are only reported when the data deviates significantly from chance. According to Kent (2015), when variables are

categorical, such as the whole of my data set, the model of multi-levelling is only viable via n-way tables, log-linear analysis, and correspondence analysis. It is used within "any simultaneous analysis of three or more variables on a set of cases" (Kent, 2015, p. 155).

The most basic regression equation possible for observation works at a single level, where the only predictor is a constant term, and ignores any hierarchy. However, in a multi-level structure, there are two-course forms: random effects and random coefficients (Snijders & Bosker, 1999)**.** More specifically, "in contextual modelling, the individual and the context are distinct sources of variability, which should both be modelled as random influences" (Snijders & Bosker, 1999, p. 2)**.**

5.5.2 Multiple Correspondence Analysis

This research also uses multiple correspondence analysis to explore the collected data. Multiple Correspondence Analysis is an exploratory technique of data analysis that aims to examine two or more entries. Whilst a Simple Correspondence Analysis is defined as a multivariate analytical technique, which is most suitable for the collection and analysis of categorical data and permits the graphic analysis of the existent relationships through the reduction of the general data. The Multiple Correspondence Analysis has a priori characteristics that allow the setting up of individual profiles for each strand of observable data, thus permitting the evaluation of the relationships between the latter and the analysed variables. As I have established, one of the intentions of this study is to inquire into the possible relationship between science journalists and their uses of statistical information. For this reason, this research used it as a means to study the relationships and similarities within its data sets.

5.6. Close Reading Analysis

This study also allows for a qualitative analysis of close reading. This research strategy aims to find shared features among newspapers in the articulation of statistical data in science news. To do so, it aims to answer the question of how journalists articulate news stories on science using statistics and their attitudes towards its uses in the news, as well as possible divergences between the United Kingdom and Brazilian media cultures in the shaping of science discourses in the news. Furthermore, it looks to analyse whether science news is differently treated in terms of quantity of sources quoted, preferred sources, statistical information and presentation of data. Thus, subsequent to the content analysis, this study performs a close reading of a systematically selected sample of 4 (n=4) articles from the total universe of 1,089 (n=1,089) newspaper news items in order to carry out a disciplined reading of science news as to understand the nuances in the discourses of the object of study (Brummett, 2010, p. 28). Still in accordance to Brummett (2010), "close reading is the mindful, disciplined reading of an object with a view to deeper understanding of its meanings" (Brummett, 2010, p. 3). Accordingly, a multi-layered close reading analysis is carried out on the ways in which these four news media covered science news during the year of 2013. To do so, this study looks beyond the media outlets and takes into account the social actors, constructions and contexts that serve as sources of information, thus affecting media representations of science issues – more specifically in relation to the gathering and dissemination of quantitative data.

Thus, as suggested by Carvalho (2008, p. 166), this research focuses on a multimodal analysis of the 'corpus' of the news, paying close attention to headlines and the way through which the sources delivered the statistical information. According to Luke (2002), this critical analysis "involves a principled and transparent shunting

backwards and forth between the microanalysis of texts using varied tools of linguistic, semiotic and literary analysis, and the macro analysis of social formations, institutions and power relations that these texts index and construct" (p. 100). Similarly, Carvalho (2008) argues it is a usual term for multiple ways of studying the relationship between language and meaning, as well as their social and political repercussions and constructions.

> *"Most studies of media discourse are like snapshots examining some news items in detail but covering a short time span (often only a day or a few days). While this may be relevant for some events, most public issues have a significantly long ''life'', which is tied to representations in the media" (Carvalho, 2008, p. 164).*

Furthermore, media portrayals of social problems are, unavoidably, dependent on the preferences and opinions of those who produce and shape information – information that derives from the discourses of other social actors. More than that, the analysis of journalistic discourse (or the construction of a robust discourse analysis of news material) must take into account two discursive interventions: (1) the sources and social actors' intervention and (2) the journalists' intervention (Carvalho, 2008, p. 164).

Conversely, Brown and Yule (1983) argue that, in spite of having speech as its primary object of investigation, there is a broad range of meanings that encompasses the term 'discourse analysis.' According to Lowe (2003)

> *"these 'contextual' approaches to meaning assume that word's meaning is constituted primarily by its use rather than, e.g. its reference. Specifically, it is constituted by constraints on the linguistic contexts a word can appear in. In particular, a contextual theory of meaning states that two words are similar in meaning to the extent that they can be substituted for each other in the same context" (pp. 2-3).*

The field of discourse studies was born from different schools of thought (Van Dijk, 1997) and, consequently, it does not follow one particular approach nor does it

concentrate on the same areas of concern. Many critics argue that the field of discourse analysis is too extensive and random with no underlying premises (Hammersley, 1997) lacking systematicity, transparency and detailed strategies (Cohen & Manion, 2007; Coyle, 1995; Flick, 2002).

In defence of this approach, Locke (2004) suggests that close reading analysis of discourse must be seen as a 'scholarly orientation' rather than as an isolated methodology. Similarly, Wetherell, Taylor and Yates (2001) propose that the analysis of discourse is a "field of research" (p. 5), meaning that within this broad field of research there is a wide range of different methodological approaches. Furthermore, Potter (2004) claims that there are four distinctive sets of study when analysing discourse: linguistics, sociolinguistics, cognitive psychology, and poststructuralism. The first set studies "the way sentences or utterances cohere into discourse" (Potter, 2004, p. 201) e.g. how words such as 'however' and 'but' function differently between sentences. The sociolinguistics set aims to make sense, through work on classroom interaction, of discourse structure in a variety of different settings (Coulthard, 1986; Coulthard & Montgomery, 1981). The third set focuses then on the way 'mental scripts' operate as a means of making sense of the narrative and, lastly, poststructuralism aims to understand how a discourse "comes to constitute objects and subjects" (Potter, 2004, p. 201).

In the field of media studies, discourse analysis has been widely used among scholars, as it is a practical way of exploring how conceptions of frames are rooted within discourses and how editorial inclinations are reflected in certain vocabularies.

> *"the discourse analyst treats his data as the record (text) of a dynamic process in which language was used as an instrument of communication in a context by a speaker/writer to express meanings and achieve intensions (discourse)" (Brown & Yule, 1983, p. 26).*

Moreover, discourse analysis can also be seen as a means of interpreting and analysing reading (Breeze, 2011). It analyses the discourse surrounding a particular issue and how it can underscore agendas and assumptions of the discourse participants. Having in mind then that both have the social production of meaning as objectives, this relationship between discourse analysis and media studies can be seen as an important means of enriching these two (complementary) fields.

As seen in the previous chapter, the current literature focuses more on theories regarding the correlation between objectivity, truth and news, disregarding the role of statistics in science newsroom as a means of articulation and legitimation. The linguistic approach provided by the use of discourse analysis as a methodology thus facilitated the application of critical thought to this social situation, i.e. the administration of quantitative data when gathering and disseminating news stories, in order to analyse discourses within the United Kingdom and Brazilian media. Moreover, I was "interested in the function or purpose of a piece of linguistic data and also how that data is processed, both by the producer and by the receiver" (Brown & Yule, 1983, p. 25). To this end, this linguistic approach and methodology were chosen because they critically analyse social constructions such as statistics and science in order to understand the development of media discourses.

5.7. In-Depth Interviews

This research strategy aims at explaining and substantiating the findings of the content and close reading analysis. It hopes to understand how statistical information is used to articulate discourses of science in the news. Also it seeks to answer directly how science journalists use statistics in their stories. If various journalists use it differently, what are the many attitudes towards its uses and understanding, and how

do they gather, manage and understand its information. I am using this approach as it provides me with a unique point of view that neither the content or close reading analysis does. This research strategy and use of in-depth interviews allowed for a closer and more direct insight into the studied subject. Overall, it substantiated some findings while looking from within the newsroom.

As to avoid what Allan (2004) defines as "messy complexities, and troublesome contradictions, which otherwise tend to be neatly swept under the conceptual carpet" (p. 3), this study goes further than the aforementioned content and discourse analysis by conducting five (n=five) semi-structured interviews with science journalists in the time between 2015 and 2016. Thus, this study is completed by semi-structured interviews carried out with a small group of journalists from different media outlets in the United Kingdom and Brazil, who cover science news. The interviews are designed to augment the analyses of news articles. In doing so, this study provides knowledge on the practices and related methodologies used in the newsroom when gathering and disseminating data. To do so, a series of standard questions were posed to all participants to explore the decisions involved in the selection of statistical data, while allowing freedom for answers to migrate into other areas, such as clarifying or expanding on particular problems and limitations.

Haguette (1997) defines interviews as the "process of social interaction between two people in which one, the interviewer, seeks to obtain information from the other, the respondent" (p. 17). There is a comprehensive body of scholarly work regarding the uses, advantages, and disadvantages of using interviews as a method to collect research data (Anderson, 1997; Demo, 1995; Hitchcock & Hughes, 1989; Manzini, 1990; 2003; Minayo, 1996; Trivinos, 1987). Amongst the range of interview techniques, semi-structured, in-depth interviews are widely used as a method of

research in social sciences. A semi-structured interview involves the use of guided, previously elaborated, open-ended questions, and seldom, closed ones. This approach is recognised amongst scholars in the area of journalism studies as it supplements "a media-based assessment of source activity with observational analysis, or interviews with source representatives themselves, in order fully to assess their success or failure in influencing agendas" (Anderson, 1997, p. 37). In that sense, interviews are unique as a means to provide insightful information into how statistics are used within newsrooms, by journalists themselves.

As an attempt to define what comes to be a semi-structured interview, Hitchcock and Hughes (1989) believe the semi-structured interview

> *"allows depth to be achieved by providing the opportunity on the part of the interviewer to probe and expand the interviewee's responses. (...) Some kind of balance between the interviewer and the interviewee can develop which can provide room for negotiation, discussion and expansion of the interviewee's responses" (Hitchcock & Hughes, 1989, p. 83).*

Demo (1995) defines it as a scientific method, which allows the researcher to discover reality. Minayo (1996), on the other hand, argues it is the observable fact that allows the approximation of events to existing theory on the subject researched, as it combines both.

To Manzini (2003) and Trivinos (1987), in the case of semi-structured interviews, attention should be given to the preparation of questions as they hold critical importance to the matter to be investigated. Both authors argue in favour of the need to propose basic and major key issues to achieve the objective of the research. Trivinos (1987) understands it as an investigation that commences from fundamental questions, which are supported by theories and hypotheses that relate to the subject of research. Subsequently, it offers a large platform for interrogation that creates a

favourable space for the formulation of new hypotheses as these basic questions are answered.

> *"Like this, the informant spontaneously following the line of his thinking and his experiences within the main focus consigned by the investigator begins to participate in the elaboration of the research content" (Trivinos, 1987, p. 146).*

He argues further that semi-structured interviews favour the explanation and understanding of the whole situation, and not only the description of social phenomena while still maintaining the conscious and active presence of the researcher in the process of data and information gathering (Trivinos, 1987, p. 152).

Similarly, Manzini (1990) believes semi-structured interviews focus on the subject that was previously determined by fundamental questions, accompanied by other issues that may arise during momentary circumstances throughout the interview. To him, semi-structured interviews allow the emergence of information more freely and provide answers that are not subject to a standard response. He also points out that it is possible and advisable to plan the data collecting through the establishment of a previously established "roadmap" with basic questions, which aims to reach the researcher's intended goals (Manzini, 2003). This script would then, in addition to the collection of necessary information, be used as a means for the researcher to organise the process of interaction with the interviewee (Manzini, 2003).

Having established that fundamental questions are key to effective semi-structured interviews (Manzini, 1990; 2003; Trivinos, 1987), it is important to understand its possible approaches. Trivinos (1987) distinguishes two types of theoretical approaches: phenomenological and dialectical. The first phenomenological line aims to achieve maximum precision in the description of the researched phenomena. To Trivinos (1987), these questions are crucial to the understanding of the meaning of a respondent's behaviour. The dialectical line, or historical-cultural, is designed as

explanatory, aiming to determine immediate or mediate attitudes towards the phenomena. For instance, “why [do you] think students have difficulties in assimilating math content?” (Trivinos, 1987, p. 151). He further develops five other types of questions: (1) interrogative ones such as “you say you belong to the middle class. Are there any other social classes and why do they exist?” (Trivinos, 1987, p. 151); (2) consequential questions such as “what might it mean for the urban community in which you live, the large number of people who do no know how to read?” (Trivinos, 1987, p. 151); (3) evaluative questions like “how to judge the neighborhood response to the invitation to participate in the organization of a cooperative?" (Trivinos, 1987, p. 151); (4) hypothetical questions such as, "if you notice that your students often fight among themselves, what would your behavior be as a teacher?" (Trivinos, 1987, p. 151); and (5) categorical questions, “if you observe the responses of their neighbors across the possibility of organizing a cooperative, how many groups could we classify them?" (Trivinos, 1987, p. 151). For the purpose of this research, primary questions were mostly the explanatory and evaluative approaches.

Mazini (2003) considers further the development of scripts for semi-structured interviews. To him, the researcher must observe the following points when formulating questions for the interviewee: (1) attention to the language, (2) attention to the form of the questions, and (3) attention to the sequence of questions on the scripts. Thus, a good interview premise begins with the formulation of basic questions, which should facilitate the goal of the research (Manzini, 2003). Furthermore, a script analysis should identify their suitability in terms of language, structure and sequence of the questions in the script. In this research, questions were

designed bearing in mind these points, and assessed for suitability prior to the interviews being conducted.

Ultimately, the advantage of this technique is its flexibility, adaptation and the potential for fast reactions. In semi-structured interviews, questions can be adjusted according to the researcher and interviewee as well as the circumstances. Within this research design, semi-structure in-depth interviews are crucial to supporting my findings. Not only do the interviews provide a different view of the line of inquiry, but they also substantiate the results. They rationalised the choices of source, management and presentation of data, and perhaps most importantly, they elucidated the journalists' experiences from inside the newsroom and ultimately answered how science journalists use and understand statistical information. In the same way, the use of previously elaborated questions and the guided structure contribute to a systematic collection of data. Furthermore, it allows the creation of distinctions between interviewees as each is largely based on their responses. It also allows the analysis to be flexible while other issues arising can be investigated during the interviews.

Interviews are crucial to working out the patterns, practices, beliefs and classificatory systems of social universes. As a means to understand potential social conflicts, which are seldom explicitly stated, interviews allow research to grasp unparalleled information. Within the conceptions of this study, these semi-structured in-depth interviews aim to gather unique information on the ways in which each interviewed journalist understands, collects and disseminates statistical data. These, subsequently, allow me to comprehend and designate a deeper understanding of this research's questions of this research project. Most importantly, it permits understanding of the

logic behind each journalist's decision-making processes – something that is often challenging to do through any other methodology.

As previously established, the planning of interviews is crucial to the achievement of research objectives. Interviewing is a commonly used method in social research. Unlike surveys and questionnaire-based interviewing, it often produces extensive, structured data on specific topics. To Warren (1988), this method proposes to offer an interpretation and understanding of the how and why, and not a fact-finding solution. Consequently, it fits perfectly into this study's fundamental research questions, which are: how do science journalists articulate and legitimate stories using statistics; and how are statistics used to articulate narratives and shape discourses of science in the newsroom?

According to Gubrium and Holstein (2001), during in-depth qualitative interviews, the interviewee's background has qualities and produces meanings, which the interviewer can socially investigate. Furthermore, it is fundamental in the investigation of data on opinions, views, attitudes and general understandings of a topic (Arksey & Knight, 1999). Within this context, this study proposes 30-minute semi-structured interviews with science journalists. Thus, the method of data collection for this section was the in-depth interview.

According to Manzini (2003), the collection of data and planning of interview can be divided into (1) issues related to planning the collection of information; (2) questions about variables that affect data gathering and future analysis; and, (3) issues related to the processing and analysis of interviews resulting in information that does not follow the aims of the research. Among the issues that relate to the planning of information gathering, are present the need for planning issues that reach the intended goals, the adequacy of the sequence of questions preparing roadmaps, the need to adapt scripts

by judges, and to conduct a pilot project to, among other things, adjust the script and language.

Besides the usual variables that affect the collection of information and presentation of data, other points often offer control over the gathering of data through interviews. According to Manzini (2003), they often include the influence of the interviewer's intervention in the production of the interviewee's speech (Brenner, 1985; Gilbert, 1980), the influence of the interviewer's intervention in the interviewee's thought processes, and the influence of the interviewer's intervention in the respondent's memory processes.

The preparation of the interview is one of the most critical stages of research that takes time and requires care and attention to several factors, among them: the interview plan, which shall be directed to the objective to be achieved; the choice of interviewee, which should be someone who is familiar with the topic researched; the opportunity of the interview or the availability of the respondent to allow for the interview to be scheduled in advance so that the researcher can ensure it can be confirmed; favorable conditions which ensure the interviewee's confidentiality; and finally, the specific preparation of the script or form with the important issues (Lakatos & Marconi, 1996).

In the wording of the questions the researcher must be careful not to draw absurd, arbitrary, ambiguous, displaced or biased questions. In-depth interview questions should be made taking into account the sequence of thought researched, i.e., looking to continue the conversation and conducting the interview resembling logical sense to the interviewee. To obtain an original narrative is often not related to the direct question, but rather to the recollection of memory of one's life. For both the researcher may well go raising the memory of the researcher (Bourdieu, 1998).

5.8. Conclusion

This chapter has rationalised the research practicalities and foundation while accounting for the data gathering and methodological approach to be used in this project. A triangulated approach that combines content and discourse analysis with interviews has been developed to provide certainty in the collection of data. It overcomes methodological weaknesses and bias, as well as increasing accuracy in the explanation of how science journalists articulate and legitimise stories that use statistics, and how they are used to articulate narratives and shape discourses of science in the newsroom.

The chosen methodology is the most appropriate because it complements a quantitative media-based analysis of statistical activity with qualitative discourse analysis, and interviews with source representatives themselves. In the long run, as previously recognised by Atton and Wickenden (2005), this is the most suitable methodology to examine how science journalists select, understand and present statistical information in the news.

Triangulation has been developed to provide an explanation for the central question explored: how science news writers articulate and legitimate their stories using statistics. Focusing on this issue, this research intended to produce an insightful understanding into how statistics are used as a legitimation tool in science news and newsroom and how science news statistics are collected, managed and disseminated by science journalists. Through an extensive analysis of this intrinsic relationship between the coverage, design, validity, interpretation and importance of quantitative data (statistical-based and statistical-related) in science news it aimed to elucidate the uses and representations of statistical information in news articles of science.

This chapter has in great detail explained the research methods, questions, and designs of the study, as well as the chosen approaches towards the sampling, collection and analysis of data. It has dealt with the research methodologies and the decision to examine data gathered through the use of mixed methods. A content analysis of statistical data in the United Kingdom and Brazilian science news, a close reading analysis of 1,089 (n=1,089) articles, and in-depth interviews with science journalists have been conducted to learn about the uses and representations of statistics in the articulation of narratives and the shaping of discourses of science in the newsroom.

CHAPTER VI

6. Content Analysis

6.1. Introduction

This chapter presents the analysis of the data gathered in the three phases of empirical evidence collection, followed by a discussion of the research findings. It starts by introducing the findings obtained from the research, by presenting the results of the content analysis. The nature of the design and ways in which statistical information are used and represented in science news are summarised. It aims to address the first main research question. More specifically, it addresses the following questions:

(1) Is there a difference in how statistics are used to establish narratives and frame discourses of science in the United Kingdom and Brazilian newsrooms?

(2) Is there a correspondence between the management of statistics in science articles and the news sources?

(3) What is the extent to which there is a correlation in the nature of the study and statistical information in which science news are conditioned?

(4) How are statistics used in the articulation of science news?

Accordingly, it provides a detailed account of the findings in the hope that these results will elucidate the uses and representations of quantitative data in articulating narratives and shaping discourses of science in the newsroom. For this purpose, this section is divided into three chapters: (1) the first chapter describes the findings derived from the content analysis of each variable through diverse statistical analyses, (2) the second chapter aims to conduct a close reading analysis of sampled news articles, while (3) the third chapter focuses on the analysis of the in-depth interviews with science journalists. Each chapter will be followed by a critical discussion of the findings and their link to existing theory and research to determine whether this new data supports or opposes the existing literature. The focus of the following three chapters is to introduce and discuss the findings of the three stages of data collection, examining the results with the relevant academic literature.

6.2. The Results

This chapter presents the results of descriptive statistics. As noted in the previous chapter, the methodological approach of this study guides the data collection shown in this chapter. This chapter yields the presentation of results and analysis derived from the content analysis. Furthermore, it sets out the descriptive statistics as graphs and tables, which were used to identify the frequencies and percentages of all eighteen collection points. The data were evaluated using various descriptive analyses in SPSS Statistics. The descriptive analysis of data provides an all-encompassing sense of the dataset, which allowed for a complete image and representation of the study's social relevance. Under the circumstances, data shows the frequency of the use of statistics in science news in *The Guardian*, *The Times*, *Folha de S. Paulo* and *O Globo* from

various angles in the year 2013. This way, different trends can be seen from the graphs including frequencies and correlations between the type of news, byline, and main emphasis in the headline, the number of statistics, who presents the statistics, among others.

6.2.1 Frequency of Articles

As established, the content analysis targets 1,089 (n=1,089) news articles on science across four newspapers. The expectation was that science news statistics are used in similar fashion in the United Kingdom and Brazilian news media. This hypothesis was substantiated by the analyses of the articles that use quantitative data, in both countries. This research suggests statistics are used in comparable, which are however not identical, manner in the United Kingdom and Brazil. For example, according to this research, in the case of scientific news, findings show that overall Brazil publishes more news on science than the United Kingdom. For the same period, out of the 1,089 (n=1,089) articles analysed, 717 were published in the Brazilian sample (404 articles in *Folha de S. Paulo* and 313 in *O Globo),* in contrast to only 372 in the British sample (159 in *The Guardian* and 213 in *The Times).* That means that almost two times the number of articles was published in Brazil in comparison to the United Kingdom. The process in which the analysed newspapers were indexed and how the data was collected can explain this prevalence in the publishing of science news statistics in Brazil. Gregory and Miller (1998) argue that quality newspapers are easier to analyse, as they are archived and indexed in an orderly manner. This systematic arrangement of newspapers, however, is bound to create inconsistency. I believe the difference in the number of articles does not prove a rational dominance of Brazil over the United Kingdom in terms of its uses of statistical data in science news. I

propose that further research is needed, accompanied by different means of data collection.

As can be seen from Figure 1, the findings show that just over 37 per cent –that is, 37.1 per cent– of science news articles containing statistical data came from *Folha de S. Paulo*. Moreover, while addressing each newspaper more carefully, the findings show that another, 28.7 per cent comes from *O Globo*, which amounts to a total of 65.8 per cent of science news statistics that came from Brazil-based newspapers. In this manner, the frequency of the sample population shows a predominance of Brazilian science articles. According to the analysed data, only 14.9 per cent of science news statistics were written by *The Guardian* and 19.6 per cent by *The Times.* That adds up to 34.5 per cent of science news statistics being published in the United Kingdom.

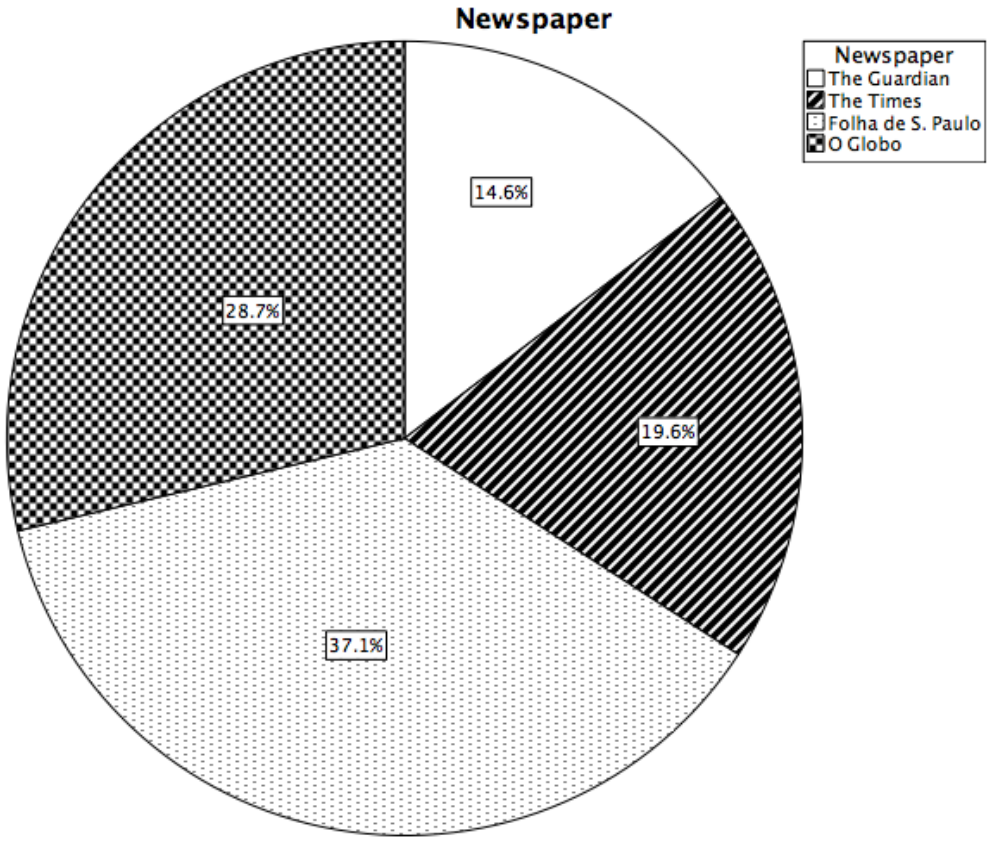


Figure 1: Percentage of Newspaper Frequencies

When looking at the frequencies of science news articles at the country level, the analysis presents an interesting finding: almost 68 per cent of science news items collected and examined are from Brazil. Only 34.1 per cent are from the United Kingdom. This is a significant finding, considering the role ascribed to science in the quotidian. This result may also be deemed noteworthy given that the analysed newspapers gather information from the same sources. As suggested, there is limited information on the processes in which those articles were indexed. Therefore, it is problematical to concretely assert there is a clear dominance of Brazilian science articles over the United Kingdom. Nevertheless, the implications of this high proportion of articles on science on the one country over the other may indicate a greater importance of scientific findings for the local population, as well as their general interest on subjects of science. Ultimately, these implications can be substantiated by the fact that while both *Folha de S. Paulo* and *O Globo* have separated sections, exclusively dedicated to science news, *The Guardian* and *The Times* do not have it. As a result, it is apparent that there is a clear gap between the number of science articles produced in Brazil and the United Kingdom.

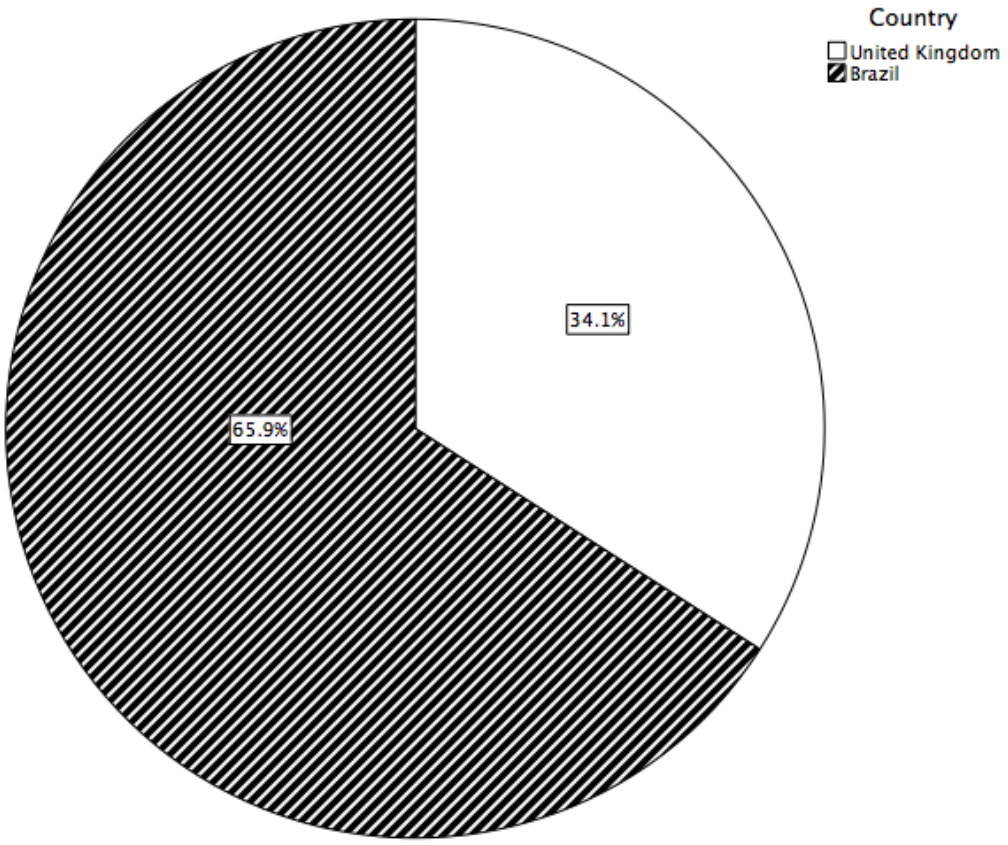


Figure 2: Percentage of Country Frequencies

As a contrast, when looking at political affiliation instead of the two countries *per se*, a more uniform indicator becomes evident. Almost 49.3 per cent of science news articles come from openly liberal newspapers, compared to 50.7 per cent from conservative ones (Figure 3).

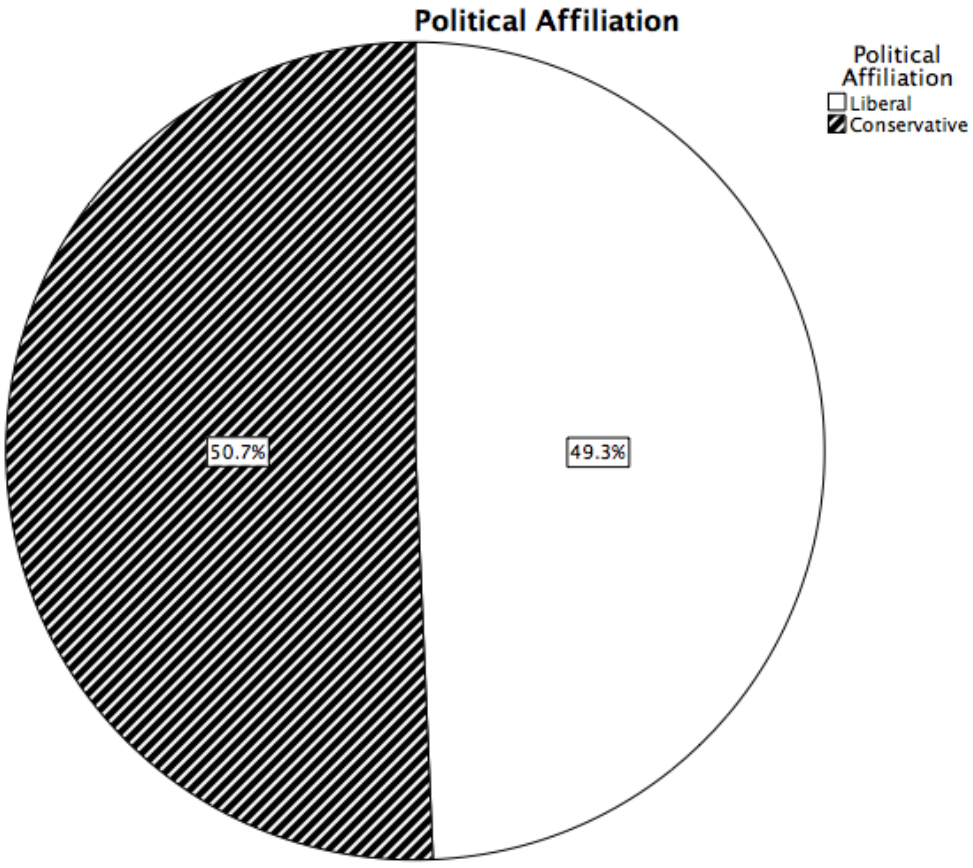


Figure 3: Percentage of Political Affiliation Frequencies

In sum, the relationship between country, writer, article emphasis, newspaper, political affiliation and sources observes positive path coefficients between all points with a strong direct path between country and newspaper. This path analysis allows for the study of the direct and indirect effect of various independent variables under the light of dependent variables. These were estimated by the linear regression analysis of the following variables: country, byline (or author), article (or type of news), newspaper, political affiliation and sources (or nature of the main source).

This is an important point. This essential finding illustrates the paths and correlations between various characteristics, systematising and statistically illustrating the ways in which statistics are used in the newsroom. As mentioned above, results suggest a positive path throughout most variables. Between country and newspaper there is a

0.87 positive path; between country and writer there is a 0.54 positive path; between writer and article a 0.64 positive path; while between newspaper and source a 0.11 positive path; and political affiliation and newspaper, 0.38 positive path. Conversely between newspaper and article a -0.11 path. Moreover, there are negatives paths between political affiliation and source, with -0.11; and between political affiliation and article, with -0.82. The positive paths infer a cause-effect relationship. In fact, the success of the path analysis is based on the consistent formulation of this cause-effect relationship between the variables. Thus, it is possible to conclude that most variables arguably correlate among each other. However, there are not correlations to political affiliation and type of news or nature of main source. Similarly, there is no correlation between the analysed newspaper and type of article. Succinctly, findings suggest that there are strong positive relationships across byline, type of news, country and newspaper. There is also a positive relationship between political affiliation and newspaper, and nature of source and type of article.

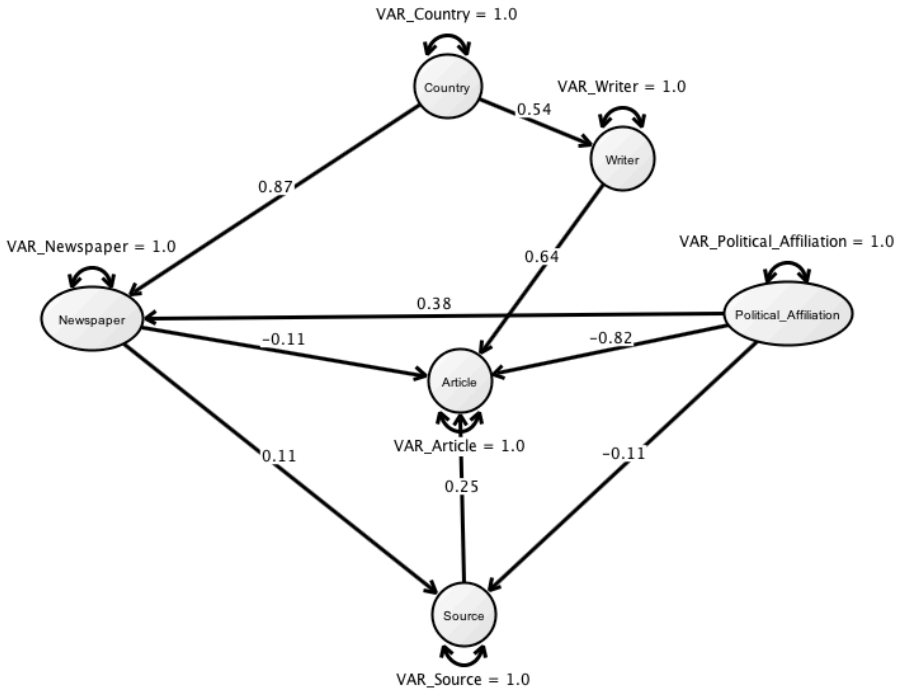


Figure 4: Simple Path Analysis via Regression

Within the context of this research, when disaggregating the variables, it becomes clear that there is an association between the analysed countries and their individual bylines. Meaning that the choice of the byline is directly related to the newspaper's country of origin. Correspondingly, the type of article correlates to the byline. Within this simple path analysis via regression, this was an expected finding as staffs habitually write hard news. On the other hand, the notion that neither newspapers nor political affiliation play a role in the choice of news type is a surprising finding. This conclusion, however, is proven by the analysis of the percentage of the type of news frequencies. Indeed, due to the high rate and preference for hard news, it is hard to imagine that it would have any substantial communication. Generally speaking, every newspaper, political affiliation or any other variable prefers hard news as it presents news within a more earnest and objective stage. The same cannot be said from the newspaper and sources. The discovery of a correlation between newspapers and their sources is very interesting. This suggests a preference between each newspaper and a certain nature of sources, which will be further developed in the interview phase on Chapter VIII.

6.2.2. Mind the Gap, Frequency of Byline

Another apparent gap is observed between the percentage of staff writer bylines and the rest. Staff writers have written the majority of news articles of science, which stands for 59 per cent. In addition, correspondents wrote 23.1 per cent of articles; freelancers and stringers were responsible for another 7 per cent; newswires just over one per cent, or exact 1.6 per cent, and press releases a mere 0.3 per cent. Other bylines were responsible for another 9.1 per cent. This reflects the nature of statistics

and their role in the construction of narratives and shaping of discourses of science in the newsroom.

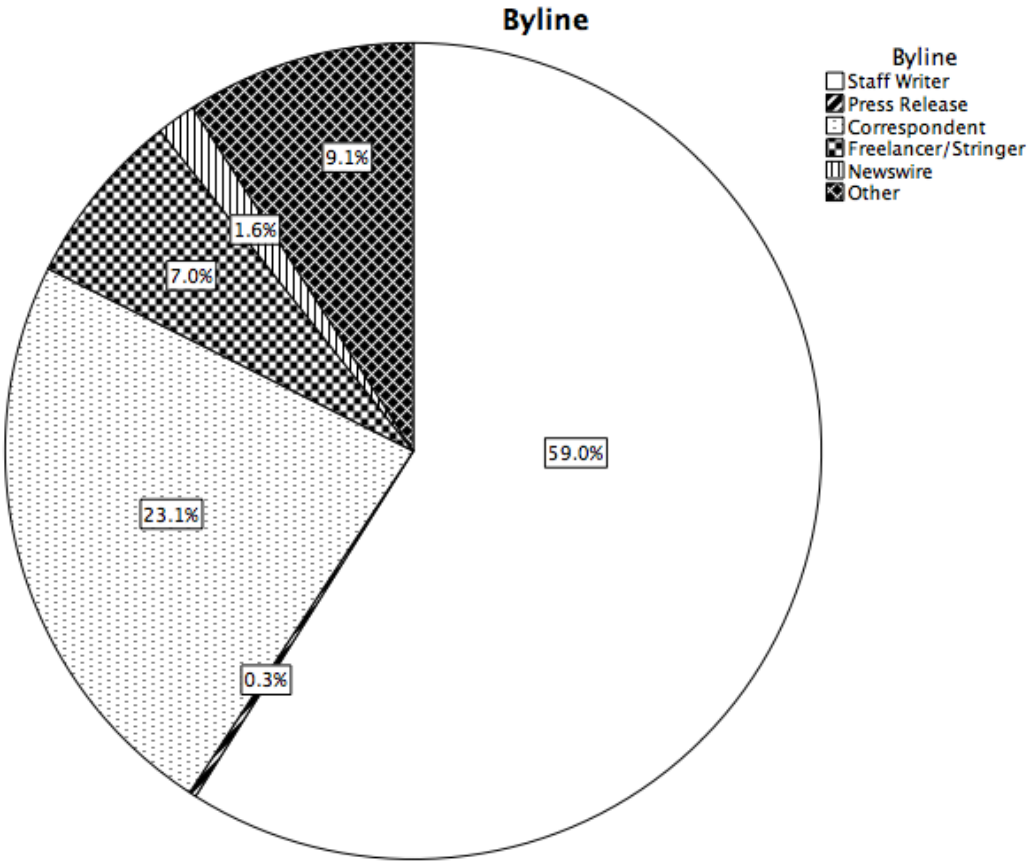


Figure 5: Percentage of Byline Frequencies

Interpreting the analysis of byline by country shows an interesting picture. According to the data analysis, *others* wrote just under 100 articles. In the UK it accounts for 43 articles –or just over 5.14 per cent of articles written by *others*. That number is 56 in Brazil. Within known writers, the UK leads the board with 244 articles written staff writers and 69 by correspondent. Comparatively, staff wrote 398 of news articles and correspondents 183 in Brazil. That leaves known bylines in the country as Newswire with 16 news articles, Freelancers and Stringers with 63, and Press Releases with only 2. In the United Kingdom, these numbers represents 1 news article (Newswire), 13(Freelancers/Stringers) and 1 (Press Release) respectively. Altogether, this shows a

clear distinction between how science news is handled in the UK and Brazilian newsroom. Moreover, how distinct Brazil and the UK are regarding the configuration of their respective newsrooms.

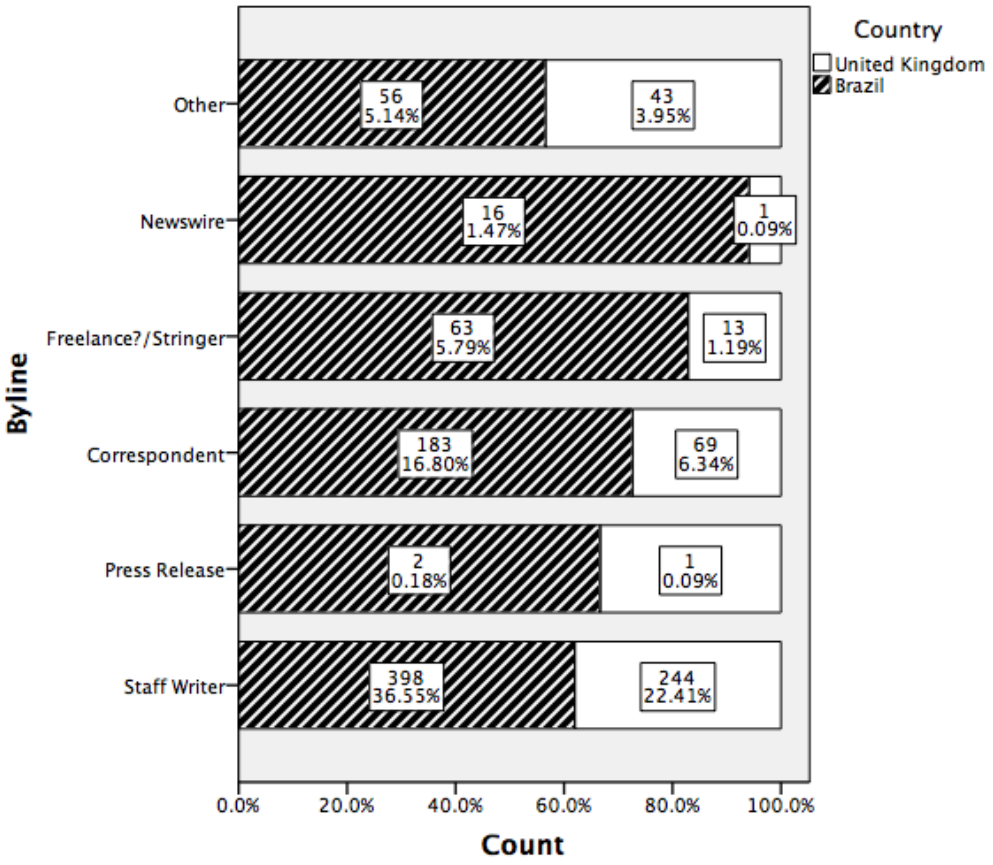


Figure 6: Percentage Byline by Country

In general terms, this is a key result of this analysis and emphasises the significance of statistics in objectively representing and reasoning news of science. It demonstrates the importance of statistical information in the articulation of arguments in objective terms. It also deemed notable that this may suggest a preference (and even training) in the newsroom towards the uses of statistics in science news. Ultimately, these findings support Bucchi and Mazzolini's (2003) conclusion in which the majority of scientific articles are written by journalists and commentators. It also corresponds to the evidence presented by DiBella, Ferri and Padderud (1991), Dunwoody & Scott

(1982), Jacobi and Schiele (1993), and Handsen (1994), which argues that science news is predominantly written by non-specialists and scientifically illiterate journalists. In this sense, it is important to remember that science, as a generic term, does not hold a unanimous interpretation. This follows Kuhn's (1962) argument that scientific paradigms repeat themselves recurrently throughout history and as a consequence always create new ways of thinking.

6.2.3. Shaping the News

In the same way, the expectation was that science news statistics would mostly frequently be reported as hard news. This hypothesis was confirmed by the quantitative analysis of the general data (Figure 6), which found that almost 73 per cent of news containing science statistics in the sample was presented to the audience in the form of hard news. Traditionally, hard news relates to news of widespread importance. Therefore, this research defines it as articles covering news of recent events considered to be o general significance. Out of the remaining 27 per cent, 10.1 per cent were reportages; 8.4 were feature articles; 5 per cent were opinion columns, followed by 2.5 per cent of editorials and 1.3 promotional. Similar to the predominance of staff writers, the prevailing use of hard news as a means to communicate scientific statistics in the news makes apparent the ways in which science is portrayed in the news. As statistics play a crucial role in conceiving an objective ground for argumentation, as well as them being a powerful rhetorical tool in the process of rational decision-making, science journalists evidently use them as a means of representing accurate information.

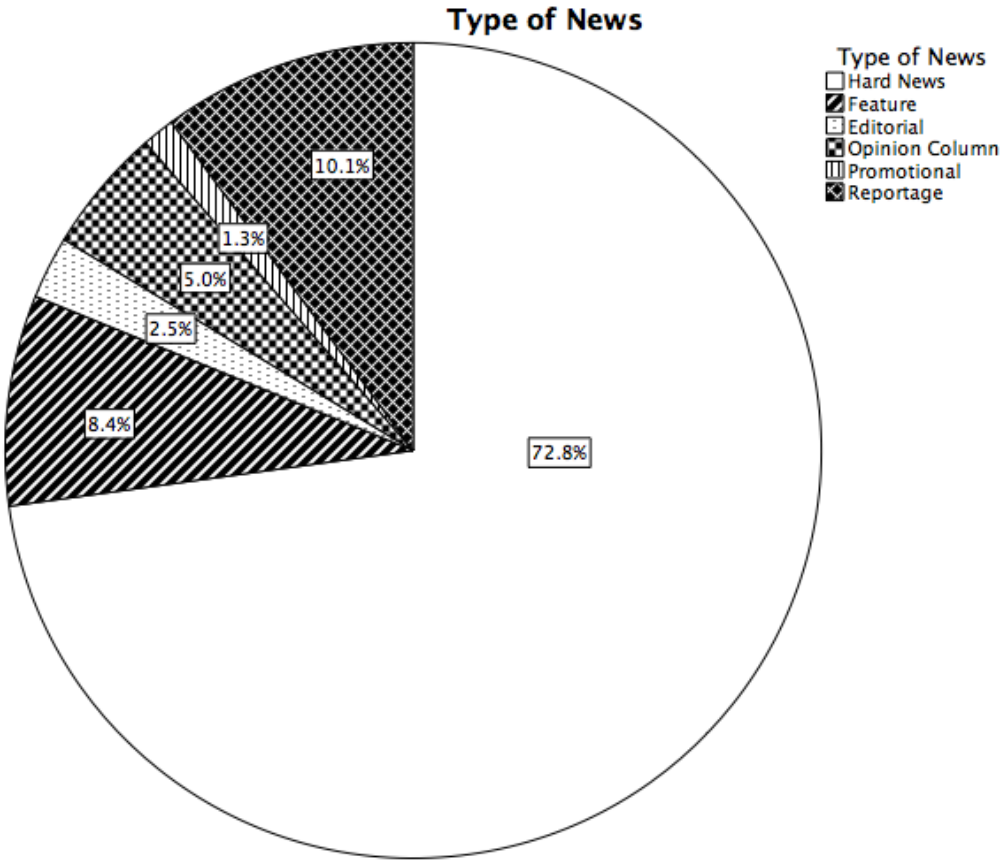


Figure 7: Percentage of Type of News Frequencies

This is a central finding. The conclusion that news of science is predominately presented as hard news says a lot about how statistics are used to articulate narrative and construct discourses of science in the newsroom. It evidences its influence in the construction of objective discourses and legitimate narratives. The dominance of hard news substantiates Stigler (1986), Desrosieres (1998), Battersby (2010) and Kuhn's (1962) inkling that there is a strong relationship between objectivity and science. Science is understood as objective knowledge and therefore a means of achieving "journalistic truth" (Battersby, 2010). As the data suggests, statistical information is mostly used in hard news stories on science because of this unique quality of being, almost unquestionably, statically significant. These statistical statements are considered clear, succinct and to the point, and thus are a major source of reliable information. Conversely, I argue these needs to be taken in small and prudent doses.

The reality that most news stories of science are hard news says something about this approach. If most science news are written in the form of hard news, then it can be said that journalist are inclined to be more objective and unbiased. Therefore, one would expect in such cases to see more statistical information. Interestingly, findings suggest a different picture: across types of news, hard news tends to be the most balanced user of statistical information. As indicated in Figure 8, the percentage of number of statistics used in news articles and hard news ranges from 24.04 per cent to 26.84 per cent.

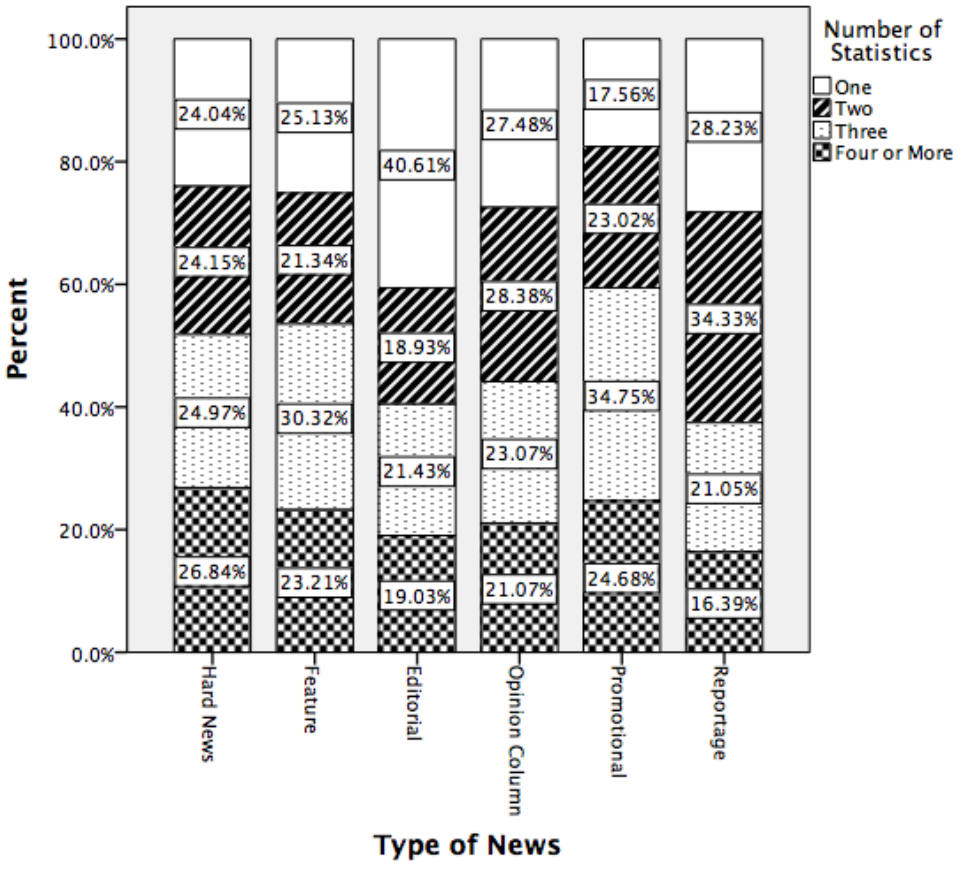


Figure 8: Percentages of Type of News by Number of Statistics Frequencies

This is a surprising result considering the role of statistics in the construction of objective information. Be that as it may, this finding demonstrates that due to it being

presented as hard news, it must portray a more balanced number of statistical information. In that sense, statistics must also be better presented throughout. That because, due to its objectivity, statistical data can easily be manipulated, be affected by serious handling problems, omission of important data, and, of course, concealed interest from the writer and/or editor (Huff, 1954). The latter is most obvious when it comes to exaggerating some nuances of the statistical data to support the newspaper's opinion or point of view. Similarly, especially with science news, there is another element of interest: the scientists themselves. According to Paulos (1995), some scientists see newspapers and their articles only as a means to publicise their research, as "simply a professional journal with a very large circulation or some sort of public relations office for their laboratory or university" (1995, p. 130). That is what most commonly happens in the news media, which when in need to sell more items, exaggerate the suggested statistical frames or do not make them known at all –as suggested by the data.

Still along the lines of numbers of sources quoted, the findings show an interesting pattern where most articles quote one, totalling 30.4 per cent –or no sources, with 24 per cent. These results are followed by 20.8 per cent for two sources quoted, 14 per cent for three, and 10.7 per cent for four or more sources (Figure 9). This is a considerable balanced set of data. Perhaps one of the most balanced throughout this research. Again, this matches the outcome presented above. Together, these findings suggest a rather even presentation of data. The study reports a uniform use of statistics, confirming the hypothesis that statistics are heavily used as a means to make science news appear objective or match conventions of journalistic objectivity. Correspondingly, it also confirms that statistics is regularly used as a tool to legitimate science news and science information when shaping discourses of science

in the newsroom.

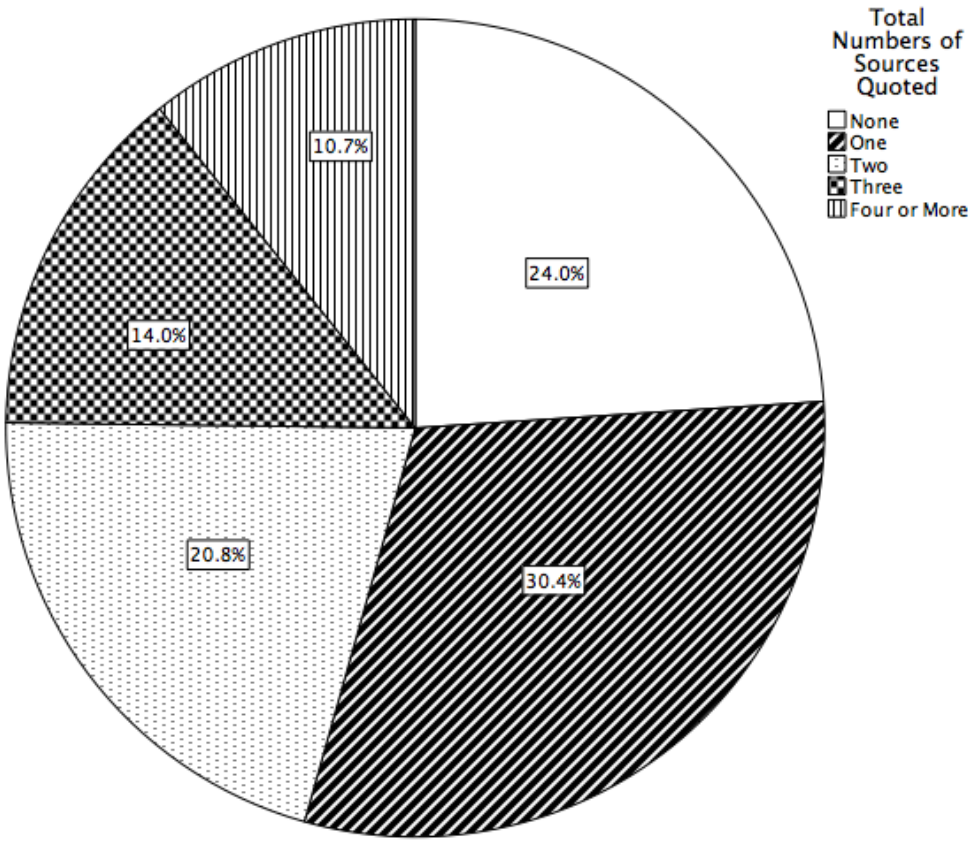


Figure 9: Percentage of Total Number of Sources Quoted and Frequencies

This result is fundamental to this research. This finding suggests an even use of statistics in the presentation of science knowledge in the news. Either due to editorial frameworks, training or available space, this result substantiates the literature suggesting that objectivity is essential to the believability of journalism (Dahlgren & Sparks, 1991; 1992; Koch, 1990; Kovach & Rosenstiel, 2001; Mindich, 1998). The balanced use of statistics in the news corroborates to the importance of their proper presentation in science article. Furthermore, it exemplifies Amaral's (1996) suggestion that the audience's response to the manipulation of statistics compelled the newsroom to change its training and start off using objectivity as a means to show news as an balanced source of information (Amaral, 1996, p. 26).

When looking at each newspaper individually, this patter becomes even more noteworthy. Arguably, in terms of percentage, the division is considerably more equal. Most frequencies fall within the spectrum 10 to 20 per cent. The one inconsistency concerns *The Guardian*, which 32.4 per cent of times uses four or more sources. When analysing the number of articles, this equal division between countries is still visible; however, the preference for quoting one or none sources becomes more obvious. According to figure 10, 186 articles in Brazil used no sources. This follows by 232 articles in Brazil used one source, 144 two, 94 three and 62 four or more. In the United Kingdom that number represents 75 articles using no sources, 99 quoting one, and 197 quoting two or more sources. This is an interesting result as it also discerns from the preference of quoting fewer sources per news articles on science as seen in the other newspapers. Indeed this balanced outcome concerning the uses of statistics in the newsroom. Further substantiates the understanding of its primary importance in journalism studies. Actually, it proves statistics role as one of the most prominent legitimising tools in the construction of news discourses, and social reality. All together, this is a noteworthy result. It shows a singular, yet interesting discrepancy across the analyses media outlets. In terms of uses of statistics in science news, it also suggests no tangible relationship between statistical information and the number of sources quoted.

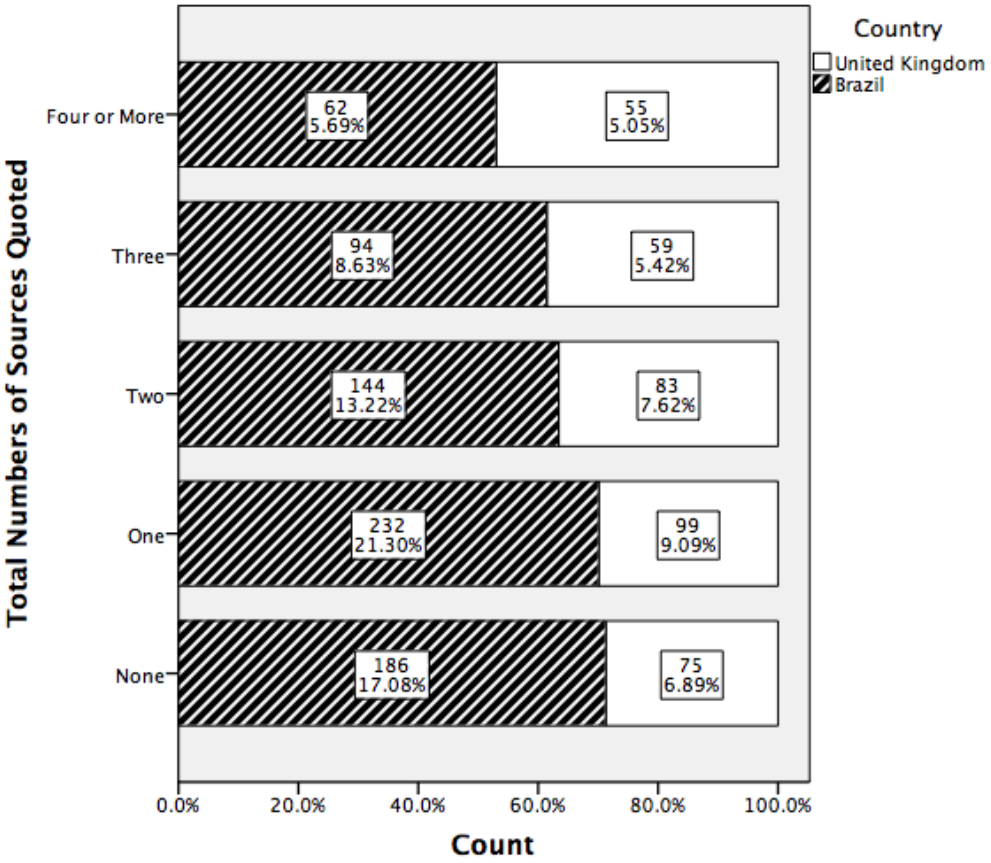


Figure 10: Percentage of Total Number of Sources Quoted by Newspaper Frequencies

Opposing to this sense of balance, the percentage of Total Number of Sources Quoted by Byline Frequencies (Figure 11) observes a clear variance between bylines and the total number of sources quoted. For example, in spite of the general frequency figure showing a predominance of articles with single or no quotations, correspondents tend to use a considerably greater amount of sources –28.9 per cent quote two sources, 34.5 per cent quote one, and 32.7 per cent quote four or more sources within articles. In fact, when broken down, Press Releases and Newswires are the only two bylines that share the same indication as of the newspapers and tend to quote one or no sources in their news stories about science –seldom two. All the others show a relatively bigger percentage in other clusters.

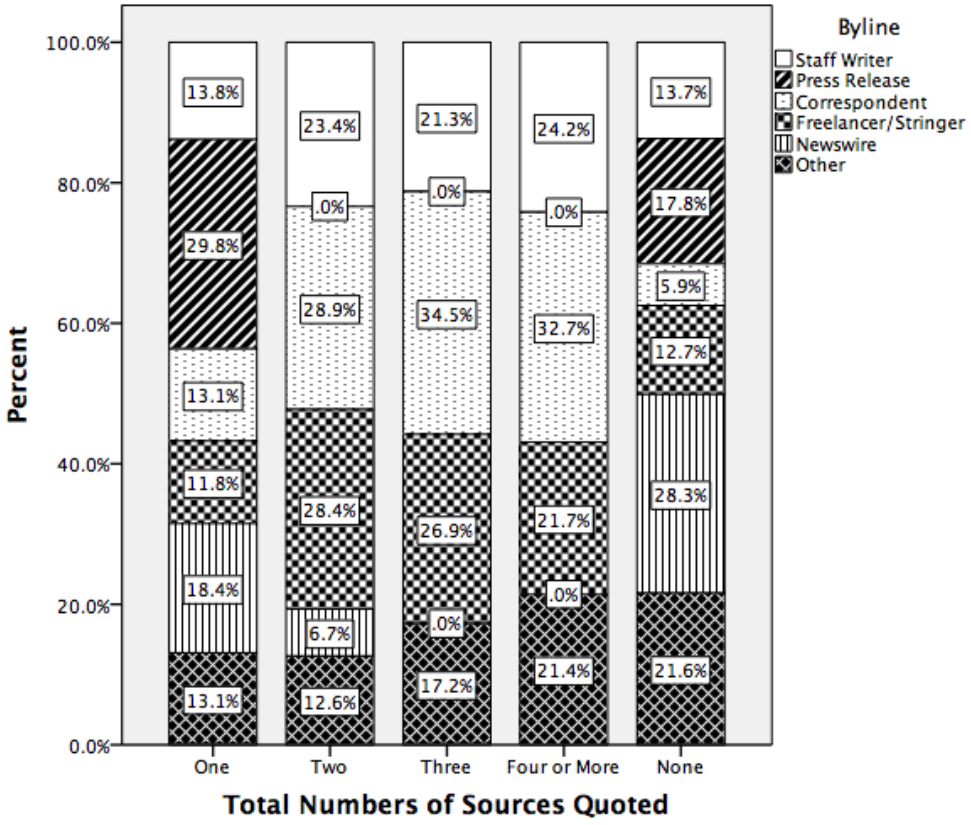


Figure 11: Percentage of Total Number of Sources Quoted by Byline Frequencies

Conversely to the suggestion above that hard news habitually presents a balanced use of statistics, in terms of bylines the result suggest a less stable use of statistics. In fact, this finding shows a less balanced use of sources and number of sources quoted. According to it, staff writers habitually use statistics in a more balanced fashion. This result allows the development of a premise, which suggest that staff journalists better use statistics due to its methodological process or training. This proposition is thoroughly scrutinised in the interview phase (Chapter VIII).

In addition to this shaping news, something similar can be seen when comparing type of news and number of sources quoted. According to the data, there is a clear correlation between the former and the journalist's choice of sources –as well as the amount sources they quotes. Distinctly, the findings show that hard news, in its vast majority, quotes sources. This finding suggest that 35.8 per cent of hard news present

two sources, followed by 34.4 per cent quoting three sources, 20.4 per cent citing one and 16.9 per cent quoting four or more sources. In fact, only less than 6 per cent of 'No Sources Quoted' data comes from Hard News. In opposition to this picture, Editorials quote almost exclusively no sources –that is, 31.5 per cent.

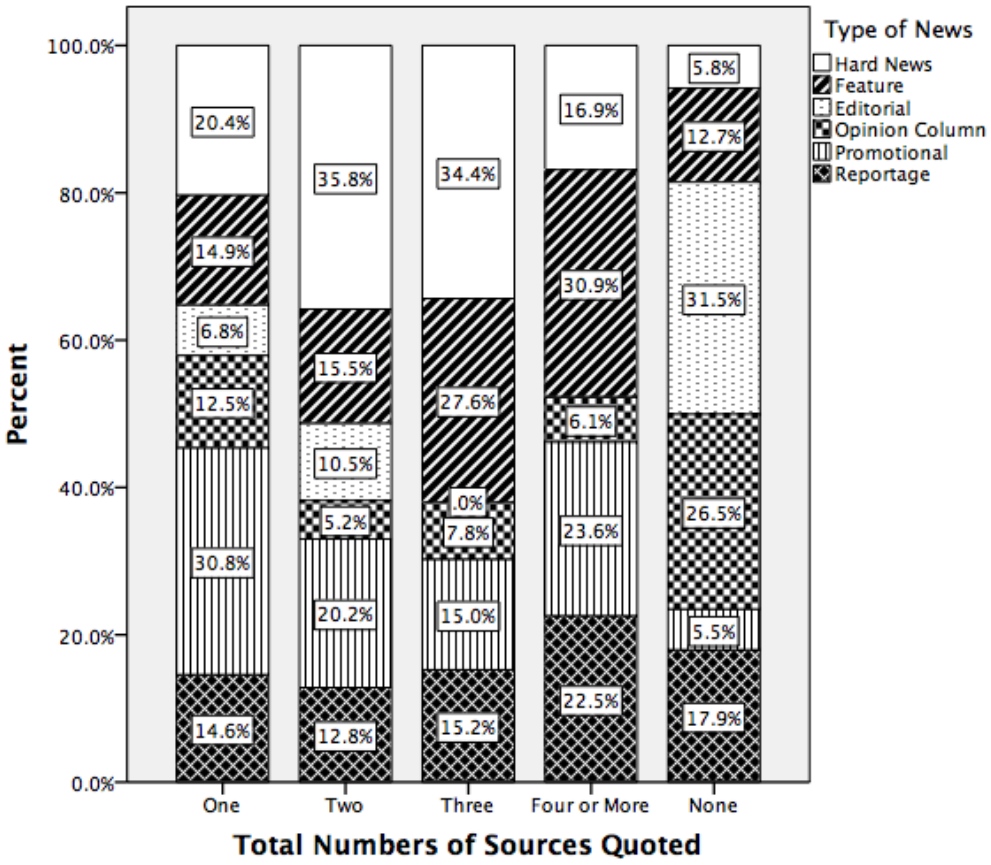


Figure 12: Percentage of Total Number of Sources Quoted by Type of News Frequencies

This is a remarkable result that shows the different construction of narrative across type of news. The clear distinction between the variables and among respective category of news and number of sources quoted, validates the habitual presentation of hard news as serious news, as substantiated by credible information. Furthermore, this finding verifies the hypothesis that statistics are used as an objective source of information. The understanding that hard news habitually use multiple sources, demonstrates the need to present it as legitimate. As this research argues, the uses of

sources, especially of statistical-based sources, in the news article legitimises the construction of news discourses.

Breaking down the number of sources quoted, 28.3 per cent of articles quote a single primary sources; followed by 14.5 per cent citing two primary sources; 8.1 per cent, three sources; 6.8 per cent; four or more sources. The preponderance, however, is of no primary sources, with 42.3 per cent of news articles. This finding shows how data is gathered within the newsroom. As this research establishes, most science journalists use academic journals to gather collect scientific news sources. The reality of this premise explains this finding (Figure 13). When using journals as main source, science journalists reinforce the premise of using primarily second hand sources.

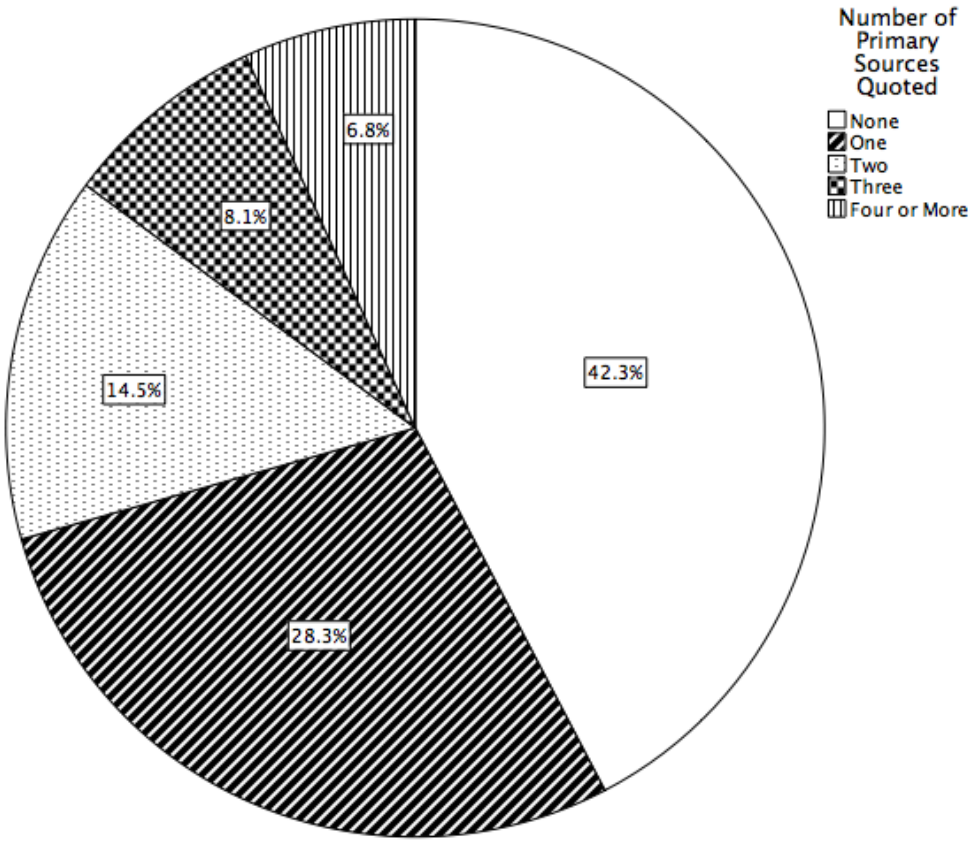


Figure 13: Percentages of Number of Primary Sources Quoted Frequencies

Similarly, in terms of secondary sources, the majority of news articles (66.9 per cent) do not quote secondary sources. Followed by 21.2 per cent quoting one secondary source; 6.8 per cent quoting two secondary sources; 3.7 per cent, three secondary sources and 1.5 per cent quoting four or more secondary sources.

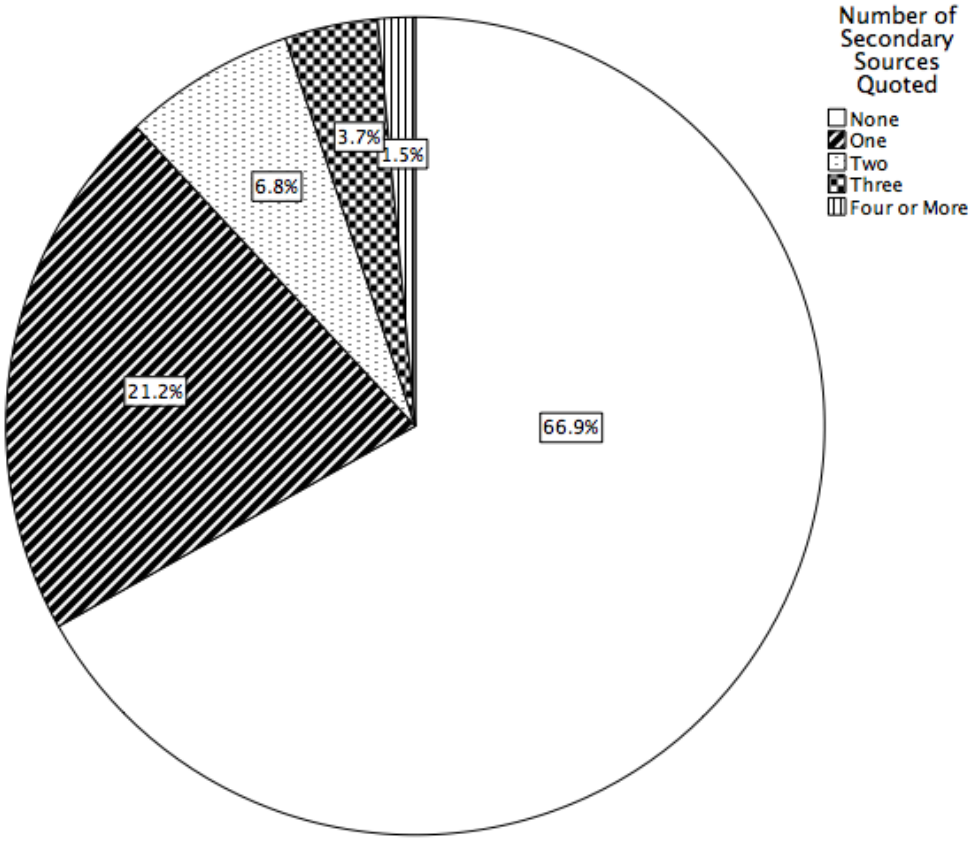


Figure 14: Percentage of Number of Secondary Sources Quoted Frequencies

Relatedly, this finding suggests science journalists prefer to not quote secondary sources. This preference indicates an absence of quotes within news of science. This relates to the notion that journalists often source their articles directly from academic journal articles and therefore do not need to quote the original source.

The most compelling evidence is conveyed through this clustered stacked bar chart.

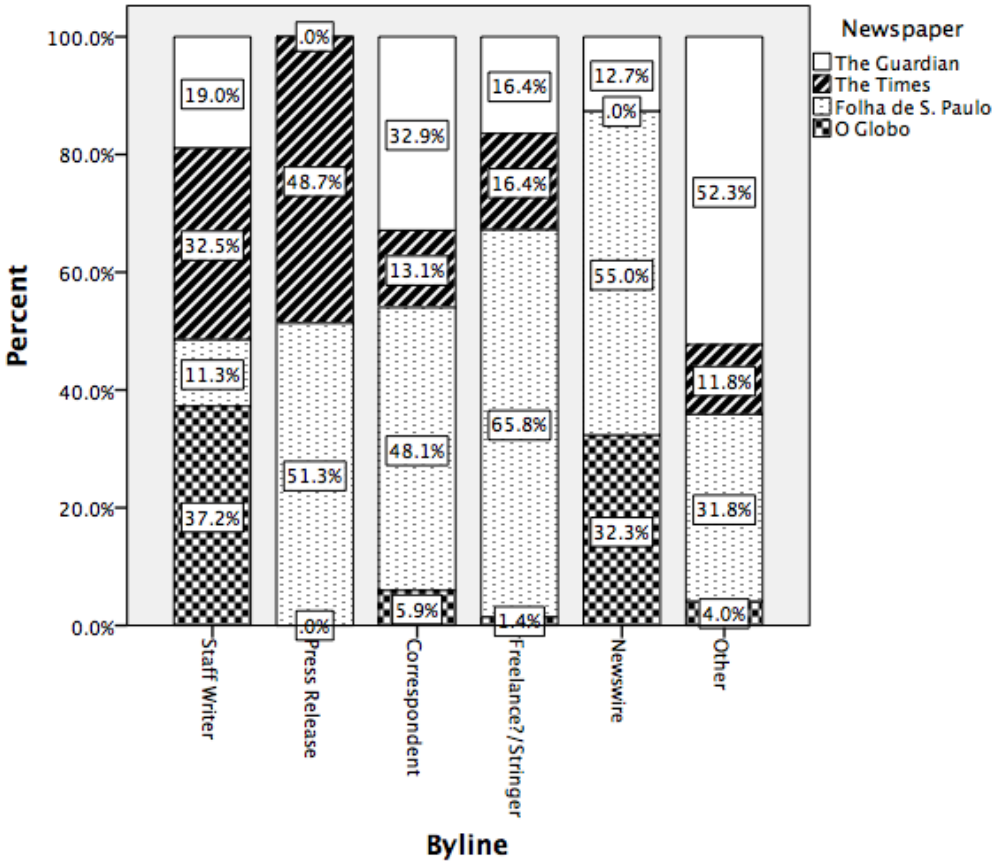


Figure 15: Percentage of Byline by Newspaper Frequencies

A stacked bar chart is fitting in order to examine whether there is a correlation between bylines and chosen newspaper, and to scrutinise whether the byline depends on the newspaper and vice-versa. The bar chart shows interesting parallels. For example, according to the presented data, *O Globo* prefers to use Staff Writers. Similarly, *The Times* habitually uses press releases. *Folha de S.* Paulo, freelances and stringers and *The Guardian 'others'*. This finding creates a very interesting image: as exposed, the source or newspaper is indeed significant. This means that newspapers are a potentially important predictor of the chosen dependent variable –that is, the byline. The relationship between byline and newspaper is thus supported.

Finalising this correspondence analysis, according to its biplot or exploratory graph correspondence map (Figure 15), one can argue that there is a strong correlation between (1) *O Globo* and the use of Staff Writers, (2) *Folha de S. Paulo* and correspondents, and (3) an existing correlation between *The Guardian* and Press Releases.

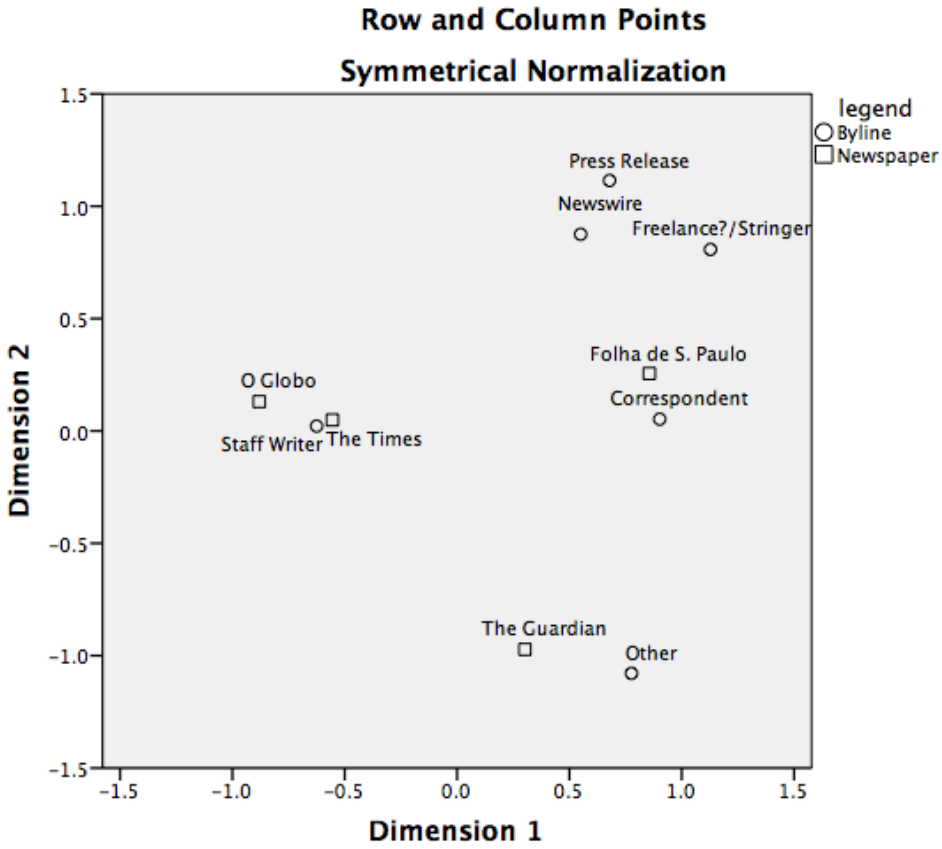


Figure 16: Biplot Correspondence Map

All in all, while it has not provided a definite answer to the question proposed, it is clear that this "byline gap" influences the ways in which both science discourses are shaped as well as how statistics are used to shape them. Furthermore, bearing in mind that byliners are those who outline and structures this discourse of science, uncovering this data is crucial to corroborating the relationship and the ways in which statistics are used to articulate news of science in the newsroom.

6.2.4 Silence of Unknowns

For my analysis of what journalists used as sources and where they took their statistics from I found that the majority of the studies' traits (that is, type, sample size and number of studies) are not widely communicated to the public. The predominance of "unknown" information was well over 70 per cent in all three cases.

Sample Size * Type of News * Single Study Crosstabulation

Count

Single Study			Type of News						
			Hard News	Feature	Editorial	Opinion Column	Promotional	Reportage	Total
Yes	Sample Size	Small	98	3	2	1	1	7	112
		Large	81	2	0	2	0	7	92
		Unknown	74	5	1	3	1	6	90
	Total		253	10	3	6	2	20	294
No	Sample Size	Small	7	3	0		0		10
		Large	9	0	1		0		10
		Unknown	18	3	0		1		22
	Total		34	6	1		1		42
Unknown	Sample Size	Small	2	0	0	0	0	0	2
		Large	0	1	0	1	0	0	2
		Unknown	504	74	23	47	11	90	749
	Total		506	75	23	48	11	90	753
Total	Sample Size	Small	107	6	2	1	1	7	124
		Large	90	3	1	3	0	7	104
		Unknown	596	82	24	50	13	96	861
	Total		793	91	27	54	14	110	1089

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.882	.897	3

Figure 17: Single Study * Type of Study * Sample Size Crosstabulation

Figure 18 shows an even more worrying picture: over 72 per cent of science news containing statistics does not clarify the type of study investigated. That is almost 500 per cent more than the first known category, which is observational with 12.8 per cent). Furthermore, it also indicates that 8.3 per cent of science news articles involved experimental studies. Followed by 6.9 per cent, which were based on survey scientific studies.

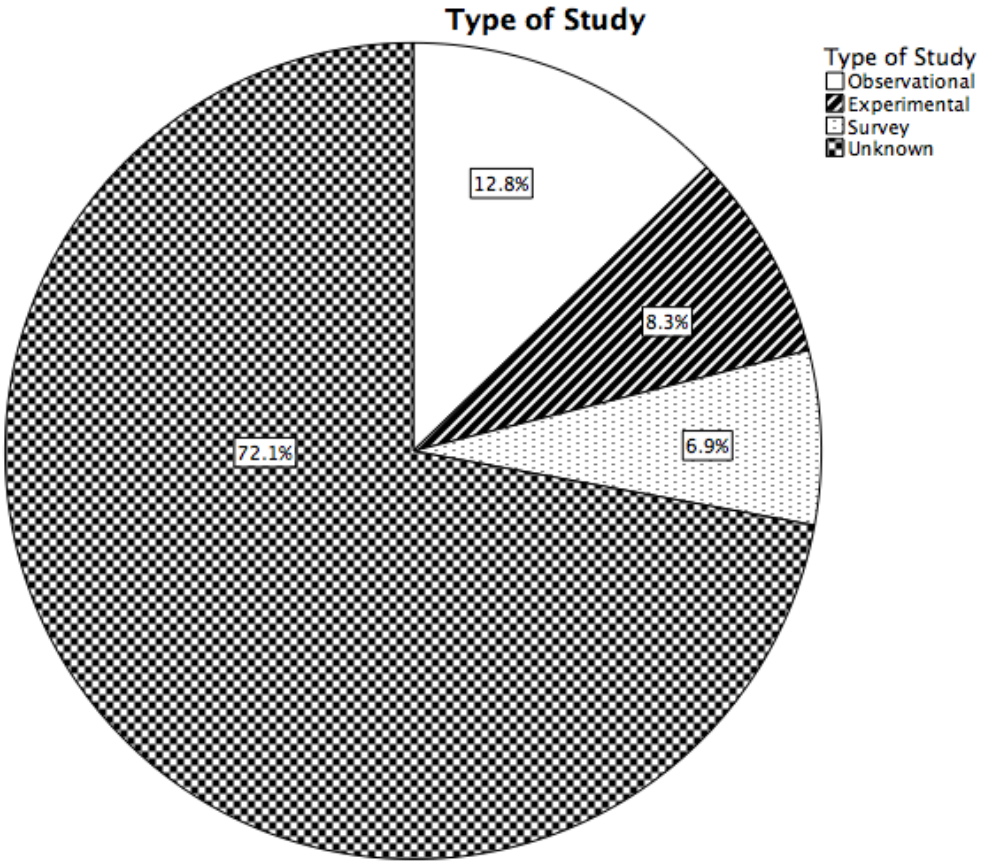


Figure 18: Percentage of Type of Study Frequencies

This is a surprising finding considering the perception of science as a repetition process. As argued before, one of the characteristics that give science and statistical information its objectivity is its repetition; the possibility to replicate its processes. Therefore, the expectation was for experimental types of study to be more frequently used. Conversely, one could argue that precisely because observational experiments are not often replicable, they are more regularly produced and thus have a bigger chance of being portrayed in the news media.

As already mentioned, most news article on science do not present the type of study analysed. The number of articles that does not present background information on the type of study conducted corresponds to 72.1 per cent of news articles. Again, this is a surprising finding considering the nature of statistical information and its uses in the

news. However, it does substantiate this research's central hypothesis that statistical information is often poorly represented in the news and that science journalists do not have the time or space to check the sources.

In the same way, the majority of science news articles did not specify the number of studies they had drawn their conclusions from. As seen in Figure 19, 69.1 per cent of news articles do not state whether or not it was a single study. This number follows the finding that 27 per cent use single studies and just under 4 per cent –3.9 per cent– use multiple studies as sources for their articles.

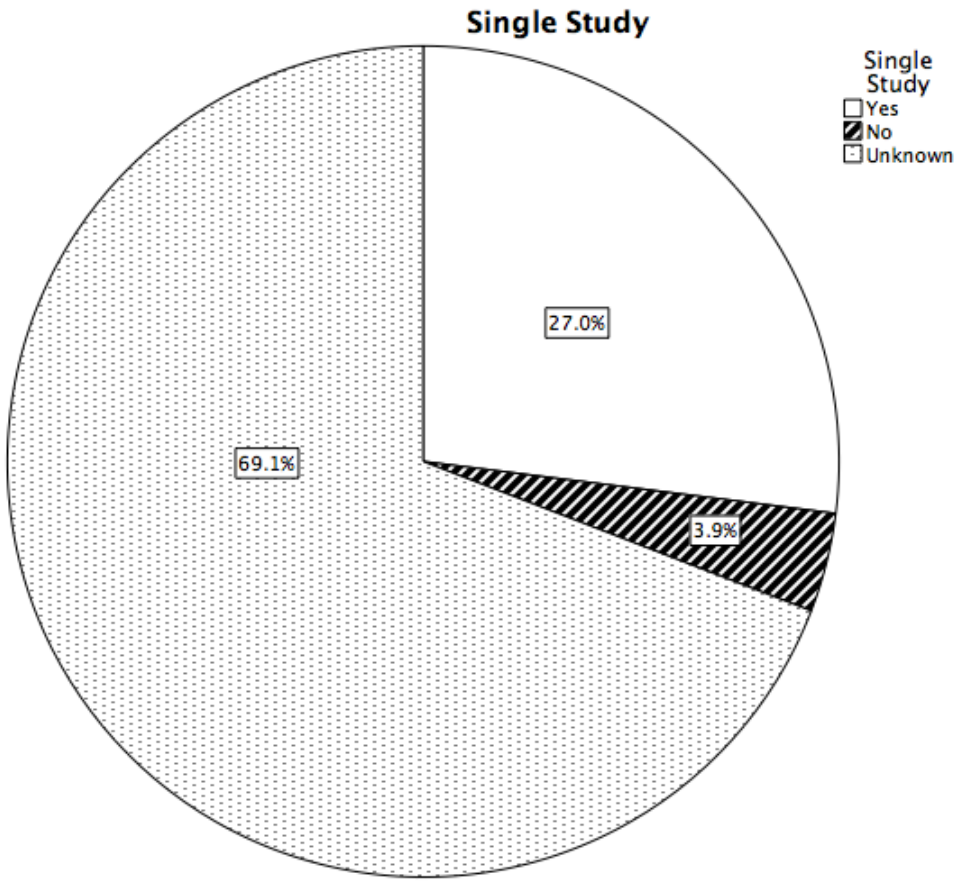


Figure 19: Percentage of Single Study Frequencies

This finding further validates the argument that statistics are often inadequately represented in news of science and that journalists lack the time or space to check the

sources. Moreover, it exposes a limitation on the exploration of the subject. The presentation of one or no study shows the singularity in terms of sources and findings. Again, this finding will be further analysed during the in-depth interviews in Chapter VIII.

Figures 20 show the frequencies of the sample sizes provided to the public, and for this study present a more disturbing picture. The relevance of statistics is heavily, if not entirely, based on the sample size (DePaulo, 2000; Oppong, 2013). If the sample size is small, the statistical data is most likely unrepresentative and it can easily be contested. When 79.1 per cent of articles do not inform us of the number of individuals on which the data was based and another 11.4 per cent are based on a small sample size (making it over 90 per cent), something is very wrong (and extremely worrying) in relation to the ways in which statistical data are used to articulate and shape narratives of science news. This is a surprising finding as the importance of sample size was a recurrent and unison there among interviewees. To them, sample sizes are important when choosing which statistics to use in the article. Nonetheless, according to this finding, they are not published for the public.

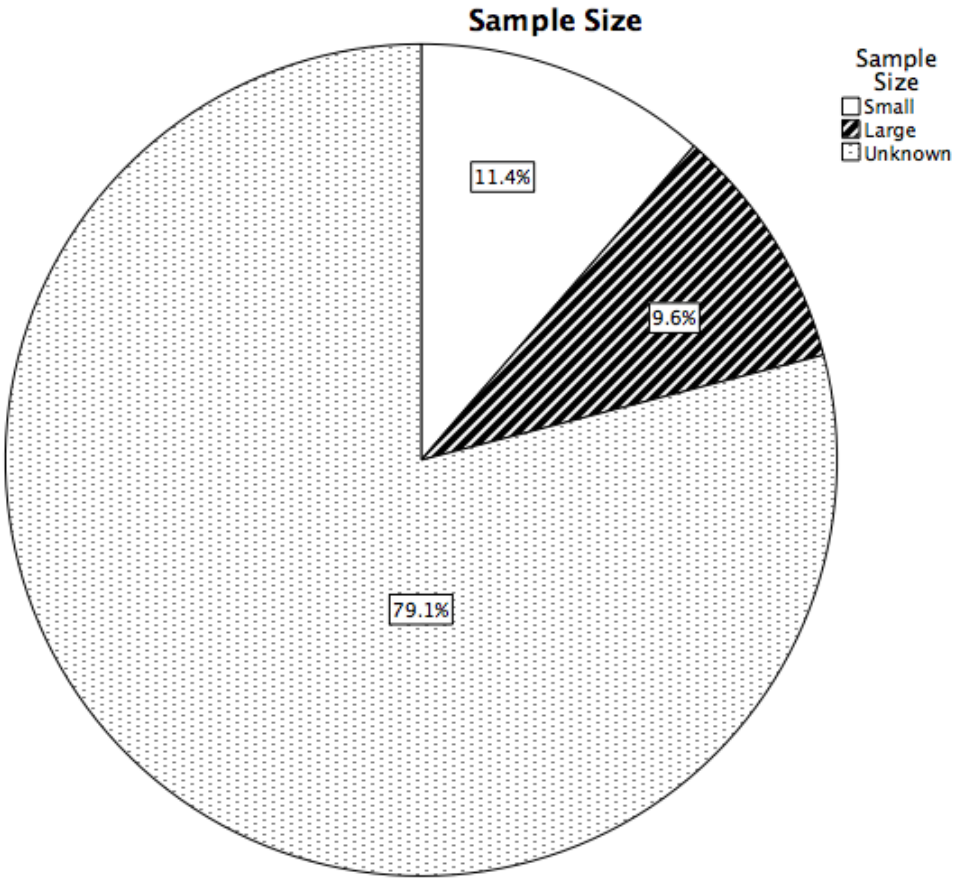


Figure 20: Percentage of Sample Size Frequencies

Regarding the presentation of statistics, this 'silence of the unknown' element plays a similar part. This finding substantiates the existing literature on the communication of uncertainty (Friedman, Dunwoody, & Rogers, 1999; Nowotny, Scott, & Gibbons, 2001). It goes beyond their analysis that contemporary society lives in an age of uncertainty by presenting results that suggests society does not have particular knowledge about science precisely because journalists omit certain information. Over 50 per cent – 56.15 per cent – of those who presented the statistics were either 'unknown' (33.27 per cent) or 'others' (22.88 per cent) – which includes the journalist themselves, etc., which means that less than 44 per cent of presenters are known. That is a very important and worrying discovery when scrutinizing and validating any statistical data. Allowing for only a minority of the data to be known is problematic

on a number of levels despite statistical data being considered a news source on its own, as pointed out by Desrosieres (1998) who says that statistics had to acquire legitimacy in the eyes of the readers and therefore establish itself as a reliable scientific discipline.

6.2.5 Sourcing Statistics

Fewer than 40 per cent of articles only cited one statistic. Nonetheless, the data shows a contrasting situation where journalists would either use one single statistic throughout the article or overwhelm it with numbers. The majority of news articles that is 37.6 per cent use only one statistics. Followed by 26.7 per cent that use four or more statistics. This analysis suggests a lack of proper journalistic edification when handling statistics. Journalists seem to understand the importance of statistics but not how to properly apply them. If the use of statistics shows the logic and power of statistical argumentation, its overuse shows a deficiency in journalistic education and newsroom instruction.

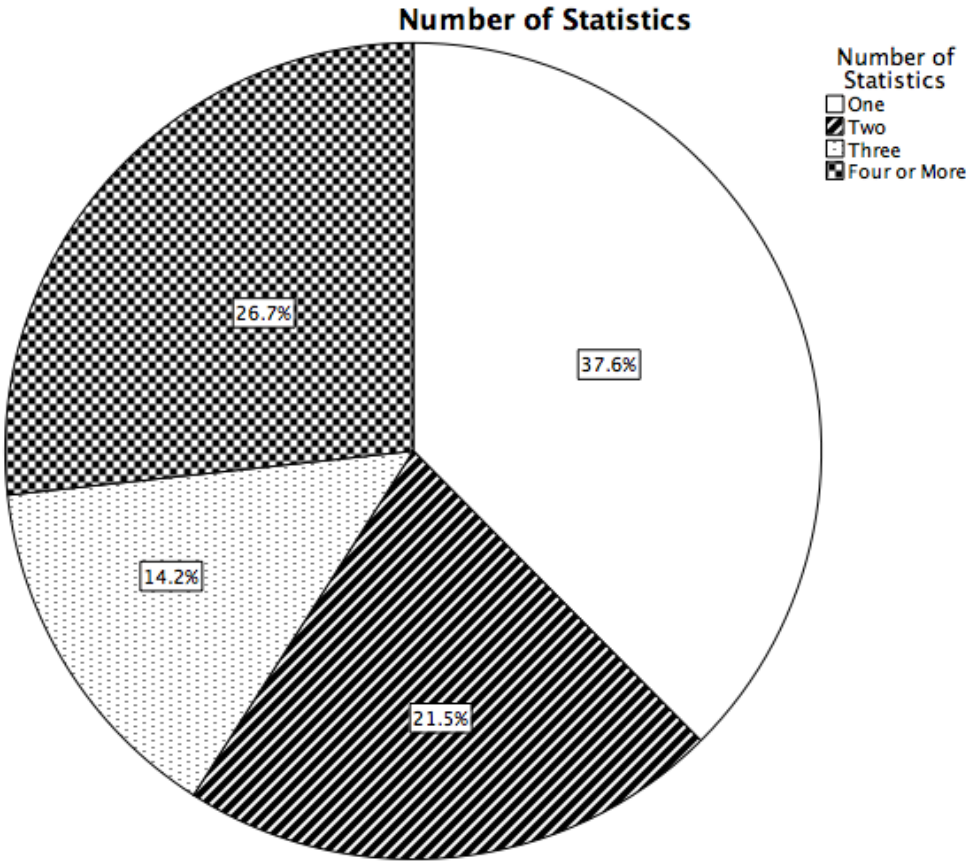


Figure 21: Percentage of Number of Statistics Frequencies

This condition in which the journalist either presents one statistic or floods the audience with numerous statistics represents how underprepared they tend to be to use statistics. When it is four or more, it is normally a lot more than four. They like to flood the reader with too much information as a means of showing and faking knowledge of information given. On the other hand, when they give only one piece of statistical data it is either due to a lack of time or to reduce extensive research on one number. In and of itself, this is quite problematic. If you think that most research consists of about 10,000 words and raises at least 3 or 4 crucial points (if not more), presenting one single piece of data to summarise all of these is a complicated if not impossible task. Indeed, that was a point touch on by the interviews science journalists.

6.2.6 Emphatic Science

Within the areas of emphasis on the collected data, another interesting tendency was observed. There is a balanced distribution between medicine, environment, biology and 'other'. Figure 22 summarises the frequency of the main emphasis in headlines of science news, for statistical use. The relationship presented supports arguments by Bucchi and Mazzolini (2003) that the disciplines of biology and medicine account for more than half of scientific articles. For science news, overall 63.77 per cent of news emphasizes biological, medical and environmental news. Of those, 41.91 per cent of news is on biomedical issues and 21.86 per cent contained environment statistics. The simplest explanation for why these three disciplines are preponderant has to do with news quality. All have proximity, impact and consequence, and most importantly, human interest. Environmental issues, in particular climate change news, have taken the spotlight over the past few decades with different groups using numbers as main sources to pursue their own agendas (Fioramonti, 2014, p. 68). Indeed, climate change is currently one of the most significant global phenomena (Schmidt, Ivanova, & Schafer, 2013). Considered of vital importance for humanity, climate change has a central role and is of both public and political concern (Hansen & Cox, 2015).

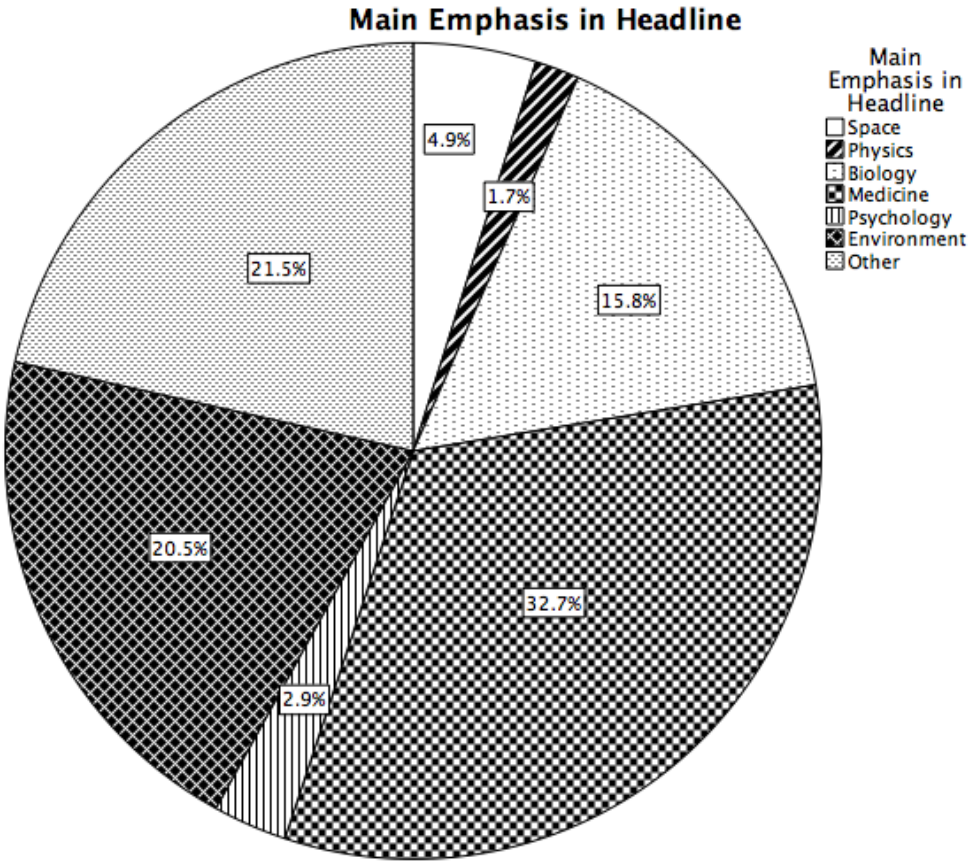


Figure 22: Percentage of Main Emphasis of the Headline Frequencies

Trigueiro (2005) would argue that, generally speaking, media present environmental issues as encompassing only interactions between fauna and flora. Furthermore, to him there is a stumbling block between the interactions of audiences. On the one hand, there are the ecologists and specialists in the field distancing themselves from the public, and on the other, the media. He develops even further this idea, acknowledging that the media must be more critical than just denouncing the current environmental situation (Trigueiro, 2003). It must also point to more intelligent and sustainable solutions to this inherent ecological destructive development. According to him, there is an urgent need for a more aggressive approach in the media towards environmental issues (Trigueiro, 2003). This becomes evident in looking at the relationship between the main emphases in headlines and the use of statistics in the

article:

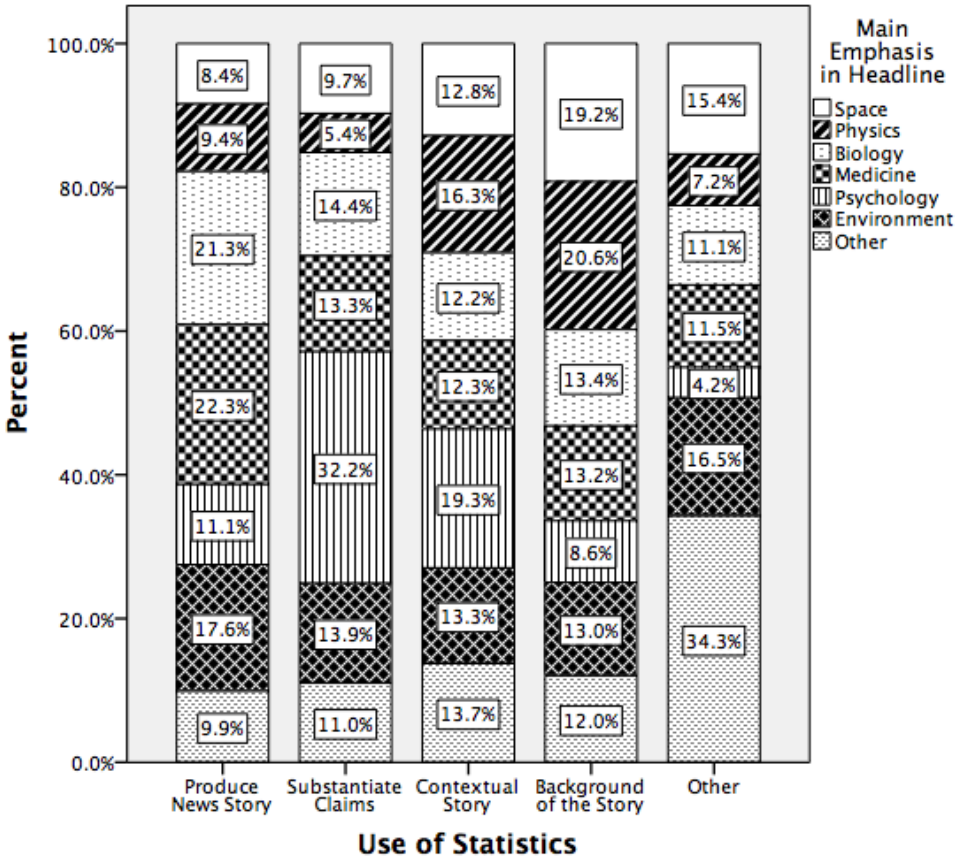


Figure 23: Percentage of Uses of Statistics by Main Emphasis in the Headline Frequencies

As can be seen, most environmental articles use statistics as a means to illustrate the background of the story thus never really using it to produce or be critical of the story itself. When examining the nature of main sources, as expected, university sourced data takes up a big portion. That is because news of science often tends to be taken from academic articles and scientific journals.

In addition, when correlating the types of news and the main emphases in headlines, the human interest in environmental news becomes apparent. Within the opinion columns, 52 articles – or 30.38 per cent – were environment-related news – compared to just over 19 per cent for hard news, 11.36 per cent for features, 20.89 per cent for editorials and almost 18 per cent for reportages.

As can be seen in Figure 23, 47 articles on science with space being an emphasis in headline are hard news, followed by two feature articles, one editorial, two opinion columns, and one reportage. There were no promotional articles within this subject. Among all articles on physics, 11 stories were hard news stories; two feature articles; two editorials; one promotional; and three reportages. There were no opinion columns within this emphasis. In terms of biological articles, 137 articles were hard news, followed by 17 features, five editorials, five opinion columns, one promotional, and seven reportages. Among articles concerning the medical sciences, 289 articles were hard news, 15 features, one editorial, eight opinion columns, four promotional, and 43 reportages. Psychological articles were again mostly constructed as hard news. Out of those, 27 were hard news, three were features, one was opinion column, and one was reportage. There were no editorials or promotional articles on psychological news. Environment articles comprised of 167 hard news stories, 16 feature articles, six editorials, 18 opinion columns, and 16 reportages. There were no promotional stories within this emphasis. Lastly, within the category of 'other', 119 articles were hard news, followed by 36 feature articles, 12 editorials, 20 opinion columns, eight promotional, and 39 reportages.

Type of News * Main Emphasis in Headline Crosstabulation

Count

		Main Emphasis in Headline							Total
		Space	Physics	Biology	Medicine	Psychology	Environment	Other	
Type of News	Hard News	47	11	137	285	27	167	119	793
	Feature	2	2	17	15	3	16	36	91
	Editorial	1	2	5	1	0	6	12	27
	Opinion Column	2	0	5	8	1	18	20	54
	Promotional	0	1	1	4	0	0	8	14
	Reportage	1	3	7	43	1	16	39	110
Total		53	19	172	356	32	223	234	1089

Figure 24: Type of News * Main Emphasis in Headline Crosstabulation

This finding yields an interesting conclusion that most reportage is not based on a single emphasis. While most other areas focus on hard news and have little reportage

coverage (sometimes even zero) on the subject, under '*other'* there are over 110 reportage articles. Other can mean a range of subjects: from politically inclined science news to less known areas.

6.2.7 Presentation

The results from the sources that present the statistics suggest that most sources are either unknown or composed of sources different from the presented ones (that is, Office for National Statistics, Government/Official, Think Tank/Non Governmental Organizations, and University). Others include 28.3 per cent of news articles. Unknown sources encompass 20.2 per cent of articles. Of known sources, however, there is a clear prevalence of university PR offices, and think tanks and NGOs with 22.5 per cent and 19.6 per cent, respectively. Government and Official statistics concerns 8.6 per cent and the Office for National Statistics, 0.8 per cent.

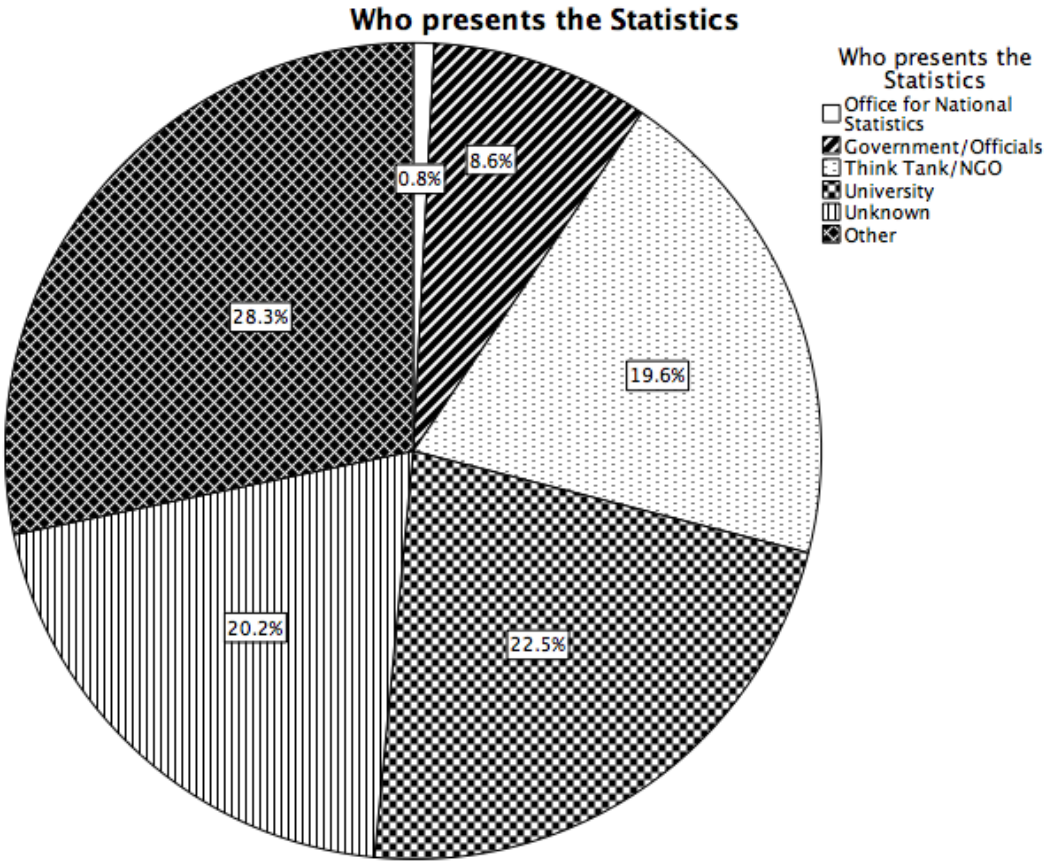


Figure 25: Percentage of Who Presents the Statistics Frequencies

The findings from this study oppose most arguments on the power of mathematical language with respect to stakeholders. This situation changes ever so slightly when looking at the nature of the main source. Almost 23 per cent of sources that presents statistics are academic or university-related.

In terms of nature of main source, just over 30 per cent of sources are university related. Almost 19 per cent are think tanks and Non Governmental Organisations. Followed by 10.7 per cent of Governmental sources and 0.3 per cent of Office for National Statistics.

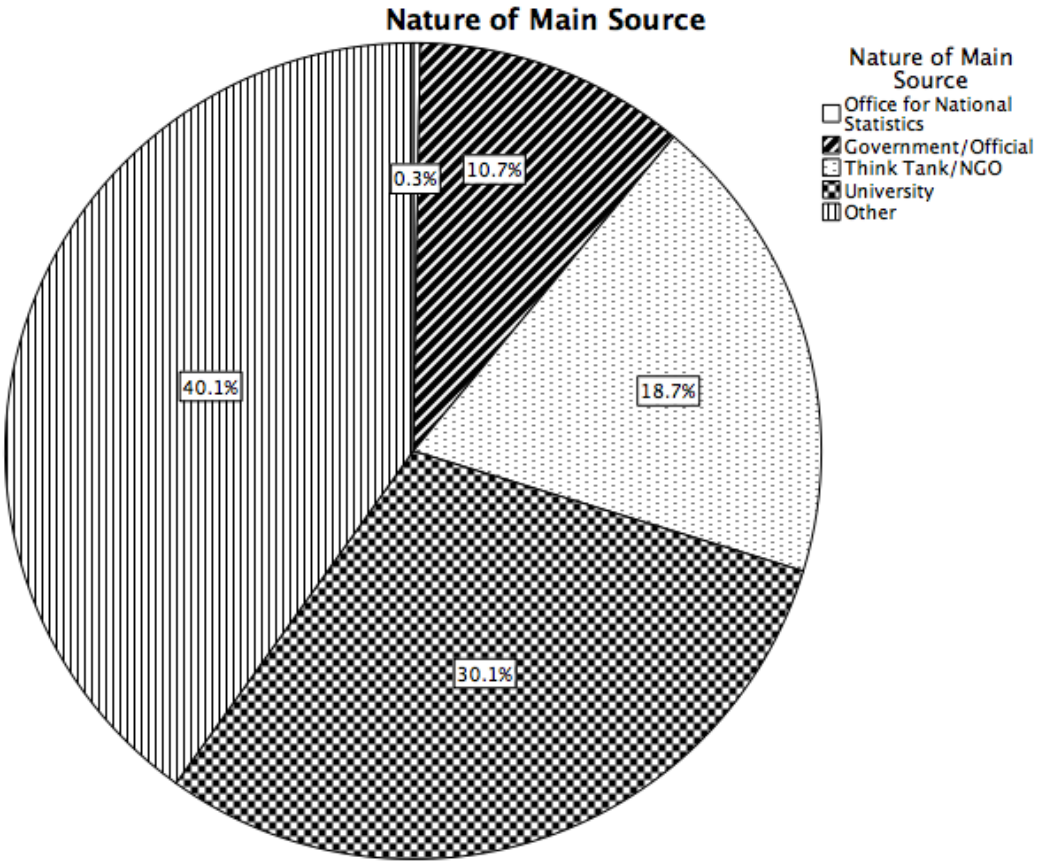


Figure 26: Percentage of Nature of Main Source Frequencies

In contemporary society the ability to understand numbers and interpret quantitative information is as imperative as the ability to speak, write and read (Jablonka, 2002). According to Jablonka (2002), mathematical language varies with respect to the values and rationale of the stakeholders who promote it. This result validates the understanding that, despite not having a direct involvement from the scientific community as suggested by Bucchi and Mazzolini (2003), there is an indirect involvement of experts in the sourcing of scientific information for the non-specialist press. Within this context, 33.8 per cent use statistics as background to the story. Another 21.2 per cent to contextualise the story, followed by 19.4 per cent to produce the news story, and 12.9 to substantiate claims.

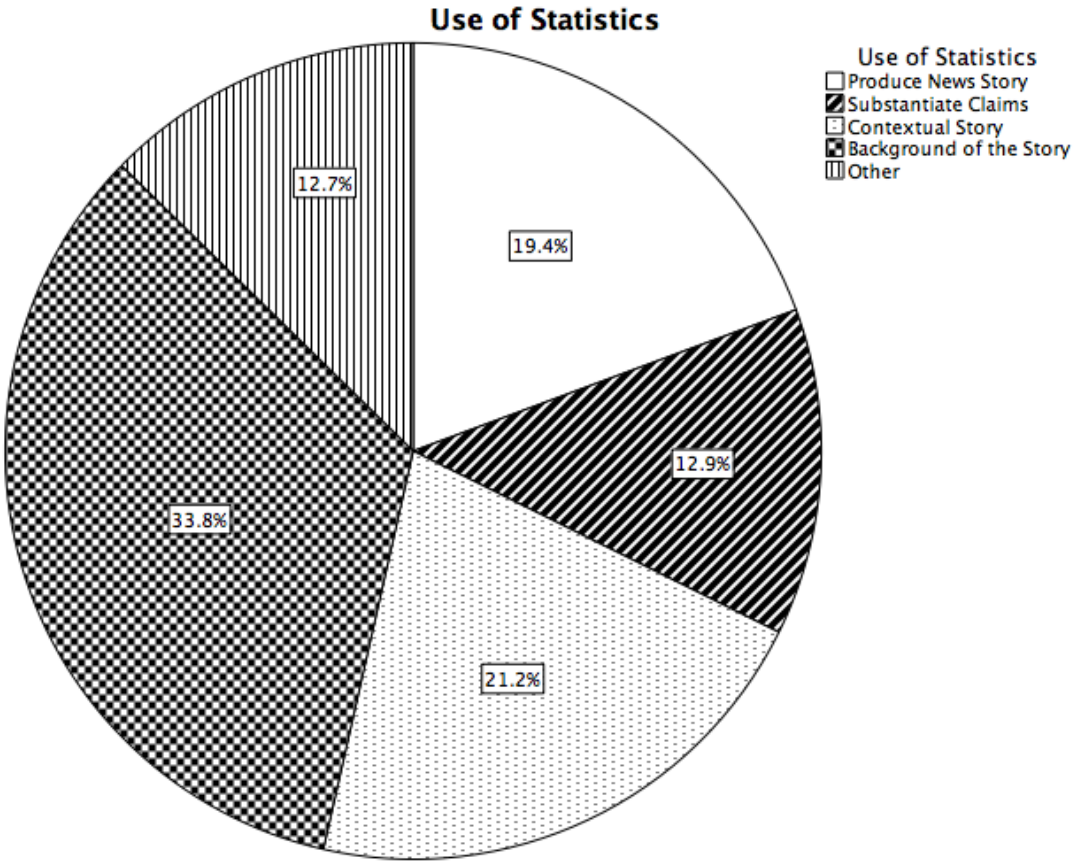


Figure 27: Percentage of Use of Statistics Frequencies

6.2.8 Visual Data

Another point where a clear gap can be observed is around the uses of visual data. Table 27 shows that 87.2 per cent of articles do not present any visual data. In addition, out of the four newspapers, *Folha de S. Paulo* is the only who has more articles with visual data than not (with 56, 81 per cent). During interviews it is pointed out that this is expected due to function of contemporary design. Furthermore, when deciding what to cover, numerous articles "squeeze" in lots of different places. Visual data being a big part of it. In order to produce more stories, the general space given to each story got reduced and thus the potential for visual data. In that sense, there is a similarity between why Brazilian newspapers cover more science news and its use of visual data. In both cases, the Brazilian media currently have more space to physically

deal with both more news as well as more visual information. What is more, due to the recent growth of literacy in Brazil, there is a stronger need to produce easy access and easily understandable data. This is because unlike in most countries where journalism has experiences some downfall, in Brazil things are going in the opposite direction; after the past two Presidencies the number of literate people in the country has grown dramatically. That means more people are now living above the poverty line, increasing the number of literate people and consequently also the number of newspaper readers.

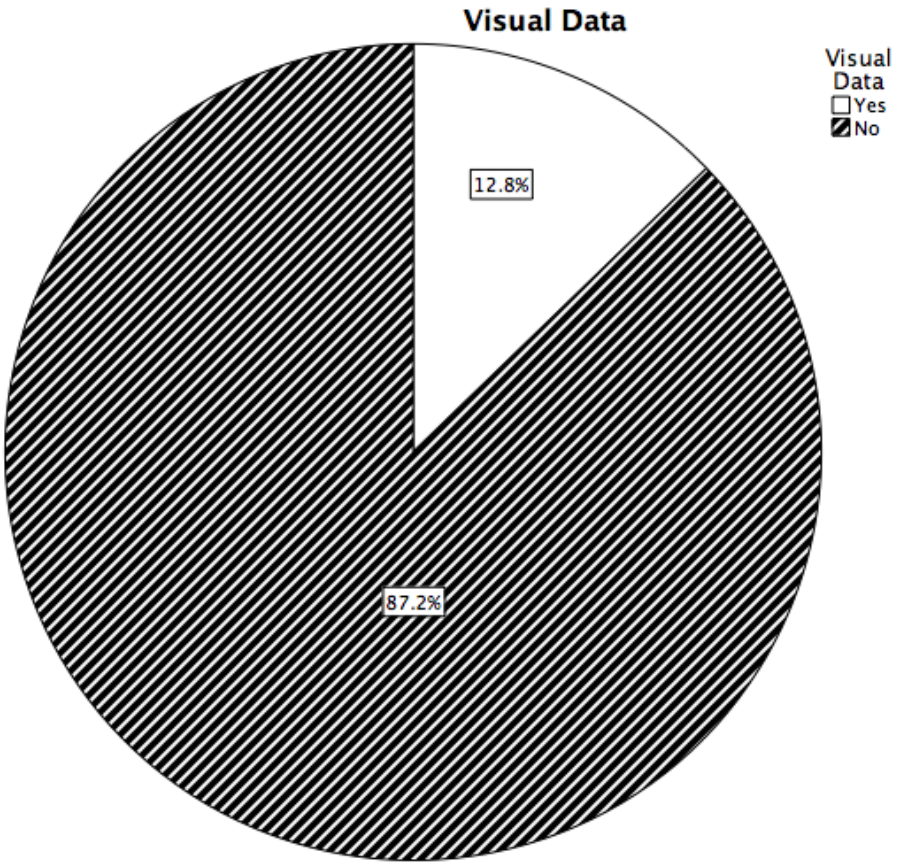


Figure 28: Percentage of Visual Data Frequencies

Breaking down the uses of visual data in news articles, it becomes clear that the Brazilian media relies heavily on visual data to present its information. Almost 60 per cent - precisely 58.3 per cent - uses visual data to display statistics. Conversely, in the

UK only 24.7 per cent of articles use visual data. Just over 75 per cent –that is, 75.3 per cent– of news reports relies solely on a nonvisual representation of data.

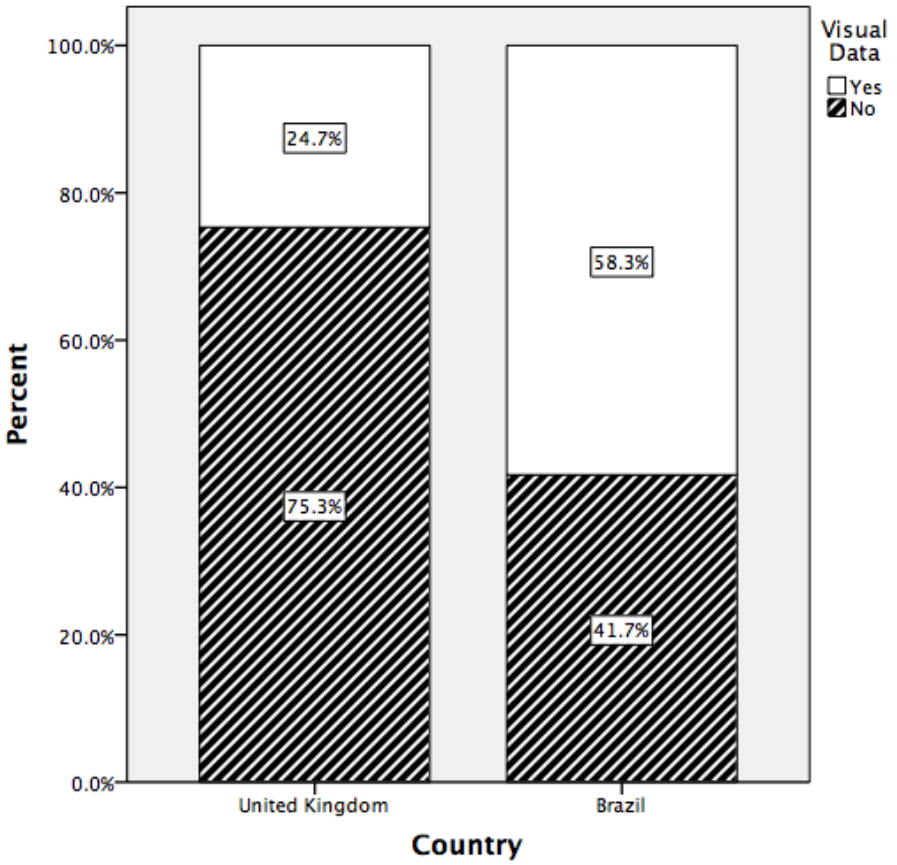


Figure 29: Percentage of Visual Data by Country

6.2.9 Nature

As can be seen from Figure 30, the findings suggest that most statistics are of a descriptive nature –at 74.2 per cent. Moreover, 13.2 per cent are inferential and almost 13 per cent (that is, 12.6 per cent) has multiple statistics, which encompasses those of both descriptive and inferential nature.

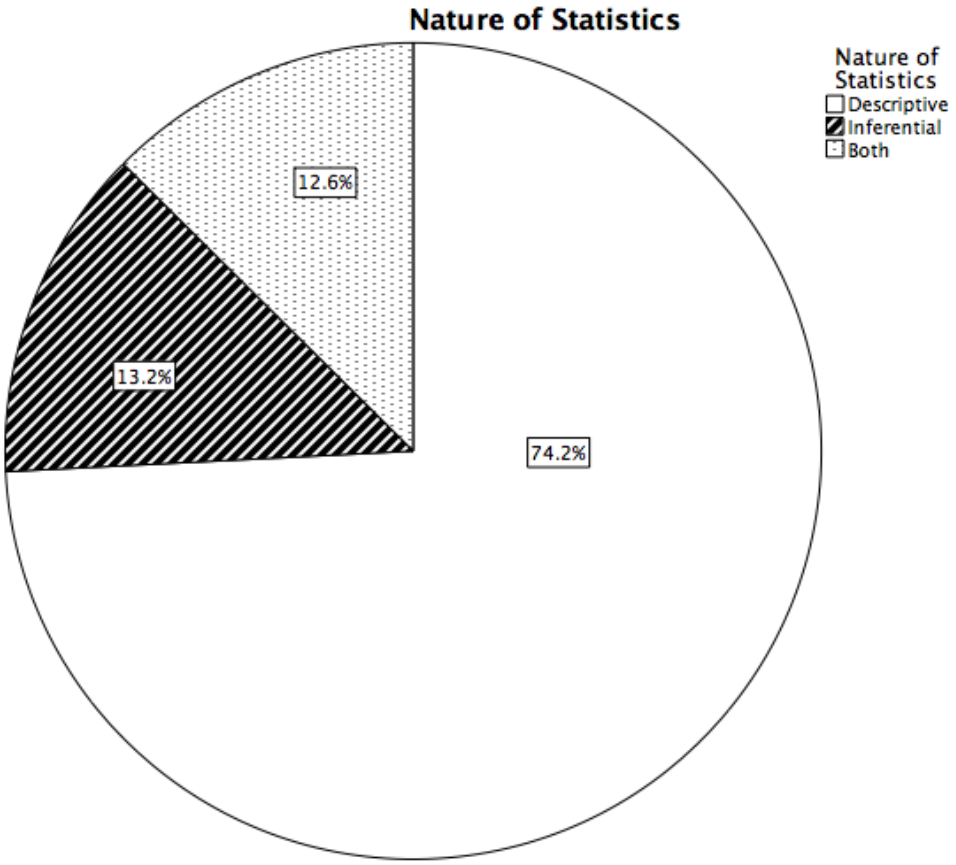


Figure 30: Percentage of Nature of Statistics Frequencies

This is an expected finding considering what has been argued before about the nature of news articles on science (hard news) and their use of statistical information (to legitimate). Ultimately, this happens because descriptive data is the initial stage of analysis, which is used to describe and summarize data, therefore making it ideal to use as a source in a newspaper article. This finding also further substantiates the uses of statistics in the newsroom as a means to articulate news and validate information.

As shown in Figure 31, just over 56 per cent (that is, 56.1 per cent) of statistical information in news articles of science is based on numerical data. Furthermore, 25.3 per cent is based on categorical data, and again due to the uses of multiple sources, 18.5 per cent of statistical information in the analysed articles uses both forms: numerical and categorical data.

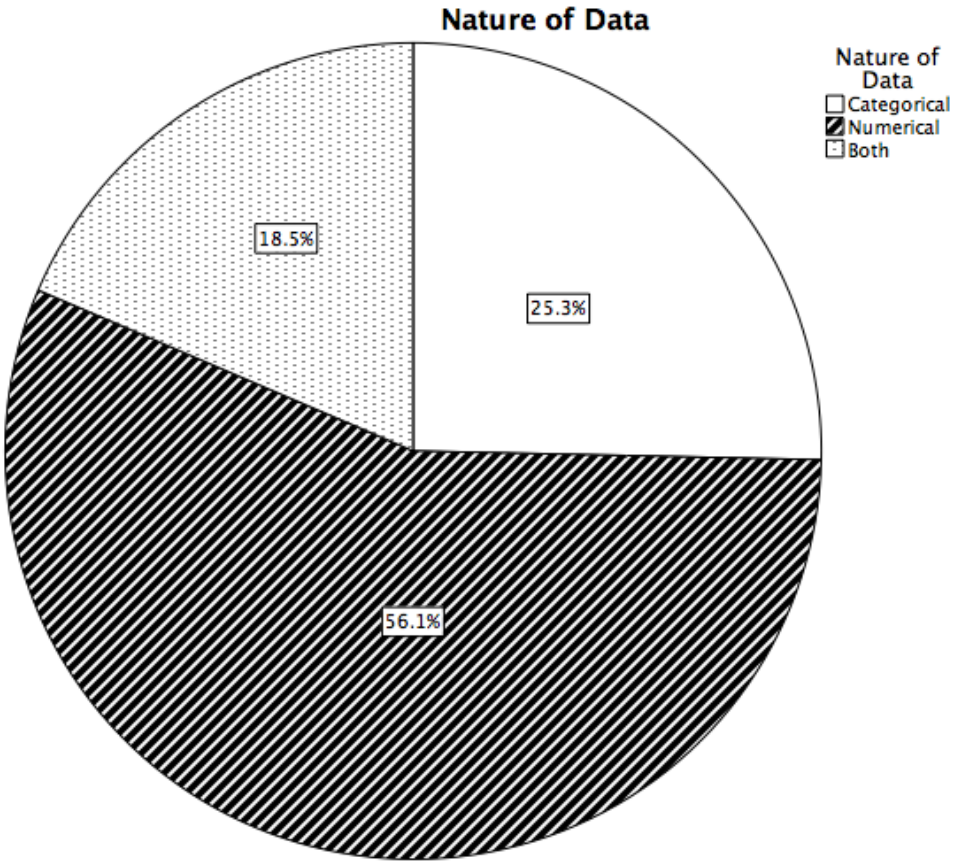


Figure 31: Percentage of Nature of Data Frequencies

This is a surprising finding considering the nature of some areas of scientific studies. Still, it presents a better understanding of the processes of constructing statistical information in the news. Taking into account what has been discussed previously, if numbers are perceived as objective sources, numerical data are also seen as unbiased and therefore have priority in the construction of discourses and validation in science news.

6.3. Summary of the Findings

In summary of this chapter it is evident that statistical information is an effective tool for the objective formulation of arguments and the presentation of news. It also reveals that quantitative data in science news are used overwhelmingly by staff

journalists and routinely treated as hard news. Furthermore, it also makes clear that although statistical evidence is crucial in the articulation of news, there is an overwhelming lack of fundamental background information about how the reported data are produced. Finally, the research has revealed that science journalists tend to include either multiple or minimal statistics from their sources.

As evidenced by the findings, the analysis of content yields some key insights into the use of science data in the newsroom: (1) whilst political affiliations do not play a card in the uses of statistics in science news, the country of origin of the studied newspaper does; (2) statistics are used overwhelmingly by staff, and (3) to treat science as hard news; (4) there is an overwhelming lack of fundamental background information about how the reported data are produced, and (5) science journalists tend to use peer-reviewed information in a unique fashion: their stories include either too few or too many statistics from original sources. Furthermore, (6) there is a well-balanced distribution of scientific information within its areas of study; (7) within known sources, University's PR Offices and NGOs are most often used; (8) Brazil uses extensively more visual data than UK-based newspapers; and, (9) statistics tend to be presented as descriptive and categorical in nature.

6.4. Discussion

Taking into consideration the foregoing research findings and analysis in terms of the uses of statistics in science news, I have come to the following conclusions. As a stylistic rhetorical instrument, statistical argumentation is central to the articulation of news, and is therefore a legitimate subject for journalism studies. As was found in this research, science journalists often understand and use statistics mainly to maintain the strategic ritual of objectivity in their social construction of science. This specific use

of statistics in the news is primarily due to the fact that this preparation is being constructed as a necessity in the profession and requirement in the everyday decision-making processes. In this framework, are statistics used to articulate stories and shape discourses of science in the newsroom? This research found that statistical information is used to promote and legitimise ideas. Within the newsroom, statistics are heavily used as a means to articulate information objectively, and is extensively used by science journalists. This finding strengthens the existing literature that argues that statistics are one of the most powerful tools in the construction of discourses in general (Battersby, 2003; Gigerenzer, 2002; Kahneman, Slovic & Tversky, 1982).

In this context, is there a variation on how statistics are used to establish accounts and frame discourses of science in the Brazilian and British newsrooms? The short answer is 'no'. This research has found a discrepancy in the number of published articles, but no substantial data that would suggest a disparity in the uses and representations of statistical information in the Brazilian and British news. Given the findings, it is clear that both countries use statistical data primarily to treat science as hard news, which is overwhelmingly handled by staff journalists. The longer answer is that, despite a similarity in using statistics to establish narratives of science in the news, Brazil often presents it differently. The uses are the same, data is still used as a means to legitimise stories. However, Brazil uses significantly more visual data than UK-based newspapers. The prevalent use of visual information points to a greater physical space for science news within the newspapers selected for study. Furthermore, it reflects the aforementioned statement that Brazil is a country with one of the lowest mathematical levels of ability; and yet the United Kingdom is also the country with the largest mean performance improvement since 2003 (PISA, 2012). Given this background, the use

of visual data is preferable as a means to present scientific information in a simple manner. Its information is easier to grasp and understand.

Finally, how does science journalist gather, handle and present statistics in the news? The findings suggest that statistics tend to be presented as descriptive data, confirming the literature and the research project's hypothesis that statistical information is used as a means to articulate news. In view of the fact that descriptive statistics, unlike inductive statistics, aim to summarise information, its use in the news validates its role as an argumentative tool. It does not infer information, but rather presents it in a way in which it can be legitimised. This simple summary and presentation further confirms its perceived objective characteristics. Still, in terms of how journalists use statistics, the analysis found that they often conceal fundamental background information about how the reported data was gathered and analysed. Furthermore, statistics are habitually used in all science news and areas of study. This is an interesting finding that further proves the importance of statistical information in the articulation of narratives and shaping of discourses of science in the news. This well-balanced distribution of scientific information within its areas of study exemplifies that it is used throughout the news and newsroom. They all use statistics as a means to legitimise information, and present them throughout sections, and countries, among others. To me, this is one of the simplest but most significant findings of this study. It seems to tell little, but informs a lot. Overall, the news media aim to present themselves as the "mirror of reality" (Broersma, 2010a; Mindich, 1998), as it claims to offer an accurate representation of reality that is as comprehensive and as objective as possible. This research analysis echoes the understanding that the use of statistical data is an essential tool for this representation of reality and legitimation of information. Thus, the following chapter provides

additional data to the study of the uses of statistics in news of science, while conducting a close reading analysis.

CHAPTER VII

7. Findings

7.1. Introduction

This chapter provides a detailed account of the findings from the close reading phase. In order to analyse the approach that science journalists took to these topics, a close reading analysis was conducted on four articles, one from each selected newspaper: *The Guardian, The Times*, *Folha de S. Paulo* and *O Globo*. Firstly, this chapter discusses the uses of close reading analysis and how language and images manipulate and persuade ideas, values and identities. Looking at the works of O'Halloran (2011), Carlson, Daniel and Okurowski (2001), Mann and Thompson (1988), Marcu (2001) and Wolf and Gibson (2004), this close reading analysis focuses on the exploration of both the written language as well as visual journalistic language –mostly, in this case, statistics and graphs. Later the chapter proposes to look at each article, allowing inferences to be made and scrutinising the ways in which statistics have been used in science news. Most importantly, it seeks to understand how mathematical language is used to shape discourses of science in the newsroom. This argument concludes by considering this mathematical language, not as a separate identity but as a concomitant one. As a matter of fact, this symbiosis becomes evident when focusing on the further discussed articles and how the need for numerical data in science news came to be. Thus, this chapter seeks to respond to the inquiry on whether there are differences in attitude towards the uses of statistical information in the news within

British and Brazilian newsrooms and how visual data are used to articulate stories of science. The analysed articles is summarised in the following table:

Title	**Newspaper**	**Date**	**Observation**
Nature: From Hills to Sea, UK wildlife is struggling: One in three species have halved over the last 50 year. Report finds limited number of bright spots	*The Guardian*	22/05/2013	• **Byline:** Staff Writer (Editor) • **Word Count:** 1154 Words. • **Visual data?** No. • **Emphasis:** Wildlife and Environmental Science.
Number of climate change sceptics soars as support for alternative energy wanes	*The Times*	19/09/2013	• **Byline:** Staff Writer (Editor) • **Word Count:** 620 Words. • **Visual data?** No. • **Emphasis:** Climate Change and Environmental Science.
Parcela de fumantes cai 20% em seis anos: número vem de estudo da Unifesp com mais de 4.600 pessoas em 149 municipios	*Folha de S. Paulo*	12/12/2013	• **Byline:** Staff Writer • **Word Count:** 427 Words. • **Visual data?** No. • **Emphasis:** Health Science.
Jovens ingerem 15% das calorias em suco de caixinha e "refri"	*O Globo*	19/03/2013	• **Byline:** Staff Writer • **Visual data?** No. • **Emphasis:** Health Science.

7. 2. Close Reading

As noted in Chapter V, the methodological approach of this study guided the data collection shown in this chapter. This section sets out to carefully analyse and interpret selected news articles on science. As a close reading analysis, it aims to consider single articles with a particular focus instead of general ones.

This close reading analysis intends to attend to particular words and syntax, and to unfold discourses of science within the news articles. Discourses are the general support to the various concrete texts. Discourses are responsible for the concretization of figures and themes, and of semi-narrative structures. The analysis will investigate semiotic choices by perceiving language use as a social practice, which needs to be considered in conjunction with cultural, social and psychological frameworks, as well as textual structures and their interaction within society. Thus, essential for this close reading analysis is the explicit awareness of their role in society. That's because "they argue that science, and especially scholarly discourse, are inherently part of and influenced by social structures, and produced in social interactions" (Van Dijk, 2001, p. 352). Nonetheless, instead of overlooking such relations between scholarship and society, discourse and its close reading analysis pleads that such relations be studied and accounted for in their own right and that scholarly practices should be based on such insights. Thus, this chapter uses a close reading analysis to present a "mindful, disciplined reading of an object with a view to deeper understand its meanings" (Brummett, 2010, p. 3).

Within the context of this study, it is also important to understand those choices of individual semiotic resources within the framework of visual discourses. Thus, within the framework for the analysis of statistical graphs, this chapter uses a multimodal close reading as an analytical tool –more specifically, an iconographical and iconological analysis, as numbers and images also signify discourses. According to O'Halloran (2011), multimodal analysis is an emerging paradigm in discourse studies, which extends the study of language to its study in combination with other resources, such as images, scientific symbolism, gesture, action, and music. It also includes graphical representations, tables, charts, and diagrams. Under the circumstances of

this project, when analysing the way journalists articulate the narratives and shape the discourse of science in the news through the use of statistics, it is crucial to understand these resources (language and data) as integrated resources which create meaning across multimodal phenomena and thus need to be read simultaneously. Although this may be true, statistical graphs differ from images, as, unlike a photograph they can be considered to be an abstract theoretical entity. While the former resembles a tangible object, the latter constructs a theoretical purpose. For this reason, although the goal of this chapter is to analyse the discourse of written and mathematical language as a concurrent element, both will be scrutinised using a theoretical approach.

For this research analysis, it is crucial to understand that multiple interpretations often coexist within the news media. For the purpose of this study, the analysis also involves numerical language. Because of this, the multitude of languages and discourses should be seen from a new perspective: a multimodal close reading analysis. This multimodal method becomes increasingly one of the many modes of cultural representation modes (Kress, 2001).

These significant changes bring up a new type of text, relatively frequent in postmodern social practices: the multimodal text (Kress, 2001). According to the theory of multimodality, the multimodal text is one whose meaning is realized by more than one semiotic code. Yet according to academics, a set of semiotic modes is involved in any production or reading of texts (Kress, 2001; O'Halloran, 2011): each mode has its representation and communication capabilities, produced culturally; both producers and readers have power over these texts; the interest of the producer implies the convergence of a complex set of factors; social and cultural histories,

current social contexts, including perspectives of the sign producer on the communicative context.

This is because language changes the studies of speech directly and motivates the transformation of all forms of communication. The growing use of images for communication proves that, increasingly, the multimodal text appears as an essential source of research for the close reading analysis. Thus, I consider the scope given to the term discourse that is also used to refer to "semiotic elements of social practices" (Chouliaraki & Fairclough, 1999, p. 38) when reflecting on the inclusion of other semiotic forms of nonverbal speech by close reading analysis.

7.2.1. *The Guardian's* From Hills to Sea, a statistical struggle.

When critically analysing discourses, one must read the text, derive inferences, and put those into reliable annotations for further consideration. The result of such a process depends on the limits imposed on the inferences one is allowed to make, and the language one uses for making such assumptions explicit. For Carlson et al. (2001), Marcu (2001) and Mann & Thompson (1988), for example, following the lines of the Rhetorical Structure Theory (RST), these constraints need to be structurally stable on both the inferences one is allowed to make as well as the language one is allowed to use when making such annotation. Wolf and Gibson (2004), on the other hand, present a less limited proposition. Their goal is to achieve more generalizable representations of discourse structures with fewer restrictions on the picture one is allowed to create and the corresponding permissible inferences. Adhering to their line of thought, the following can be inferred from *The Guardian*'s article "Nature: From Hills to Sea, UK wildlife is struggling: One in three species have halved over the last

50 year. Report finds limited number of bright spots" by Damian Carrington on May 22, 2013.

0. UK wildlife struggling:
1. One in three species has halved
2. Over the past 50 years.
3. Report finds limiting number of bright spots.

1 → 0 *elaboration*

3 → 2 *elaboration*

3 ←→ 0 *contradiction*

Note that not all of these relations are created equal. The *elab* and *sim* can be referred to in isolation, that is, in contexts that contain only the units that they relate to. All texts below make sense in isolation, by themselves. Wolf and Gibson (2004) divide such inferences or "coherence relations" into 10 (ten) elements: (1) *cause-effect,* (2) *violated expectation,* (3) *condition,* (4) *similarity,* (5) *contrast,* (6) *temporal sequence,* (7) *attribution,* (8) *example,* (9) *elaboration,* and (10) *generalization.*

Text (0; 1):

0. UK wildlife struggling:
1. One in three species has halved

Text (2; 3):

0. Over the past 50 years.
1. The report finds a limiting number of bright spots.

However, the contrast relation between units 0 and 3 cannot be interpreted in isolation. Text (0; 3) does not make sense by itself.

Text (0; 3):

1. UK wildlife struggling:
3. The report finds a limiting number of bright spots.

The contrast between the latter and former may not indicate a strong contradiction between them, but their contrast is in evidence and within different contexts may yield different inferences. One can, for example, interpret that the wildlife is struggling and currently in decline. Conversely, one can just as quickly, with only these two pieces of information – Text (0; 3) – understand that there are bright spots. The relative contradiction imposed in Text (0; 3) and title, can only be understood in the context of the whole text.

Similarly, further on in the text, in the sixth paragraph, Sir David Attenborough's quote states contradictorily that the report is "a stark warning" but then goes on to say that there are signs of hope.

4. This ground breaking report is stark warning
5. Is also a sign of hope.

5 ←→ 4 *contradiction*

Text (5; 4):

4. This ground breaking report is stark warning

5. Is also a sign of hope.

With attention to the quotation verbs and when looking at speech and speaker presentations, lexical content analysis shows that the mentioned quotation verbs can be divided between 'said' and 'report'. The former is used solely when referring directly to a person of authority (e.g. Sir David Attenborough, "Mark Eaton, a scientist at the RSPB and one of the authors of the report"[3], etc.). The latter, on the other hand, is used to quote findings from the report itself.

Furthermore, on scrutinizing the numbers in the newspapers, *The Guardian*'s article presents the reader with a total of 50 pieces of numerical data (including, number of conservation groups, sample sizes, year, among others) of which 24 are statistical data.

In the fourth paragraph of the article, the author states that 3,148 species were analysed for the report. However, in the 21st paragraph he goes to say, "just 5% of the estimated 59,000" species were analysed, meaning that 95% of the data is unknown.

[3] The Guardian's article "Nature: From Hills to Sea, UK wildlife is struggling: One in three species have halved over the last 50 year. Report finds limited number of bright spots" by Damian Carrington on May 22, 2013.

That creates an inconsistency with the title – and general appeal – of the article, which states that the wildlife in the United Kingdom is struggling. A simple mathematical equation taken from the information provided in the article would indicate that concretely only 3,2 per cent of species and thus the United Kingdom wildlife is in decline. This figure can hardly be considered "the UK wildlife". In the same way, when stating in the first paragraph that "an unprecedented stocktake (…) has revealed that most species are struggling and that one in three have halved in number", there is no allusion to the fact that this stocktake consists of only 5 per cent of the total number of species in the United Kingdom wildlife. Along these lines, if you consider that "most species" corresponds to 64 per cent of this 5 per cent (or just under 1,900 species), that means that one in ten equals under 200 species or 188.8 species in total. Therefore, having Sir David Attenborough state that "our species are in trouble" (sic) is at least slightly inaccurate. Not because our species are not in trouble, but because by "our species" he means those who have been analysed in the report – and that corresponds to under 1,900 species.

Conclusively, considering the poor mathematical abilities of the population mentioned earlier and their lack of understanding of basic numerical knowledge, the mere inference of such statistical information can be very persuasive. That is because the article (1) oversaturates the reader with information, by means of presenting 50 pieces of statistical data in an article of 1,154 words; and (2) offers generalising statements, such as "most species", which can be incredibly deceptive.

7.2.2. The Environment and *The Times*

The Times' article "Number of Climate change sceptics soars as support for alternative energy wanes" from September 19th, 2013 by environment editor Ben

Webster shows a similar approach to *The Guardian*'s article: it presents an excessive amount of data. The article presents 23 unique statistical data points and just fewer than 40 numerical data points –39 figures to be exact. Worse than the previous article, however, this one is just 620 words long – or half the length of *The Guardian*'s "Nature: From Hills to Sea, UK wildlife is struggling: One in three species have halved over the last 50 year. Report finds limited number of bright spots"– but containing just about the same number of numerical figures.

As already scrutinised in the previous chapter, this exaggeration of quantitative and numerical data is extreme. When allowing for inferences, however, the following can be said:

0. Number of Climate change sceptics soars
1. support for alternative energy wanes

1 → 0 *elaboration*

Text (0; 1):

0. Number of Climate change sceptics soars
1. support for alternative energy wanes

Again, the headline consists of *elaboration* sentences. This makes sense and it is to be expected as it needs to have a persuasive purpose to attract the attention of the audience and interest the reader in reading the news article (or in the case of front

pages headlines, in purchasing the newspaper), but they can also be designed to influence the opinion of the reader.

In addition, the author of the article uses vague terms such as "more than quadrupled", "fallen sharply", "extremely likely", "very likely", etc. with little to no explanation of what sharply, extremely or likely might mean. They go on to explain at the end of the text that sharply refers to a fall of 14 percentage points and a slight increase – "up from 30 per cent last year to 34 per cent". Similarly, according to the article, a steep decline refers to a fall from 82 per cent to 64 per cent – or 18 percentage points. Vague terms are often used either to confuse the reader or to simplify the data (Hayes, 1992).

As for sources, this entire article uses only one secondary source: a government-funded survey conducted by Ipsos MORI of 1,000 people published by the United Kingdom Energy Research Centre (UKERC). However, no statistical information was quoted directly.

7.2.3. *Folha de S. Paulo*'s Federal University Study

In comparison, *Folha de S. Paulo*'s "Parcela de fumantes cai 20% em seis anos: Número vem de estudo da Unifesp com mais de 4.600 pessoas em 149 municípios" ("Number of smokers falls by 20% in six years: Number comes from a Unifesp study of more than 4,600 people in 149 municipalities", translation by author) from December 12th, 2013, has 28 numerical data points in total – of which 16 are statistical data.

In spite of what the headline suggests, the article presents data from two different sources: one from the Federal University of São Paulo (Unifesp) and another from the

government conducted by the Health Ministry, where the latter is used to corroborate the former's data.

There is only one source quoted – a primary one – Clarice Madruga, university researcher from the Unidade de Pesquisas em Álcool e Drogas or Research Unit on Alcohol and Drug (translation by author).

0. Smoker's share falls 20%
1. in six years
2. number comes from a Unifesp study
3. of more than 4,600 people
4. in 149 municipalities

1 → 0 *elaboration*

2 → 0 attribution

3 → 2 elaboration

4 → 2 elaboration

Text (0; 1):

0. Smoker's share falls 20%
1. in six years

Text (2; 0):

0. Smoker's share falls 20%

2. number comes from a Unifesp study

Text (3; 2):

2. number comes from a Unifesp study

3. of more than 4,600 people

Text (4; 2):

2. number comes from a Unifesp study

4. in 149 municipalities

7.2.4 The Globe and *O Globo*

The article "Jovens ingerem 15% das calorias em suco de caixinha e 'refri'" ("Young people ingest 15% of calories from juice boxes and sodas", translated by author) from *Folha de S. Paulo* on March 19th, 2013, allows for the following inferences to be made:

0. Young people ingest

1. 15 per cent calories

2. from juice boxes and sodas.

1 → 0 *elaboration*

2 → 1 *elaboration*

Text (0; 1):

0. Young people ingest

1. 15 per cent calories

Text (1; 2):

1. 15 per cent calories

2. from juice boxes and sodas

In spite of such inferences and elucidations, little else can be extracted from this title. For example, it does not state who produced the given statistics or the parameters by which they should be measured (such as, per day, per month, etc.).

This info graphic, however, from the article "Jovens ingerem 15% das calorias em suco de caixinha e 'refri'" ("Young people consume 15% of calories from juice boxes and sodas", translated by author), however, uses current and frequent information visualization capabilities in the print environment. This includes use of a variable database comparing such intake with milk (for example), which allies the resources consolidated in information visualization such as graphics and bar lines. This mix of old features with new information visualization capabilities is a trend set by Cairo (2008) whose concern is with aesthetics and making information more attractive to readers, as opposed to analytical, whose foundation is the written plain language. This, however, does not mean that the analytical dispenses with the aesthetic, nor is it

simplistic, but it does not allow the predominance of the aesthetic when it comes to certain information.

The info graphic is also in line with another trend, which is the production of info graphics aiming to show complex data using visual data in a simple and concise form. Manovich (2011) is critical of this trend, because, according to him, the information displayed follows two principles: data reduction and privilege of spatial variables. The first principle relates to the act of reducing information to fit the available space, where the information must be drawn to fill the pages of the newspapers or magazines. The latter, in turn, refers to the privilege of selecting topologies that represent the displayed object and not the whole object.

7.3. Discussion

Within this framework, the previous research findings and close reading analysis of the uses of statistics in science news, suggests the following outcomes. Multimodal information should be at the heart of the preparation and representation of statistical data in science news, as it is its presentation that contains specific information about the research and subject of study. It is clear that much more work will be required before a complete understanding of this phenomenon can be achieved. However, it can be said that upon the construction of a given text, whether written, oral or imagery, the author can make use of a vast amount of multimodal linguistic resources from both the verbal and the visual platforms. Moreover, all these different ways to build a text entail substantial changes in the way people work out meaning and significance, transcending, in this way, the primacy given to the word. Multimodality provides then the outbreak of multiple and diverse sense-making resources. This

multimodality mainly fits the construction of narratives and discourses of science in the news.

Therefore, the next chapter will provide a final analysis and discussion, as well as a general conclusion to these research findings, their importance to existing literature and contribution to research and practitioners.

CHAPTER VIII

8. Findings

8.1. Introduction

This chapter presents a comprehensive account of the findings from the in-depth interviews. It aims to discuss and interpret them while trying to elucidate on the ways in which statistics are used to articulate and shape discourses of science in the newsroom. Accordingly, the in-depth interview proposed to investigate actively on the uses of statistical data from within the newsroom. Each conversation aimed to discuss particularities regarding the understanding, gathering and dissemination of statistics. Moreover, it observed the specificities of each journalist and their respective newsrooms in the handling of statistical information. The interviewee's general background is summarised in the following table:

Country	**Newspaper**	**Interviewees**	**Background**
United Kingdom	*The Times*	Two	• Science Editor and Correspondent. • Writes both hard news and features. • BA in Maths.
Brazil	*Folha de S. Paulo*	Two	• One general science journalist, and one specialised in science and science policies. • Heavily academic background. • PhD in Science Policies.

Brazil	*O Globo*	One	• Science journalist, specialised in enviromental sicence. • Writes mostly hard news. • BA in Journalism.

As an introduction to the ways in which statistics are handled in the media and quotiedien, Dr. Grossman's (2015) argues that "in terms of mathematical abilities at GSCE levels, (…) 16-year-olds were three years behind their counterparts in the Far East. This, according to all accounts, is a pretty poor situation. Children in the UK seem to be leaving school with poor numerical skills, little confidence in [their] abilities, and little appreciation for the relevance of maths in everyday life. As a matter of fact, it is estimated that half of the UK population have the maths ability (…) of a primary school child. The Royal Academy on this topic has issued a statement this week communicating that they are deeply concerned at the lack of basic quantitative skills [and] statistical illiteracy; not only affecting businesses, schools and universities but having serious consequences on the future of the UK as a world leader in research and higher education, stymieing the employability of our graduates in the competitiveness of the UK as an economy." (Grossman, 2015)

Similarly, a recent report asked MPs what they felt were their numerical abilities, and reassuringly ¾ of the conservative MPs said that they felt comfortable dealing with large numbers. Be that as it may, when just over 100 of them were asked a simple probability question – the probability of tossing and getting two heads in a row if a simple coin was tossed at any given point – only 53 per cent of the Conservatives and 22 per cent of the Labour MPs got it right.

So the "question is why can't the nation as a whole add up?" as was queried by Grossman (2015). She argued: "One reason for me is the way that it is taught. My

opinion often is that maths is taught in a way that is dry, irrelevant and has no real practical applications in real life. Now, the statistics show that if you do not get a basic understanding of maths by the age of 11 you will rarely catch up. They say that 95 per cent of people who are inept at maths by the age of 11 will not get out from there" (Grossman, 2015). So what is taught is the first level of mathematics. "The problem is not only the teaching methods, that they are old and dry. It is also that the majority of high school teachers – the research found – did not study maths beyond GCSE levels. So they are perhaps themselves not apt, they themselves lack the basic appreciation of mathematics and even understanding for the subject to pass on to the students" (Grossman, 2015).

Ultimately, "only 11 to 15 per cent of our current students study maths at A-levels or beyond. And then, when we go on to looking at degree level study, many degrees offer very little quantitative skills training" (Grossman, 2015).

8.2. Selecting Numbers

The content and close reading analysis set out to develop a database for the interviews. The in-depth semi-structured interviews aimed to explain the findings from this database while answering the ultimate question of how statistical information is used to articulate, legitimate, and shape discourses of science in the newsroom. Furthermore, it allowed me to further explore what was the journalists' reasoning behind their uses of statistics, and how they understood its information. For this purpose, this study involved the collection of data from five science journalists at *The Times, Folha de S. Paulo* and *O Globo.* This section presents the results deriving from these interviews.

Firstly, I believe it was important to establish their methods of data collection. Grossman (2015) exposes an unpleasant situation within the mathematics educational system in England. This argument is validated by PISA (2012), which presents data that corroborates the low levels of statistical literacy in the country. Accordingly, if so many people do not understand statistic, how do journalists themselves select statistical information relating to science? One science writer believes that

> *It depends very much on the story. Normally, how I get stories is, I have been looking at the new journals' stories that are coming out. So things in Nature, Science, Cell, stuff like that. And then, whatever it is about, I mean, there are a lot of involved statistics, and the classic ones, you know, be it eating something rather or exercising, how ever many minutes a day improves/lowers mortality by…and that will be 20 per cent or whatever; that is just one example. And obviously I just used, that would be the crucial number in the story. Whatever their figures tend to be. I do not normally go out; there are not many situations for me to go out to find some particular statistics to bolster a story today. It depends very, very much from story to story.*

According to the journalist above, the main statistical information (or crucial number, as he puts it) is sourced from the academic journals. This seems to corroborate the finding from the content analysis that, when analysing the nature of the main source, close to 26 per cent of sources is academic-related. Furthermore it supports the literature that journalists look for reliable peer-reviewed statistical sources. It also indicates reliance on an existing safe journalistic route towards statistical information. Science journalists mostly rely on journals. On the one hand, this exposes a special dependence on peer-reviewed data. On the other, it singularises sources. As a matter of fact, Gregory and Miller (1998) call this safe route, an easy, if not lazy, strategy (p. 108). Indeed, as the interviewed journalist points out, it depends on the story, but customarily statistics on science are taken directly from academic articles published in well-established and known scientific journals.

Much in the same way, another science writer supports this argument by stating that

> *A lot of statistical data comes from scientific articles. When it comes to corroborative data, the main sources are articles, the paper that is being published. From that, we can add information that has already been published in previous pieces. They are pieces, which are already in the newspaper's archive. And also, we can gather some information – besides doing interviews with the authors, which is something we always try to do – from foreigner newspapers such as the* BBC*,* The Independent*,* The Guardian*,* The Telegraph*,* The New York Times*,* El País*. They always have something to add to the article. They have a strong editorial efficiency.*

This account further expands on the close relationship between science journalists and their scientific sources. As suggested, their primary sources are scientific journals. However, this writer further argues that they can and do, at times, add information that has been published before. This dichotomy in journalism perspectives, where news is only that which is new, is due to the subject of discussion: science. News of science, differently from the ordinary news, is based on information that has already been published. It is a derived knowledge from research that has been studied for months, if not years. "They have been published in a peer-reviewed journal first and gone public second" (Gregory & Miller, 1998, p. 108). Within the context of this research, this supports key findings. On account of it being crucial to the understanding of how statistical information is gathered, handled and presented to the public, I asked for a detailed account of its manipulation.

Within the context of Brazil, a science journalist argues further that in addition to the above-mentioned processes,

> *Then you see if there are any Brazilian authors or have studies that are relevant to Brazil, in any way. This is always the first step. So much so that almost every Wednesday and Friday there is a study sourced by Science and Nature.*

Still, he points out

> *There are a few other ways as well. For example, a scientist can call me directly to tell me about a study he/she will present, or if he/she has presented an article that has been approved. Or he/she can call me to make a complaint. In fact, when I first started I did a lot of articles on scientific policy, on bad conduct, plagiarism, problems regarding the importation of equipment, laboratorial disagreement, that one stole the equipment of the other or forbid one to use it…things that are the 'every day' of science.*

As a matter of fact, this has been a widespread response: that there are several ways to gather statistical information, however, journal articles and official sources are ultimately their preferred choices. To this research, as a cross-country comparison, this observation is extremely interesting. I see this attempt to look for Brazilian authors or research relevant to Brazil as a hint of a practice at the journalistic core. As the literature confirms, news stories need to be relevant. The simplest way to make it relevant to a specific community is to make it personal. By seeking a national author, the science journalist already engages the audience in a more personal account. That said, this trend was not observed or mentioned by British journalists. However, that does not suggest the disuse of national sources, authors or of interest in science articles. Ultimately, in spite of this not being the aim of this research, this is undoubtedly an interesting finding.

Indeed, if in Brazil science journalists often request national scientists to give opinion in international or national researchers, in the United Kingdom they habitually use a more direct and impersonal approach. It was unison among science journalists in the United Kingdom that EurekaAlert! is their fist contact with research. One of the science journalists explains that

There are a few ways. One of the most used platforms is the EurekaAlert! It is a platform of scientific periodicals that journalists can access with certain antecedence. So, there you can access Science, Lancet, PNAS (Proceedings of the National Academy of Sciences), PLOS (Public Library of Science), etc. So, we receive early access to the research, where we can find information on the author's contact information, bibliography, and images. That helps a lot. So the path we take always starts with EurekaAlert!

Similarly, another argues that

That is a very complicated question. The first thing, and I am sure other science journalists would have mentioned it, that we look into is Eureka Alert! They will work as central resource distributing press releases. On top of that, there will be press releases that will come directly to us from various institutions. There will be social media. There will be sometimes scientists that we worked with in the past. We will sometimes actively contact scientists if we see reports that are working on something interesting. Sometimes we will just be looking through journals. There are a lot of journals that push out a lot of papers with a reasonable impact factor but do not press release them. It is quite a mixture.

Still in this regard, one journalist explained further that,

It depends greatly. In fact, it is a little bit of everything. For reports and specific columns on science and environment, I hold good preference from different sources. I would say that I still take a look at the summaries of academic journals. At present I am aware of things that can be published either in less known newspapers, of smaller or more specialised circulation, or studies or reports that are coming out through NGOs or multilateral organisations.

Opposing to others, this journalists cites various sources of information. According to him,

Sometimes, even through social media and social networking platforms such as Twitter and even Facebook, which often provides things that if you are only following journals like Nature, Science or BNAS, you end up not knowing. And increasingly important, for the past ten years now, has been the direct contact with researchers and sources that I have been

> *building over the years that "warn" me themselves of what they are publishing or are about to publish or other interesting things they learned from other researchers and such. The same applies for NGOs that also produce reports with scientific quality.*

Nonetheless, the unison argument is that

> *The initial source of information can come from a variety of sources, scientific journals, scientists themselves, sometimes press agencies, sometimes the Internet, debates, blogs, numerous places.*

8.3. Verifying Numbers

This broad range of choices and selection of data creates a rather chaotic decision on the uses and used statistics. A common complaint among scientists today is that the number of academic publications has been growing exponentially. To academics, researchers are publishing too much, too fast. Thomson Reuters Scientific INC (SCImago, 2007) ratifies this argument. Their Web of Science academic database, for example, has increased its coverage by 3 per cent per year. According to their data in indexing and scientific production, there were over 1,190,000 articles published globally in 2009 (SCImago, 2007). In Brazil, alone, that number surpasses 32,000 annual publications (SCImago, 2007). This means that, if understood daily, over 3,260 articles are published everyday, and of all those academic articles, journalists must choose one story to report. Under those circumstances, it is therefore essential to know how journalists verify the presented data.

> *It depends very much on the study. I am trying to think of recent examples that I have done, (…) I am not going to be going out and actually, you know, checking the data if they got all the data correctly collected. If it is a large meta-study… for instance, a very recent article that springs to mind is the big meta-analysis of breast cancer screening, which looked at sixteen million women and found that breast cancer screening did not decrease mortality and then, in that case, the crucial statistics were zero. And, you know, if someone has done a study and literature and has been*

> *published in Nature, I mean that is [official]. I am definitely not going to try to go out to try to find another study.*

By these means, statistical information is hardly ever checked. In fact, this one-dimensioned sourcing indicates a preferred means of accessing scientific sources. This suggests a repudiation of incorporating different, multiple sources that would either support or question the data. Furthermore, it presents a rather elitist approach to sourcing of scientific publications. And it is this lack of diversity, fuelled by this elitist choice, which causes this lack of verification.

> *In that case there was another study that was out on the same day on breast cancer screening where there was a slight improvement on fatality rates, which I did put in the article. The ways that I would normally check them would not be in trying to find other studies but more of a seeing and looking at where the statistics come from, you know, what sample size and all the things considered. But it all depends on what the article is about.*

By some means, this presents a consistent explanation. The number of scientific studies being published every day is too great to be fully explored. Thus, the validation or verification of every data is extremely unlikely. In that sense, the science journalist's choice of source –that is, journal– is ideal as it provides already peer-reviewed data. As those data often have already been analysed and verified, it rarely presents inaccurate information. Indeed, as journalism practice asks for accuracy and objectivity, science journalists rely on the scientific community for accurate facts (Gregory & Miller, 1998, p. 107). This, however, does not mean the journalists themselves understand or know how to articulate and communicate its information. According to this science journalist, the exception to this finding has to do with public and health concerns. In these cases, writers tend to look for second articles and opinions.

> *If it is something like that, which actually has serious impact and could save real people's lives, and could cause a health scare, and change the way they lived, then yes. That's the only way I would then publish, but I would not normally look for second article; I would be checking the sample sizes. What we normally do is try to find another expert or someone that has been involved in the study, an expert in the field to give me their views on it.*

This is a crucial finding. The role news media plays in the communication of scientific information is especially significant in the communication of health risks and risk perception. The relationship between health-related science communication and journalists has been widely studied (Boyce, 2007; Hilton & Hunt, 2011; Lieberman & Kwon, 2004; Tanner, 2004). Throughout the years, however, the amount of misinformation in areas of health news – a classic example being Wakefield's MMR vaccine controversy – has improved the perception and dissemination of factual health news.

In spite of that, as previously suggested, statistical information derived from journals are still rarely checked. Throughout the interviews, journalists have suggested that they agree that validation is important, however, they themselves tend not to do it. Interestingly, when it comes to data and number verification, both countries agree with the premise that if the research was published in an academic journal, it does not need to be data checked. Gans (1979) suggests that news is controlled by elite sources and that journalists prefer sources that hold authority. In this sense, scientific journals are a natural source of information of science. However, this almost blind trust in the journals and its peer reviews can and has caused gaffes and inaccuracies throughout the years, but it still seems to be the norm in the newsrooms. One journalist reasons that science journalist

> *Set out from the principle that if it has been published in the [Journal], the data is somewhat consolidated. It has a certain acceptance by its peers and colleagues. We also always try to get the articles from well-known journals, such as PNAS, Nature, Science and all the "children" of Nature and Science, such as Nature Climate Change, etc. So these renowned names are very unlikely to require data verification.*

As I have demonstrated, the high volume of data, in addition to the lack of time, causes this fastidious sourcing. Because these are renowned journals, science journalists within the newsroom rarely ever insist upon data verification. As a result, second-hand statistics are still the choice of source:

> *I am not going out and surveying people so, yes, I mean, whatever the scientists have found, I definitely do not have the time to conduct my own surveys. We have occasionally run experiments but that is a lot of work", said one journalist.*

8.4. Governmental Data

Because the science journalists rely on and trust official science sources, which does not require further verification, among second-hand statistics, governments are often pursued as a means of obtaining a legitimate piece of information. As argued, the attraction towards statistical information as a reliable source has led the news media to look ever more frequently to data as a means to legitimise their stories. As a result, it has created a demand for government officials and a range of official-looking institutions to produce statistical information (Higgs, 2013). As a matter of fact, according to one science journalist, especially when writing about environmental issues, they

> *Often use governmental data sources. Especially when talking about the Amazon, because the only establishment that can monitor the Amazon Rain Forest is the government, through INPE, which is a federal body. In this case, either the minister itself or INPE provides data to the ministry. And that is very interesting because whenever we, as science journalists,*

> *receive environmental data we ask firstly and foremost: where is it coming from? For example, in this newspaper, we have a very serious rule of not using NGOs as data sources – with very few exceptions. MATA, for example, have a strong data culture – a proper team of scientists that releases survey numbers on the Atlantic Forest. But, generally speaking, we do not use NGOs' data. We prefer official data, such as INPE, government, and in some cases NGOs that are renowned for its official sources. The government often uses the data from (SOS) rainforest to speak of the Atlantic Forest. Therefore we use it too. Because, if not, anyone can open an NGO tomorrow and drop out data. So this is a very sensitive situation and decision.*

This puts forward the belief that other sources can be corrupted, while the government cannot. In fact, throughout the interviews, science journalists have a consistent belief that governmental produced data are more authoritative. To one journalist, for example, the

> *Government is always…official.*

Similarly, UK-based science journalists argued that Governmental sources are "okay". To one particular writer, in terms of sources,

> *Reliability will always depend on the individual study. And we are quite careful not to dismiss studies simply because of where they came from. It will always depends on strengthens and weaknesses of the study itself. Generally, Government works, in my experience, are okay. Most of the researches you see in the journals, their high impact factors are pretty good. Equally we would not assume that just because it comes from Science or Nature that it is automatically a strong study.*

This confirms something that has been observed and researched before: journalists over-depend on official sources to articulate news stories (Brown, Bybee, Wearden, & Straughan, 1987; Goldacre, 2009; Manning, 2001; Lewis, Williams, & Franklin, 2008). Moreover, this data corroborates an interesting finding that was uncovered in this research's content analysis –and presented in Chapter VI– regarding the uses of

governmental sources on science news. Research consistently shows that sources can create or destroy stories, set agendas and greatly influence the articulation of news and the shaping of science discourses (Brown, Bybee, Wearden, & Straughan, 1987; Ericson, Baranek, & Chan, 1989; Gans, 1979; Hansen, 1991; Manning, 2001; Miller, 1993; Soley, 1992). Ericson, Baranek and Chan (1989) argue there is a preference for official informers that possesses a certain authority over reality. This being the case, government sources, thus, have a natural advantage over other sources. This dominance of government sources can also be problematic. It speeds the news through specific agendas and prerogatives, overlooking a system of checks and verifications. This indicates a lack of self-assessment of science journalists, as well as their sources. Instead, it exposes the mimicry of scientific information. It creates a repetition of statistical and scientific data by repeating what these sources offer. Rather than accounting for an objective communication of science, and acting as a key stakeholder in terms of scientific knowledge dissemination among the public, it assumes a repetitive, ritualistic form of execution.

One science writer argues that

> *Governmental data are used because they are the main source; they are the authority figures that have more facility to collect data. It is the government who gives/produces the raw data.*

If in the United Kingdom they are often taken as reliable sources, in Brazil, however, the relationship between all sides of the scientific sources has drawbacks:

> *The government furnishes this data, if I look on their website I will find this data, but they are very badly obtainable. (...) But we notice there is a very precarious dialogue between (1) the government and (2) the academia; and between (2) the academia and (3) the press; and between (1) the government and (3) the press. These three parts tend not to talk.*

8.5. Environment and NGOs

In terms of the United Kingdom, however, this relationship between journalists and scientific sources does not seem to be such a big problem. At least when writing about environmental issues, the statistical data often comes directly from academic journal articles:

> *Environmental stuff, normally when I do it, it comes from Nature Climate Change rather than [other science news]. There is a lot of statistics knocking around in the environment. A lot of them particularly from the NGOs, you know, are your exaggerator in one particular way…I am surprised they come from government. Generally, you know, whenever you get a good source from statistics that sounds impressive to someone who sounds official, then, I guess that's sort of what one would look for. As a journalist, being lazy, I suppose no one criticises you for using government statistics because if it is wrong, it is the fault of the government rather than you. But yes it is not particularly my area.*

This validates Gregory and Miller (1998) suggestion that this is an easy strategy for science journalists. It is also an easy way out of any possible or future mistakes. If any of the official data is wrong, science journalists can easily claim they were merely repeating information given to them by official and authoritative sources. Furthermore, again as Gregory and Miller (1998) suggest, this arrangement also suits the scientific community as this way "they do not get pestered by journalists looking for facts" (1998, p. 108). This is an interesting finding as it suggests the existence of a repetitive ritual from not only the media perspective but also a complacent agreement by scientists themselves.

Moving towards other sources of statistical information, alternative second-hand statistical information sources also include Non-Governmental Organizations. According to the data analysis presented above, in Chapter VI, just over 19.6 per cent of articles of science use Think Tanks/NGOs as primary source. A fact that the

content analysis does not show is that there is a larger dependence on NGOs as sources in Brazil than in the United Kingdom. In Brazil, the

> *Relationship with NGOs tends to be very positive. They are always open to help. It is easy to find them. I, at least, have a very good dialog with them when it comes to environmental news. There are a lot of NGOs that when they cannot help at that very moment, they nominate another person. It is easy.*

Still on this point, another science journalist argues that

> *Consequently, the use of official data sources is a caution we habitually take. Because that way we certify it is not a preconceived idea. It is a matter of making sure the chosen institution has the capacity to generate useful mathematical information. In that sense, a university is a university because it had to undergo a series of requirements to get the university status. It was accredited, evaluated. A research institute, a governmental research institute is a part of the government so we trust them.*

This presents an important discovery: the beneficial and even preferential sourcing from NGOs in Brazil is not shared in the United Kingdom. This contrast is seen throughout the interviews. In the United Kingdom, science journalists have a much more sceptical take on NGOs' data presentation. To them, NGOs often have a conflict of interest that affects the objectivity of information and therefore the communication of any scientific findings. Conversely, most interviewed Brazilian journalists agree that NGOs are a trustworthy source of statistical information. Furthermore, they suggest that often they are the only ones who can access certain types of data. In any case, unlike the blind trust in scientific journals and government sources, NGO sources are generally taken with a *pinch of salt*. That's because, there are several types of NGOs and then

> *When it comes to NGOs, when it is a serious NGO, working with scientists, then it is ok. But we have to be careful, or it may be a type of*

> *NGO that has a company behind them. Thus, whenever a company sends me a press release with numbers, I will ask how the data was collected. No matter how well known the company, I will ask how the survey was conducted. That is something we often do: we question regularly how it was done. We often send public opinion data to specialised people to evaluate if the sample size makes sense, etc. It often does.*

This is an essential insight into the ways statistics are used in the articulation of news as it corroborates one of the key questions in this research: how do science journalists understand statistical information? According to these interviews, science journalists are often critical of statistical data. Moreover, they are aware of its standards and routinely follow an orderly course of news production and articulation of statistical information in the story.

8.6. Protocol

Contributing towards these methodical ways of proceeding, gathering, understanding and communicating statistical information in the news about science, they further explain that they

> *Have a protocol: even if a study is in the cover of Science magazine, we have to question its veracity. Some scientists do not deal well with this situation. They often question who are we, journalists, to question their data and validity?*

That is the process. They gather data from known, well-trusted journals; they agree on its validity, thus not requiring further verification and communicate it to the public, as they understand it. Within that perspective, in the same way that news articles are often legitimised due to their protocols, scientific statistical data are legitimised by their methodologies. According to one science journalist, in terms of technical methodological procedures, sample sizes, and the number of studies, among other

factors, are crucial. As a matter of fact, in terms of background information, sample sizes, for example, are

> *Always important. I do not think that the number of people involved in the research, is that important. The important things it that the research comes from renowned universities that "have a name" –for example, in the United Kingdom, the University of Sheffield is an important University, Cambridge is important; in the United States, Harvard is, San Francisco…are the main universities. Therefore, if the researcher is from one of those universities, we are satisfied with only that information.*

Despite further corroborating the understanding of how science journalists understand statistics, this information contradicts the content analysis findings. Better yet, it presents a rather unusual picture where the journalists understand the importance of key background information but do not find it relevant to communicate to the public. Possible hypotheses for this finding include the notion that the general population lacks the required knowledge to understand the importance of this kind of information. Altogether, further research on the matter would be needed. For this research, however, it is important that science journalists are at least aware and know what they are doing.

> *You know, I am not a peer reviewer but I know what I am saying. The breast screening that involves 60 million women; you know that this is far more definitive data. And, you know, you have a vague awareness of what statistical trickery people can use, like the p-value forces and small samples sizes to look for lots of different effects that can normally get you something of significance. And I suppose in my head I do a trade-off between the sample sizes and the interest of the study and the extent to which it is a serious study; and then it does not necessarily mean that something to do with a low mean sample size I would not do it, but I would do it more sceptically. And some problems do not matter all that much; they might not be interesting; you know, something about monkeys.*

This exemplifies that journalists are knowledgeable about statistical generalities and most importantly their means of manipulation. The understanding that statistical information can be manipulated and thus is not always objective is crucial to a better representation of such information in the newsroom. In that regard, this data is important to this research analysis. Again, it provides further confirmation to the hypothesis that statistics are essential in making news objective and that the improvement in its coverage could have positive effects on the process of policy formulation and decision-making. As this research has exemplified, these generalities are crucial to both presenting objective information as well as improving its uses in the newsroom. For example, as one journalist argues, they often present observations in a non-technical manner.

> *In terms of sample size, we often usually give you only the generalities. For example, "the study involved the monitoring of a thousand people over x years". Or the opposite, where we are publishing something that is very interesting, new and such, but it must be taken into account that it is a very small sample; that its toxicity was tested on only 5 individuals, etc.; that in the research processes there is still a long way to go; that the public should not anticipate too much; etc. So, yes, I do not think we present it in a technical way, but we present the generalities.*

This same journalist continues that,

> *Often, though, this turns into a chaotic situation. That's because common sense tells you not to think that if you have evidence that something does cure cancer, then why not give it to everyone. Then you say, wait a minute, this study did not have any clinical study of episodic cases – even though so-and-so healed ok. What does it mean?*

This self-awareness and critical thinking is essential to the articulation of news, statistical information and the communication of science in the news. This finding shows that this protocol appears to be rooted in the very essence of the

communication of science using statistical information. In fact, it is this fundamental nature of handling and understanding statistics that needs to be followed throughout the processes of communicating science. In the end, one science journalist believes that

> *If there is a methodology, a protocol to be followed, it has to be followed by the ordinary citizen as well. But it was terrible to explain this to people. Even inside the newsroom, people thought it was a bureaucracy. But bureaucracy is the reason remedies are safe, because they follow this methodological protocol. It is not easy, it is incredibly hard to explain but I think it is crucial to give them at least a notion. You cannot write in technical terms – for example, p-values…these terms I barely understand myself, but these general pieces of information it is always important to present to the reader.*

Although this may be true, according to the statistical analysis conducted in Chapter VI, in case after case newspapers were inclined not to share with their audience the research's sample size, whether it was based on an observational study or survey, etc. Thus, if journalists know the importance of following a protocol and in fact state that readers must follow it too, why do they not present the public with the required information to make an informed decision. If that information is clearly relevant for the journalist, why is it not given to the audience? Is that information not relevant for them to know? For interviewed journalists, there is the challenge of lack of time. To them, this information is

> *Always relevant but sometimes I am rushing the time of the article. I am sure there are occasions when I have not put it in, but I think it should always be there. It is actually quite a good test for me as an editor. If I am reading an article over and, at some point, it did show results from a survey with a sample size of 12 people; then it is quite embarrassing to have that in the paper. So it is quite useful to have that as a check on myself. To ask myself, would people find it odd if they read the sample size and if they did, should the sample size really not be published or at mentioned? In that sense, if it is really interesting, the sample size of one is such an extraordinary result and such a unique result that we have to*

go with it. For example, a surgeon made a man with a [shattered] spine walk again.

With attention to the reader, how important are statistics? One science writer thinks that:

Is important for them as well. If it were not, we would not be so emphatic in having them.

As a matter of fact, what journalists are expressing is that statistical data is not only useful but ultimately is as crucial as a source:

I suppose it depends on whether you believe in them. I mean, statistics are the reason why modern society works and exists. I do not have anything to say and I mean the developments of [statistics] are the sole reason we do not burn witches. Yes, I think that statistics are very important.

In fact, on this, there is general consensus. All interviewed journalists have argued that:

If I do not understand [the data], I cannot publish the article because I have responsibility for what I write.

This elucidates the importance of statistical information as a news source. It further argues its use as a means to legitimize news and its role as a key rhetorical tool in the decision-making process. Within this context, one science journalist makes that point very clear when stressing that:

When we write a story, we are leaving a thousand other stories and reports aside because you have to make a choice. So you have to question yourself, why am I going to tell the reader, why am I going to give space to talk about studies on baboons today and not a thousand other things I could say or give space to? So yes, Science is okay; it is an important journal, validated and with credibility, animal behaviour is cool and

> *readers tend to like it. But is it, really, a worthy study? Has it been replicated? What is its methodology? We question everything. Some tend to bring it to the science area, but no…you need to question the methodology. I think it is crucial to question numbers. To question if they make sense, when it was done, etc. To take it to other sources and have them question, evaluate and speak about it. To say, this looks weird, this sample size is too small, etc. This way, you have a more credible data in your hands. This way you can be sure that the data is a validated piece of information.*

The selection of science information is important to understanding the articulation of news and construction of science discourses in the news. This further validates the assumption that science journalists prefer authoritative sources for statistical information as they provide the objective ground journalists are ultimately aiming for. Furthermore, this response again verifies the basic understanding of science journalists when handling science news and statistical information. It clarifies that none have statistical or scientific training, however, after years of working in the business must believe themselves to be confident *enough* in its terminology to communicate information. Please note the emphasis on 'enough'. None believe themselves to be an expert. They merely agree that they have enough common knowledge to communicate news, considering that the public itself lacks this knowledge from the very start.

To this research, this is a central finding: statistics are used to articulate news of science, however a non-expert who often has time and space restrictions communicates them. The research literature has established the importance of statistical information in the formulation of an objective ground. However, "newspapers are a finite size" (Gregory & Miller, 1998). Thus, this research has found that due to lack of either training or time and space, statistical information is often misused in the articulation and communication of science news, but errs whom

thinks that journalists do this consciously, or that they do not care that they are producing possible wrong information. As a matter of fact, most interviewed journalists have shown disconcert and even embarrassment within the environment in which they need to make decisions and write science stories.

> *Sometimes, a research resulting from a small sample size can be extremely important for the context of the situation. Sometimes the key finding ends up not being the most important point. In any case, the space is limited. It is very hard to produce a good piece of science news, especially a complex subject like science, but it is possible. We want to properly explain the science, but there is no space. It is very hard. Some days I want to cry because I cannot explain all the science behind the article in the small space available.*

8.7. Visual Numbers

As an answer to this lack of time and finite space, visual data have become key. This is another key finding of this research: visual information are a particular choice for journalists who want to write about science.

> *I think that graphics are good as a visual element. Sometimes, for example, the reader will read the info-graphic and not the article. That is not a problem. More so because, I was the one who did the info-graph – that is, the arts department and me. I think that graphs are an interesting resource, especially in science news, because it is a theme that needs to be dealt with more delicately. It helps the reader to contextualise and even "see" the statistics. That is a new tendency in journalism; for you to reduce the article [word count]. To make it small.*

Here, this finite space in newspapers becomes even clearer. Visual data are presented as a response, a loophole, to this deficit of space. Still on visual information, one science journalist argues they:

> *Prefer to use visual information. In fact, sometimes it becomes a problem because when we are writing, there is a high demand for the text to be shorter to give privilege to visual information. Especially in terms of scientific graphs, may they be info graphs or didactic explanatory graphs*

> *that show how the experiment was done, or even normal graphs: flow charts, bar graphs, etc. There is a preference for them!*

As a matter of fact, he further argues that

> *We dedicate a lot of thought and effort to designing the best way to present given data in a manner that is accessible to the common people, who perhaps do not even have an interest in science or are not able to process that pile of information. With visual data, we try to present things in a synthetic and informative way, but at the same time attractive.*

If on the one hand, visual data are appropriate and often used as a means to shape science discourses, on the other, at least one journalist noticed an even bigger lack of education towards its production and communication.

> *The whole problem is that people have a very low ability to read charts and graphs, in its traditional sense of x-axis, y-axis, pie charts, etc. I find it impressive, how in the newsroom itself, including graphic designs that often work with this, people often make conceptual errors. Even in the production of flow charts. For example, when the data must be presented annually and the last year is incomplete and you only have eight months of data, and not twelve, they often do not understand that those are two different data. You can perhaps put a dotted line or extrapolate but you cannot use the two pieces of information as being the same. I notice these fallacies because I have some understanding of numbers, but it is usual for the reader not to understand why you cannot add an eight month data point on an annual graph. It is relevant information but you have to compare equal periods. Charts are comparisons – what people often do not understand is that a chart is showing you visually what is really a comparison.*

From this angle, there is a fundamental lack of understanding of how visual information works, due to the inadequate capacity to peruse outlines, charts and diagrams. Still with this in mind he further argues that

> *There are a few other problems, which I think are not relevant to your research theme but the other side of the coin is that there is a certain dictatorship of visual information – which includes photography and*

> *more. That impairs the proper communication of science. I am a text journalist, a science journalist, and I think text is highly undervalued. They have very little narrative; they are very short, and poorly written.*

As pointed out by the journalist, this is not the focus of this research. However, the scrutiny of this dictatorship of visual information is an additional point of view and area in the study of statistical data in the news. Therefore, it is a good proposition for further analysis and research. In the framework of this research, however, one science journalist argues that they

> *Try to do long, highly interpretive texts with some graphics, but it only gets reported/space for online use. Online there are no space limitations. You can add a video, photo, also various charts – including some animated graphics with interactive sections, etc. For example, you can click, you can turn, you can see the flow, show the transposition of the São Francisco so that you see it all the way as if you were flying over. These are the sorts of "experiments" that we are currently doing. Trying to figure out the best way to match text without affecting the narrative, but within daily news it is more difficult to do so because the limitation of space is greater.*

But is there a difference between Brazil and the United Kingdom when it comes to the presentation of visual data? The concise answer is: yes. However, it is primarily a design-related one,

> *Yes, we do not use graphs that much at all. I cannot remember the last time that I used one in a news story. Partially that is just the function of a current newspaper design in which were made a decision to make, to try to cover lots of things in the paper and that means squeezing them in lots of different places, having shorter articles everywhere. When we used illustrations we wanted to have visually interesting illustrations, pictures. I think that is probably the reason why we left it; we wanted to be, you know, graphs… which can be useful, but they are not immediately something that comes to mind. They are also, you know, a lot more work to put on your own graphs. But that is a slight change I started in the newspaper; we were more interested in doing fewer longer articles and then we would quite often have graphs of some sort, depending on what we were illustrating. So we can go both ways.*

For this research, it is interesting how the difficulty and question to be solved always returns to the finite number of pages. Visual data are used to articulate science news in a short frame of time and space; however, giving room to visual representation also cuts important space to develop its narrative. This is a distinctive condition, and a weighty finding of this study. Therefore, how do the different newspapers deal with this dichotomy?

> *The Guardian has a lot more space, because of the size of its pages as well. So having that better format enables them to do more things then we can. And yes we just have taken up a different design strategy. Basically. And it is not much more complicated than that. It has just been a decision that we imposed this year. It is the right thing for a newspaper…so there has just been a decision made that we needed a lot more articles and what we would have left on the side, that sort of thing. Also The Guardian is very much website first and gets a lot more space than The Times.*

Ultimately, I found that the application of visual representation in science news is not only founded in this lack of space within the limited number of pages of newspapers. Its preference is often related to its applicability. Science journalists often use visual information as a means of presenting complex information succinctly and in a short period of time. Visual data are faster and easier to read, comprehend and therefore communicate. Moreover, it is suggested that it is key in attracting readers. Good visual information can appeal to the readership when the information given is as highly technical as science, often does not. Still, as pointed out, at the end of the day the choice is an editorial one.

> *Generally, in daily journal newspapers, there are not that many articles where I think it would be very nice to have a graph. I mean all the graphic is showing is bars because of this bar or is the… here is a scatterplot, then I am not sure how useful it is, or how much it adds to the story anyway.*

8.8. Uses of Numbers

On that premise, it is also important to look not only at the statistical sources but also how they are used in the articles. Different ways of using it means completely different ways of using it as a validating tool and a means of discourse shaping. In that sense, across the interviewees, it seems that journalists .

> *Normally we use statistics as a background in the story. I mean, normally, in certain journal articles, the statistics do not normally stand out as extraordinary enough to make a point of why you are using it. Normally, I would…normally the intro is very basic boring news stories, you know, "porridge raises or lowers your risk of heart disease" but then you might say in a certain paragraph "the study of 500 porridge eaters found they were 20 per cent less likely to die of a heart attack than 50 per cent…". These bits and pieces are not the reason why you are doing it. But it depends on if you discovered that eating porridge makes you a thousand times less likely to get liver cancer or something; that is such an extraordinary statistics that I think it is worth putting in right on top of the story.*

With regards to the uses of statistical information, there was a consensus that its data are fundamentally utilised as background information. They are used to substantiate, validate and legitimate the story and its ideas. That is to say, generally, that statistical information are often not overly evident within news articles of science. The previous journalist, for example, points out that statistics are regularly taken as a background, and therefore it does not stand out too pronouncedly. To another journalist, on the other hand,

> *No, it is always important to build up your strength of numbers. Certain research will give you a new number, and you can improve its legitimacy with an old number. And maybe this new number shows an evolution of that subject. Or this new number shows how for example, again, a certain experiment reduced by 20 per cent the chance that the lab rats' develop a certain type of dementia; estimations that in Brazil there are 8 million people with difference dementia types. This number is very interesting because it shows the scale of the problem.*

As a background or to substantiate stories, statistics are crucial in shaping discourses of science in the newsroom. To one journalist, when it comes to news of science, if quantitative data

> *Are there not then science probably has not been done. So they are absolutely crucial. It is absolutely crucial to know that they are there. I do not necessarily think this in all examples, but it is particularly crucial to say as much to the reader. Sometimes they are not particularly interesting, sometimes they are very interesting, sometimes they are not very interesting but they need to be there. Like, you know, the engine in your car. I am not especially interested in what my carburettor cylinders are doing, but you do want to know what the carburettors do. So there will be some things where if …someone discovered, for example that monkeys like to get drunk and steal people's cocktails at the beach, now, I want to know, that someone sat there and a certain number of monkeys, in a certain period of time and recorded a certain number of incidents in which the monkeys have taken cocktails and concluded that this is a statistically significant measure that there is a statistical link between monkeys and cocktail.*

This responds to the question of how statistics are used in the newsroom. Numbers are crucial. However,

> *I do not think anyone particularly cares, as the reader, about the precise nature of those numbers that they were hoping that I accept that I trust the finders to check. So it is not always important for the reader to see them, I think, but it is always important that they are there. A lot of times it is important that they are there and it is important for the reader to see them. That also means I need to be absolutely critical about the statistics that have been found: "two hundred per cent rise of a particularly rare blood cancer" it is very relevant for the reader to actually know what that means, what that goes through, that this is one in a hundred thousands, two in a hundred thousand or whatever.. So, you know, it remains very rare because if you say a hundred per cent rise, it seems very catastrophic.*

8.9. Shaping Discourses

For this research, one of the most important discoveries stemming from the interviews is the corroboration that statistical information is important to the audience:

> *We always bring out that "this research open doors to new therapies that could be developed". That is something that we always make very clear because, every piece of research, in its last instance, is interesting to something. Sometimes the reader will read the article and ponder: what does that have to do with me? But it does. Now, it might not seem a lot but in the future it will be useful to him/her in some way or another.*

By these means, it is also essential that the readers are able to be critical and able to digest numbers for their own understanding,

> *A good rule of thumb for journalist is to think that your readers are intelligent, interested but not experts. (...) I would not use jargon and P-values or chi-square test's request or something. Normally, I would not be bothered. I might say that this is the statistically significant result but I would not necessarily tell you, you know, there are 0.3 per cent or whatever. (...) I do not think the readers would understand everything that is in the papers. I mean, frankly depending on what I am covering, I also do not understand everything that is put in the paper. By paper I mean the journal paper, not the newspaper. So I do not think they would understand everything that is in the journal paper but I hope they would understand everything that is in my article about it. And I should never be putting anything in the article that I do not understand. And I surely should not be putting anything that the readers would not understand. I mean, by the times it reaches the article, then I would expect anyone who buys* The Times *to be able to understand. I mean if they can't, then I would not be doing my job correctly.*

In fact, this research has found that this is a determining factor when shaping news discourses of news. They are used as a means to legitimise information but they also need to be understood by the audiences as ultimately they are used to bolster stories. At the end of the day, can statistics be used as a means to shape discourses of science?

> *They can be, I am trying to think of statistical examples…statistics are useful to bolster stories, they can be useful to, you know, misuse to bolster weak stories. I mean the classic example I was talking about is relative rather than absolute rises. Them saying that this particular inspection will make it far more likely than something that's completely rare, to the extent to which they affect the heart of the discourse we have in science. In environment there is a lot, a lot of it; then you know single numbers about either something like Himalayan Glaciers (...) or about the*

> *definition of the poles that are 50 per cent of the size that they were in the 1970s. That is a big number that become a crucial number in the debate. In science we tend to just sort of evolve from day to day happily writing about dinosaurs, etc. and whatever else we do. So I just think statistics are a useful part, whether it is a sign post or reason that the science is there at all.*

All this considered there seems to be a consensus on the significant role of statistics in the articulation of narratives and shaping of science discourses in the newsroom. Statistical information needs to be intelligible, while also reinforcing social and cultural views, as well as be preconceptions and expectations of the desired social reality. In this sense, it creates the means to construct social and media reality. That's because it provides information that articulates reasoning. Indeed,

> *Statistics are very important because numbers… we always say, it is a question we always ask: are there numbers? It is an important thing because it supports the article. (…)…if you do not speak in the numerical language, it looks like you are digressing. You are instituting a rule that does not exist. You need a number that supports that research. For example, a certain experiment reduced by 20 (twenty) per cent the chance of the lab rats' developing something; we need this "20 (twenty) per cent" because it gives us the dimension of the research. This number is always essential. In its vast majority, the papers – at least the papers that are usually published – have numbers. That is very important.*

8.10. Training

Indeed, amongst the interviewed science journalists, there was a unified sense that statistical information is crucial in the production and legitimation of science news and knowledge. Confirming the data presented in the previous chapters, principally Chapter VI, statistics are regularly used as a means of assigning science news importance, legitimacy and objectivity. In spite of that, the interview and interviewees themselves make clear that there is a significant gap in mathematical education. There

is a clear awareness of statistics and their values, but little more than a general knowledge of it. To a particular journalist:

> *Really, that is where the rubber meets the road because I do not have any training in statistics. I have never done any scientific activity that forced me to use any statistical package, as I know that many researchers have - even without understanding these softwares too. Things like R Square, p-value, etc. Thus, I consider the following: first, if it was published in a journal, a scientific journal. [If that is the case,] you assume that it was reviewed. And that, if there are any gaps that may lead to major statistical discrepancies, that these have been resolved in the review process. It is an assumption that we use every day. I would say the vast majority of science journalists, at least in Brazil, does not have the expertise in statistical information to make an assessment of the methodology and tests applied in that particular article, in that particular research. Eventually you take a look at the margin of error, sample sizes, but it is more a matter of intuition than of technical knowledge. It is an informed critique. For example, let's say you are publishing research in medicine. You looked at the methodology and it is a sample size of 10 people. You understand that it had a very limited validity. It may be an important indicator for the future, etc. [but it is limited]. It is different than, for example, if you get a piece of meta-analylitical medical research that has a pool of 200 items and represents an n of 200 000 people. You know that the statistical power of this is much bigger; but, as I said before, it is more an intuitive thing than a technical capacity. Like you, any science journalist knows that a new anti-tumour study with mice is one thing, with humans is another. It is this general scientific culture order that journalists often rely upon.*

If the importance of the uses of statistics in the newsroom is agreed upon among interviewed journalists, the lack of training in its knowledge and information is even more clearly articulated. All interviewed journalists argued they have a basic knowledge of statistics, but no training in it. As a matter of fact, most have never done any scientific or statistical training and often have not been in a position or activity that required any knowledge of statistical packages or analytical programs.

> *Another thing we often do, whenever you have a higher degree of uncertainty, either due to statistical questions, the interpretation the*

> *authors are giving to the data, or conclusions that are being done, is to show the original article to another researcher of your confidence that has no relation to that work. As a matter of fact, academic journals often send us – via accredited means – each of these articles prior to publication while requesting that we do not to publish it before the end of the embargo. The embargo period serves precisely this point, for you to study the subject and eventually, confidentially of course, submit the article to another person you trust – as to tell you if the result is important or not, if it is pioneering or not, if the statistics are good or not, if the methodology is good or not, if they should have done this or that, etc.*

That because,

> *Sometimes the journals Nature and Science are also known for doing a bit of sensationalistic work by choosing the most "sexy" research to disseminate in the abstracts that they send to journalists.*

If even the most renowned journal can be biased, how does science journalist discern good statistics from "sexy" ones?

> *My expertise in statistics is, if not zero, 0.9. It is incredibly low. I really do not have any training in the area. I have a notion, I understand. But I have no training. You know, when you spend decades in the area, you acquire a certain sensibility to [knowing it]. In that sense, I think it is important to distrust that a number can be less important than it looks at first glance.*

From this perspective, a general finding of this research is that science journalists have no specific training in the uses of statistics. This can be highly problematic as it can lead to the misuse and even abuse of statistical information. Furthermore, it is such an important source of knowledge that journalists need to better understanding it and receive training on its uses. In terms of the science journalists, they use statistics so intrinsically that it needs to be better collected, gathered and disseminated. With reference to the audiences, statistical information is so widely assumed as objective and truthful that it is imperative for it to be better presented in the news. Ultimately,

whatever way you look at it, this finding suggests a need for improved education in statistics so as to improve the adequacy of the representation of numbers in the news of science.

In fact, one British journalist argues that

> *I think it will vary a great deal from publication, to publication. In specialist publications, I think a lot of the reporters have good science qualification –to Master or PhD level or even beyond. They are generally quite well qualified to use and examine statistics. Quite often in national news media, the journalist might not have the same level of scientific qualification. They would often come from a different discipline and would not have a science background at all. So you end up learning it with practice. And you can teach yourself statistics, but that takes a long time. And some journalists do not bother. That leaves national news quite dependent on press releases.*

8.11. In Numbers We Trust

For this research, this is an essential matter. How important is statistical information to the articulation of news? What about in terms of narrative construction and shaping of discourses of news? Similarly, how important it is to the general public? One science journalist advocated that:

> *I would go further and say that statistics are important to everyone. If you want to be an informed citizen nowadays, you need to understand numbers. The newspaper, television, everywhere is filled with statistics. Everyone bases themselves in research studies. "Study shows" this and that…but does it really? How many people participated in the study? What was the sample size?*

This trend is seen throughout the interviews. There is consent that statistics are fundamental to most aspects of society, especially in terms of science and news:

> *I would argue that understanding statistics is a matter of basic scientific culture. Even a person that finished high school should not have any problem, I believe, in understanding numbers. On the contrary, as a journalist I wanted to have learnt more mathematics and statistics. I think I would have been an even better journalist if that were the case.*

Still, at least one science writer has exemplified that the poor education of mathematics within these countries, creates a problem in the articulation of information and news.

Within this research's questions and framework, the aforementioned position is interesting to understanding whether writers of an article determine how statistics are used in the articulation of news of science? Because of this lack of education, quantitative data on science needs to be shaped in one way or another, depending on a preference for one source of information or another.

Much in the same way, what is discussed is that numbers are frequently used and are an important part in the articulation of news. However, there is limited knowledge on the principles of their use:

> *One thing I would tell you is that there is certain fetishism for numbers in Brazil, generally in the media, in a way that it gives great importance to data and new data sets. Not always with great care. Regardless of whether among journalists, opinion formers or policy makers, in general, there is very little ability to discern what is important from what is not so relevant. There was a time when any number would be turned into a headline. And you must be very careful.*

In this framework, what does this mean in relation to this research and its central argument? Conclusively this sums up the evidence of this research. To this research, it presents one clear argument: Statistical information is quintessential to the articulation of news and as a means to shape discourses of science in the newsroom. Nevertheless, precisely within the newsroom and science journalists, there is little ability to recognise and determine what is pertinent and what is not relevant. This finding is fundamental to understandings statistical information beyond its uses in the news and more so in the newsroom.

> *People often reproduce information very uncritically. I believe too much space/importance is given to monthly governmental data. It is very good because it is incredibly transparent, and published monthly; but the press looks too much into it.*

This further backs up the belief that individuals regularly repeat information uncritically. Considerably more worrying is the fact that journalists and editors often reproduce statistical information uncritically, and often carelessly. This is hugely problematic to the communication of science.

> *People attach too much value to these percentage changes when it is not so significant, not so important from the point of view of valuable pieces of information. These are examples of what I think is missing in the edification of people in general, science journalists, and all kinds of readers. There is a lack of ability to handle numbers in a more critical way, to have a better critical sense towards numbers that are printed daily in newspapers everywhere. This is what I call [number] fetishism. They attach greater importance than one's own understanding, one's own capacity for processing numbers.*

This is evidence of the following condition: this uncritical use and representation of statistical information, fuelled by this so-called number fetishism creates a situation in which its data is crucial in the argumentation of information but that few know how to use properly.

> *They are deep down inside, not equipped to assess that numerical importance – if it is too large or too small, if nature or the government sources it, if it is good data. Everyone has to be able to, at least, notice the propaganda. This is the least we can do with all this, to be critical of all data because no correlation with the figures that are published.*

Ultimately, why is statistical information important to the communication of science and science news?

> *We say that it is something that is ironic, someone who "does" journalism, chooses humanities because we wanted to flee from numbers, but we get here and what we do mostly is deal with numbers. So it is important because numbers give you dimension, they give you dimension of the problem. I cover climate change a lot, I am a science journalist, but I am a specialist in climate change. And numbers, for me, are fundamental. The goal is, for example, that the temperature does not rise X degree centigrade, but if we continue as we are now temperatures will rise, at least, 4 degrees centigrade.*

As previously evidenced, numbers are habitually offered uncritically. In this framework, what would it mean to present statistical information critically? How could science journalists communicate it in a more active and informative way? Following the previous example, for one science journalist:

> *To give this particular number is fundamental, even because, this is the number that is being negotiated internationally. So I have to explain this number, what it means and what can happen. For example, the quantity of rain storms in the west of Amazonia will fall 45 per cent. The west of the Amazon will go through a process of becoming a savannah. So one needs to give the data and explain what that data entails. It will fall 45 per cent – what does that entail? What will happen? It will turn into a savannah. So without this quantitative data, this data is alarmist. It is a fundamental piece of information. (…) The reader feels attracted to numbers. And I feel attracted to them as well. Numbers are what people will talk about. That is only one example of how important numbers are, how indispensable statistics are. It is very hard to convince an editor to publish a piece if you do not convince him/her, and to do so you need a number.*

Presently, statistics are indispensable in the communication and shaping of discourses of science in the news. As a matter of fact:

> *Statistics are crucial. I would say most of [scientific] articles, especially NGO (Non Governmental Organisations) reports, are based heavily on numbers. (…) Really, it is very important as the…, as long as they are reliable, they are much more eloquent than a value of judgment, than any other source. It adds another element to the discussion.*

Indeed, numbers are crucial. Still, in spite of this:

> *Every journalist has to make subjective choices. To believe that journalism is objective is an idealisation, a utopia. Consequently, when I read a scientific article, I have to select which story I am going to tell about that study. And, most likely, in a daily newspaper, I will be able to focus on one or two data points. Maybe I will be able to explain a little bit of its methodology: the scientists from this or that place found this or that information. That is it. There is not enough space! I normally have to select pieces of information. In those cases, what we usually do is to talk with the research team directly. To ask them what are its key findings. "Of this study, that you found 20 (twenty) data sets, which one is the most important?" "Those?" So those are the ones we will write about because you cannot talk about everything. There is too much information. You have to choose, to discuss two key points. And that is extremely subjective.*

Ultimately, this is the central argument of this research: statistics are used as a means to legitimate science news and information. Moreover, statistics are used as a tool towards the strategic ritual of objectivity in their social construction of science. However, within the newsroom, subjective decisions are made. Editors and science journalists opt to focus on this or that statistic. Therefore, it cannot be taken outside of the context. It can be used and most certainly is used as a rhetorical tool, but it must be understood as a tool that is often also manipulated. In conclusion, thus, statistical information is used to shape news of science as serious news of widespread importance.

8.12. Discussion

The interviews mentioned above validate the findings in Chapter VI and VII. Sagan (1995) argues, "in all uses of science, it is insufficient –indeed it is dangerous to produce only a small, highly competent, well-rewarded priesthood of professionals. Instead, some fundamental understanding of the findings and methodologies of science must be available on the broadest scale" (Sagan, 1995, p. 37). Still, it is clear

that most science journalists have no training in the methodologies of mathematics. There is a clear gap between the importance of statistical data and its comprehension by journalists. This research highlighted two main issues: (1) the first one is the types of limitations that journalists face when they validate and process data, and their over-dependence on official, academic sources to do this for them. (2) The second is the problem of training, taking into account that none of the interviewed journalists have the proper training to gather, interpret and present an authentic interpretation of the scientific information.

It seems that journalists and news editors feel that the reporting of statistics feeds the process of science communication, therefore strengthening the initial hypothesis that improving its coverage could have positive effects on the process of policy formulation and decision-making by reducing public anxiety and pressure on policy formulation.

However, given the problems of accessing and validating the data, the traditional mechanism of verification and validation frequently used in other areas of journalism are not performed by journalists and sub-editors. Therefore the public tends to receive information that is not always up to usual standard. Hence, the public has a limited scope to make well–grounded interventions in the process of decision-making.

8.13. Conclusion

In terms of this research's framework, the foregoing research findings and close reading analysis of the uses of statistics in science news, suggests the following outcomes. The articulation of statistical scientific information in the media has an influential impact on the construction of science. This is due to the fact that knowledge is an essential rhetorical tool and crucial in the development of the process

of decision-making. Thus, its understanding is critical for an informed societal environment. As evidenced by the foregoing findings, citizens should have more influence and general knowledge on the perception, construction, and representation of scientific information. This section, composed of three chapters, has presented the empirical findings from the content, close reading and in-depth interview analyses. With reference to this research, these chapters aimed to understand how statistical information is used in the production of science news articles.

Current scholarship suggests there is an on-going miscommunication between the scientific community, media and public due to the misrepresentation, miscommunication, inaccuracy and distortion of scientific information (Sumner, et al., 2014). While the mass media are considered a vital means to form public opinion (Peters and Heinrichs, 2015), the findings suggest that news coverage of scientific issues habitually uses statistical information as a means to make news objective. In this framework, it legitimates science information while shaping discourses of science in the newsroom. However, the findings also indicate that science journalists often misrepresent its statistical information (1) by under- or over-using numbers, (2) by not informing readers on the raw data, methodologies, etc., but most importantly (3) through their selection of data. In various aspects, this study illustrates more general features of the way in which the media report social statistics (Best, 2001; 2004) and contributes to the social scientific construction of social problems (Osborne & Rose, 1999). Additionally, it evidences the lack of statistical knowledge and time constraints faced by journalists (Lugo-Ocando & Brandão, 2015); as well as how statistical information needs to be contextualised (Franklin & Carlson, 2011) and correctly used (Huff, 1954).

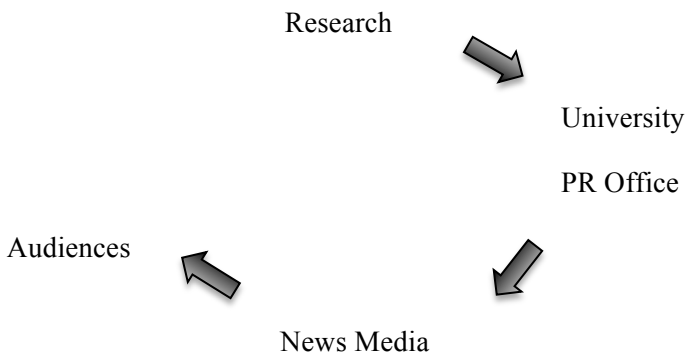
This evidence, however, is a reaction to one major problem and general characteristic of current society: the lack of literacy in statistical and scientific information. There is an expanding body of literature on the lack of mathematical literacy among the general public. Overall, it is believed that citizens do not have a grasp of basic scientific facts. Within this perspective, it is important to look at a journalist as a mediator of science information, as a facilitator of knowledge in an interpretative community (Berkowitz & James, 1999; Zelizer, 1993). Moreover, a better understanding of statistical scientific facts is imperative for a better understanding of science-related news. As a matter of fact, this research's hypothesis that improving the coverage of statistics could have positive effects on the process of science communication and decision-making was proven by the findings. From this angle, Maienschein (1999) argues it is not only important to keep up with science-related news, but also to evaluate the validity of any information – especially that which may influence the political process.

The main reason there is a lack of proper communication of scientific statistical information in the news regards the Science communicators' belief that there is no general audience for information on science. To them, articles must be tailored to the needs and knowledge level of specific audiences. In that sense, there are two recent trends that make this more difficult: (1) the Internet has revolutionised communication and (2) news reporting has become increasingly fragmented (Borchelt, 2001).

Reports on scientific studies, even those written for lay readers, often include supporting statistics and related terminology.

When scientific academic papers make their way into the media and end up in front of the eyes of the public, science news processes often work as a broken telephone,

affecting the clarity of the information:



Due to the general lack of statistical and scientific literacy, this cycle of passing information from one stakeholder to the next, often accumulates errors in the retellings. The Programme for International Student Assessment (PISA) finds that Brazil performs below the OECD (Organisation for Economic Co-operation and Development) average, with 391 score points. Comparatively, the United Kingdom's mean score is 494 points. Undeniably, in relation to previous assessments, Brazil has improved its performance in mathematics, reading and science. "Figures accounting for social and demographic changes between 2003 and 2012 shows that this improvement in mathematics performance results, for about half, from improvements in the economic, social and cultural status of the student population" (PISA, 2012). However, its low levels of literacy still suggest a significant need for improvement in the development of the presentation of statistical information – as well in the schooling of such. Somewhere, within that circle, needs to be restructured thoroughly.

For the purpose of this study, the scrutiny concentrates on the media section and, therefore, its need for a statistical reformation. Numbers derived from academic journals have been widely used – and often misused – without context, perpetuating thus the miss-education of the mathematical language. When science journalists choose not to provide context, they limit the information presented to the audiences. Moreover, it takes away the full picture. Science news loses worth without contextualization. And that is what makes, or should make, scientific statistical information and news relevant to the construction of science and social reality. The study reminds us that the mass media is produced by people that are pressured into creating news quickly who, in doing so, avoid one of the core principles of journalism: context. The resulting effect is the production of a constrained version of facts; a particular version of reality.

In several European countries, the scientific community has been meeting with the public to create a scientific public arena and to generate a more scientifically sound population. Case histories can be seen in cases such as the Danish panels of consultation, the Arenas for Risk Governance project (funded by the European Commission), the events in connection to nuclear waste management in Sweden, United Kingdom's People's Panel, the weekly consultations with ministers in Iceland, Denmark's special committee for EU policy-making, among others. These examples seek not only the dissemination of scientific information but also the wider contextualization of academic research within the daily reality. Another less formal example of this need to create an open space for the discussion of science is the festival 'Pint of Science' which as of next year will happen in nine countries (United Kingdom, Ireland, France, Italy, United States, Australia, Spain, Germany and Brazil), 50 cities and over three nights, around the globe. The festival aims to deliver

science talks in an open, engaging and fun way by bringing them to our everyday pub. In 2012, two research scientists from Imperial College London put together an event called 'Meet the Researchers' that brought people affected by a multitude of diseases into their lab to demonstrate to them the kind of research they did. The event was highly acclaimed and hugely successful. Since then, the interest and need for scientific engagement with the community have grown and thus the 'Pint of Science' was born.

Indeed, the mixed methods outcome of this case study points to a present need for the expansion of the scientific community to the general public. This study suggests that aside from the need to further educate the public in mathematical and scientific language, there is a need to have an all-embracing gathering and amalgamation of both the scientific and the regular community. According to the Brazilian Secretary of Basic Education of the Ministry of Education, Manuel Palacios da Cunha Melo, one of the biggest difficulties in having such a dialogue is the scepticism of many researchers who still believe that the layman will not understand their data. Still, he urges the academy to try and engage more extensively with the community. Ultimately, on the side of the journalistic community, this study makes clear the need for its members to better understand the data presented, critically think about and further diversify their statistical information and data sources.

CHAPTER IX

9. Conclusion

9.1. Introduction

This research set out to address the role statistics have in the articulation of narrative and shaping of discourses of science in the newsroom. Having presented the findings

of this analysis in preceding chapters, the task is to determine its importance in the academic field. This dissertation is critical because it provides new insights into the uses of statistical data in the newsroom. This chapter outlines the contributions of this research in the field of journalism studies. In this concluding chapter I will summarise the contributions of this dissertation, restate principal findings and its impacts, and discuss possible recommendations for future research.

9.2. Summary and Main Conclusions

The research yields diverse insights into the use of statistics in science news in the United Kingdom and Brazilian newsroom: (1) while political affiliations does not play a card in the uses of numbers in the newsroom, the country of origin of the studied newspaper does; (2) statistical data are used overwhelmingly by staff writers, and (3) to treat science as hard news; (4) most writers quote only one source and often from the (5) university. Moreover, (6) there is an overwhelming lack of fundamental background information about how the reported data are produced; (7) main reported articles are of medicine and environmental nature; (8) statistics are habitually presented by universities; (9) science journalists tend to use peer-reviewed information in a unique way: their stories include either too few or too many statistics from original sources. Furthermore, (10) there is a well-balanced distribution of mathematical information in terms of nature and number of statistics, as well as (11) nature of data and (12) how statistics are used. Lastly, (13) Brazil uses significantly more visual data than United Kingdom-based newspapers. According to this research, Brazil circulates a greater amount of science news.

The finding that statistical information are time and again used by staff writers and as hard news goes to prove this research's initial hypothesis that statistics are perceived

as a bearer of objectively derived knowledge and truth. Much in the same way, the finding which state that there is a lack of presentation of fundamental background information and that they often present data in a singular fashion shows the fundamental need for better training of journalists in the uses of statistics in the news. Lastly, the fact that Brazil uses overwhelmingly more visual data than the United Kingdom was a surprise, however it substantiates the aforementioned statement that it was the country with the largest mean performance improvement since 2003 (PISA, 2012).

Moreover, the research suggests that the process of naturalisation of science as actual knowledge has become embedded in contemporary society, which accordingly has attributed statistics as a method towards a rational way of thinking. Indeed, the interviews endeavour to clarify this pattern while looking at how journalists access and interpret statistics when writing stories about science, the nature of numbers within news sources, and how they evaluate and treat such experts in articulating science news stories. Finally, this study observes that science journalists often utilise statistics mainly to maintain the necessary ritual of objectivity in their social construction of science.

9.3. Contribution and significance of research

In 2009 an Expert Group on Science and the Media was created as part of the UK's Science and Society Strategy. One of the major findings of their report was that scientist should better communicate their research and science among citizens. This research reflects on one key factor within the process of science communication: data. It questions the use of statistical data as an objectifying tool while writing about science. Indeed, the understanding of science, statistics and media interplay is crucial

to make rational decisions, to gain aware of the significance of spreading scientific knowledge and information as to ensure that science adequately influence on daily life. This interaction is essential because it helps disseminating scientific knowledge as to make sure that science has a greater impact on people's lives. Furthermore, it provides theoretical understanding of strategies and approaches to educate the public regarding the latest scientific developments and knowledge, and analytical skills that allow the audiences to make informed decisions. Within this framework, this chapter proves the importance to communicate science statistics as it is essential to the public understanding of science and therefore to the decision-making processes. Science has a significant impact on society and daily life and therefore it is imperative to understand its fundamentals and how its information is mediated. Undeniably, scientific knowledge is valuable to humanity. In this context, when communicating and disseminating science information, journalists are contributing to the scientific literacy of citizens. This chapter questions this contribution in the news media and on daily life.

The main contribution of the thesis is a better understanding of the use and abuse of statistical data as primary means for the construction of journalistic objectivity grounded in a triangulation of quantitative and qualitative empirical data from content analysis, close reading analysis and in-depth interviews. This conclusion is specific to the area of science journalism, and particularly to Brazil and the United Kingdom, as it analyses the uses of statistics in the news of science and how science journalists articulate this data in the newsroom within the two nations. The findings confirmed the portrayal of statistics as a means for the construction of journalistic objectivity. The study found that science journalists use statistics to maintain the strategic ritual of objectivity in their social construction of science. Among other outcomes, it

established links between the uses of statistics and the portrayal of science as hard news. It exposes a gap in the description of fundamental background knowledge, especially concerning methodology designs, of reported data. It also shows a general need for a better systematic training of science journalists in the use of statistics in the newsroom. This is crucial for the improvement of the exposition of science in the news and therefore the public's understanding of science. The research exposes the importance of communicating science as essential to the public understanding of science and therefore to the decision-making processes. Taking into account that modern society lives in an era of information, it is ever more crucial to properly present information. So why is it important to communicate science?

First and foremost, the communication of science in the news is an ethical duty. Society and its masses have the right to know, much like in journalism, the "Five Ws and one H". It is essential to understand *what* is being discovered, by *whom, when, where, why* and, more often than not, *how* this information is being studied. These questions are key to rhetoric argumentation and therefore the making of rational decisions. Furthermore, science has a significant impact on society and daily life and therefore it is imperative to understand its foundations and for it to have a connection, even if mediated, with its connectors –such as public, society, journalists. Ultimately, scientific knowledge is valuable to humanity, in terms of growth and improvement, as well as to economical and technological development. Thus, when communicating and disseminating science information journalists are contributing to the scientific literacy of laymen and citizens.

Still within this framework, why is it so important that both journalists and the public understand and engage with statistics appropriately? Statistical information offers an essential insight into rational thinking, it determines which data are relevant, and is in

possession of skills and particular expertise to analyse how reliable are certain pieces of information. The appropriate use and representation of its information is thus crucial to the correct formulation or reformulation of conclusions as well as decision-making. Statistics make sense of the world. Consequently, it is very important that both journalists and the public learn to understand and engage with statistics, as many of the decisions we make in our daily lives are based on them. From political campaigns to drug testing, all the way to the stock market, statistically based decisions and information are used throughout most spheres of society.

9.3. Final Perceptions

The research presented in this thesis has investigated how science journalists use statistics to articulate and legitimate stories while shaping narratives and discourses of science in the news. When understanding the uses and representations of science statistics in science news, three main issues need to be considered. These questions take account of the notion of objectivity as central to the discipline of the agency of journalism (Koch, 1990; Kovach & Rosenstiel, 2001; Mindich, 1998; Sparks & Dahlgren, 1991; 1992); science's aspiration to objectivity as a means to try and overcome subjective conditions; as well as the association of statistics to the idea of objectivity and legitimacy (Boyle, 2000; Davis & Hersh, 1988; Desrosieres, 1993; Eberstadt, 1995; Goldacre, 2009; Hacking, 1965; Koch, 1990; Livingston & Voakes, 2005; Zuberi, 2001). The aim of studying this science-journalism-statistics nexus is to improve the ways in which statistics are used in the articulation of science news stories in the newsroom.

Many issues need consideration when understanding links between statistical information and its uses in science news stories. These include the significance of

statistical information on our daily news (Randal, 2000, p. 72); the understanding of journalism as an objective entity, as well as statistics and science (Koch, 1990; Kovach & Rosenstiel, 2001; Mindich, 1998; Sparks & Dahlgren, 1991; 1992); the general social construction of reality (Berger & Luckmann, 1966); and the fact that trivial elements are often used to increase public persuasion but seldom through scientific or mathematical expertise or objective sustenance (Wansink & Tal, 2014). One of the aims of this research is thus to understand how these issues influence this statistics-news nexus and to open the discussion on the necessity of a better understanding, as well as the use of statistical information in science news.

This research has tried to fill the gap in the area of statistics journalism. In addition, it has questioned the use of statistical data as an objectifying tool while writing about science, as it supports and validates arguments (Chapter I). Ultimately, the study has been of a multi-disciplinary nature encompassing the area of journalism studies, science, as well as science communication, and statistics.

9.4. Findings

Findings from this study support the argument of statistical information as a tool for achieving the "journalistic truth" (Battersby, 2010). The assumption of this study is that numbers are used primarily as legitimising tools in the construction of social reality and to maintain the rituals of objectivity in the newsroom. Its uses (and abuses) in the newsroom are fundamental to creating and understanding scientific information by the public at large. Moreover, it is habitually used to create this deceptive understanding of objectiveness and a false sense of truthiness. Some key issues were presented in this research, including the limitations that journalists have to validate and process data and the overdependence on official sources to do this for them, the

problems of legitimisation, as well as the overuse of statistical information and a lack of journalistic training in the gathering, management and analysis of quantitative data.

The research questions were answered as follows:

1. *How do science journalists articulate and legitimate stories using statistics?* (Chapter V)

This dissertation affirms that there is a relationship between the uses of statistics and how science information is legitimated. The relationship between country, writer, article emphasis, newspaper, political affiliation and sources observes positive path coefficients between all points with a strong direct path between country and newspaper. Furthermore, one can also argue that there is a convincing association between (1) *O Globo* and the use of Staff Writers, (2) *Folha de S. Paulo* and correspondents, (3) as well as an existing correlation between *The Guardian* and Opinion-based News, such as Press Releases.

In line with the evidence from the existing literature, science seeks to objectivity as an external assessment of accuracy to overcome subjective conditions (Stigler, 1986). Within the pursuit of objectivity, the use of statistical information aims to legitimise this process from the scope of mathematical neutrality, reasoning that the mathematical language should be the language of science. Accordingly, statistics turn out to be the very tool for the construction of science. It is the language that legitimises scientific information. The insight that there is a relationship between the usage of statistical data and how science information is legitimate in the news validates the literature. Moreover, it advances the existing literature as it elucidates the uses of statistical information in science as hard news. This study illustrates that

statistics is often used to portray relevant and current news in a sophisticated but objective fashion. The articulations of statistical data by science journalists, however, depend on the latter. The findings suggest that statistical information is used as relevant news. In spite of it, science journalists still do not have access to specific training in handling either statistical or scientific data.

2. *How are statistics used to articulate narratives and shape discourses of science in the newsroom?* (Chapter V)

Statistics are used as a means to obtaining journalistic objectivity. They hold the most important aspects in the legitimation of scientific information and possess a unique authority in the construction of reality. Indeed, to the interviewed journalists statistics are not only key to constructing social reality but also the reason that modern society works, and even exists. Quantitative data information are thus used as a tool to achieve an objective reality and information but also an entity near Truth.

From the literature review in the field of articulation of news and uses of statistics in the news, it is argued that, due to their technical-scientific feature, quantitative data are tightly associated with the idea of objectivity and legitimacy (Boyle, 2000; Davis & Hersh, 1988; Desrosieres, 1998; Eberstadt, 1995; Goldacre, 2009; Hacking, 1965; Koch, 1990; Livingston & Voakes, 2005). Furthermore, the statistical language supports the objectivity, neutrality and transparency of journalistic discourses. The evidence from the existing literature and presented interviews confirms that statistical information are used as a means to present objective material. Moreover, they aim to portray their evidence as truth. This notion, however, is profoundly questionable. For example, according to the interviews, science journalists are not sufficiently critical of

the statistics they present on the grounds that they think statistical information are facts (incapable of being inaccurate) and therefore overlook the fact that statistics are a product of human agency. Thus being susceptible to errors, exaggerations, impressions and subjectivity. This is a key advance in the existing literature. In the context of its uses to articulate narrative and shape discourses, statistics prove to be used as a broken telephone where misinterpretations typically accumulate in its retellings. The lack of understanding of statistics from the journalists' perspectives will cause the audience to, much in a similar fashion, underestimate its information and therefore possibly make erroneous decisions.

Overall, the content analysis addresses the understanding that statistics are significantly used as a means to legitimate news stories. Furthermore, it showed that there is a widespread lack of fundamental background information about how they produce the reported data, and that science journalists tend to use either too few or too many statistics from original sources. The findings of the content analysis enable a better understanding of the methods of data presentation and representation in the news media.

Similarly, Chapter VI has presented findings on the consumption of scientific statistical news. According to the analysis, Brazil consumes more science articles than the United Kingdom. The main reason for this discrepancy is the majoritarian role that science plays in the production of news in *Folha de S. Paulo.* On the other hand, there is a relationship between the uses of statistics and its portrayal of the majority in hard news. This finding reaffirms the perception of statistics as a means to access the truth in the newsroom.

In spite of this key role, this study's validated assumption is that journalists with science backgrounds have a better understanding of numbers than journalists who

were merely assigned science news but do not necessarily have a background in science or statistics. Furthermore, given the problems of accessing and validating the data, the traditional mechanisms of verification and validation routinely used in other areas of journalism are not performed by science journalists and science editors. Therefore, the public tends to receive information that is not always up to standard.

In the same way, the close reading analysis (Chapter VII) suggests that statistics are used not necessarily as a means to present objective information but mostly as an attention grabber as well as a provider of accurate information. And indeed, statistics are used every day in a range of news subjects and headlines. Focusing on the understanding of both the written language and the visual journalistic language, Chapter VII looked at each article, while inferring and scrutinising the ways in which statistics has been used in science news. It concluded by considering this mathematical language, not as a separate identity but as an intrinsically connected one.

Lastly, the interviews provided an in-depth understanding of how science journalists deal with statistics in the newsroom. There was an overarching response to the understanding that statistics are used as a means to convey objective information, with the amalgamation between science news and statistics being presented as key in the construction of reality. Additionally, it points out a crucial limitation from the part of the science journalist: the lack of any official training, or any suggestion of an understanding of statistical information. Consequently, in spite of previous analyses suggesting that the majority of journalists use statistical data as a means to present objective information, frequently science journalists in the newsroom misunderstand it. This lack of training thus further creates this erroneous transmission of information; one that starts with the researchers, passes through the reporters, and

ends with the readers. From the journalists' perspectives, the (mis)communication of science in the mass media has two main roots: (1) The lack of fluency in the scientific and mathematical language; and, (2) the lack of time to verify accessed data.

Nonetheless, numbers are considered, by most, as the reason the world is constructed the way it is, and as a principal objective source. These mathematical abstractions, however, have often been used as a means to misinform audiences (Huff, 1991; Moore, 1994) by the regular misrepresentation or even distortion of data sources simply due to inaccuracy or lack of mathematical skill, which has been seen as a disorientating skill by word professionals. In fact, previous research has suggested there is on going miscommunication between the scientific community and the media, mainly due to this misrepresentation, misunderstanding, inaccuracy and distortion of news processes (Sumner, et al., 2014)**.**

Overall, the findings of the analysis of the interview transcripts enabled the understanding of this correlation from a journalistic perspective. While the content and discourse analysis presented the news media as a "mirror of reality" (Broersma, 2010b; Mindich, 1998)**,** claiming to offer a factual and objective representation of the world, with statistical information as its primary tool, the interviews provided a different picture. It distinguishes this simplistic view to one that is largely dependent on numbers but with little to no training on its use, further affected by the manipulation of statistics, as well as the restriction on time, space and general study of quantitative methods.

9.5. General Conclusions

Overall, it would seem legitimate to understand statistics in science news as a legitimising tool that most journalists use but only a few are familiar with its

mathematical language. This lack of familiarity with the mathematical language, however, does not mean that there is no space for the uses of statistical information in the news or daily life. On the contrary, there is an enormous need for the delivery of statistical information and its knowledge to the public. Mathematical knowledge is intrinsic to the development of society and social development. Life could not be imagined without it. What needs to be further developed are the study, training and contextualisation of such language. As seen in the findings, it needs a vast improvement in the understanding and usage of statistics. From the ways in which journalists select statistical data, to the way they present it to the audiences, all the way to the education on statistics and ways in which the public understands statistical information.

When the understanding of how scientific statistics are used to articulate and legitimate stories and how they are used to articulate narratives and shape discourses of science, the importance of understanding statistical information can be seen. Understanding the mathematical language is imperative. Once one understands mathematical terms, its potential for assuring power becomes necessary. Most importantly, only when one understands these terms can they securely pass such information forward. Thus, there is a vital need for general education on this knowledge. However, while there is this need for general education of statistics, further understanding of how this could be better presented is perhaps far more urgent. In this way, this chapter presents a necessity – an explicit dependence on statistical data – but also a clear gap in the knowledge of scientifically statistical data; nonetheless, it does not offer any response to how it could be better used and articulated. It is recommended, thus, that this area needs further development. Expectation outcomes of such a study would suggest a more encompassing partaking

of the public in the conception (and communication) of scientific research. Case in point is the production of scientific information in European countries where the public plays a role in the development of studies (where channels for communication are open). This movement of digitalisation of the processes of current social interaction, which has statistics as an essential element and core basis, also reaches many other different social environments. From science and scientific knowledge to health and nature, the quantification of data is now a prominent figure. Nonetheless, the consequences to this over-mathematization – and somewhat statistisation and digitalisation – it is still not known.

9.6. Strengths and Limitations

9.6.1. Strengths

The strengths of this research can be characterised as follows:

Broader methodological approach to research

The methodological approach of research was developed through the analysis of the content of statistical data in the United Kingdom and Brazilian science news, close reading analysis and in-depth interviews with science journalists. Through this use of triangulation of research methodologies in the field of study, a comprehensive picture of aspects of the research and answers to the research questions emerged. In the study presented in Chapter VI, a content analysis was used to quantitatively evaluate how science journalists use statistical information in the portrayal of science news. The following chapter (Chapter VII) reports a qualitative inquiry into its uses as a means to articulate and legitimate science news. Furthermore, it explores its methods as sources and deciphers its implementation in the construction of discourses of science.

Lastly, Chapter VIII offers a view towards the perspective of journalists themselves and ways in which statistics are seen in the newsroom. The research presented in Chapters VI, VII and VIII shows a broader image of how statistics are used and abused in the newsroom when writing about science, achieving thus an all-encompassing understanding of the situation while cross-checking information between the analysis in the search for consistencies, correlations and causations.

Internationalisation of population framework

Secondly, and as an addition to the first point, the choice of newspapers can be seen as strength because it analyses two considerably different countries. This research has allowed a wider sample of news media content when including other countries in order to introduce some comparative analysis. It has helped better understand the construction of news, more specifically science news, in the UK and Brazil while comparing its means and uses of statistical data in the articulation of news. Furthermore, the presented in-depth interviews with respective journalists allowed for a unique insight into both newsrooms and how they are trained and how they understand numbers. Similarly to the uses of mixed methods, the analysis of two different singular points, namely the UK and Brazil, allowed for a more wide-ranging account in the articulation of statistical information in science news. It looked at statistical information from content and multimodal reading points of view, while conducting a profound gathering of inside knowledge on its uses in the newsroom. This triangulation of methodological approaches has never been seen in research on the representations of statistical data across media outlets, especially focusing on the uses of statistics when reporting science news.

Combinations of aspects of journalism, science and statistics

Lastly, the importance of analysing these three particular research dispositions needs to be stressed. Ultimately, this is possibly the greatest contribution of this research: the interconnectivity of the agencies of journalism, science and statistical information in the construction of news discourses and the articulation of journalistic narratives. The understanding of these aspects separately does not account for the intermingling and the incredibly connected link between these parties. The study of these three points is possibly the main strength of this research. The analysis of statistical information in the news or its use in science has widely been done; it is the perception of aspects of journalism, science and statistics that makes this research unique. Indeed, this innovative research understands that science, statistics, and journalism are critical for making rational and practical decisions in everyday life and therefore need to be studied as interweaved establishments and not separately. It explored, analysed and explained journalistic techniques in using statistics in the process of newsgathering and dissemination of scientific information. That is something that has never been done before.

9.6.2. Limitations

The limitations of this study include:

Some degree of limitation of the number of target population

As argued in Chapter V, the restriction of observations to a functional subset of elements that is statistically representative of the total universe (Krippendorff, 2004) provides the researcher with a rationale to study a smaller number of data by limiting

their research to a manageable body of text. That is a necessary means to a research of such scope, however, it causes an apparent limitation when considering the samples. The target population for the studies presented in this thesis were only two out of 104 daily the United Kingdom newspapers and 465 daily Brazilian newspapers. Meaning that, statistically speaking, only around two per cent of the United Kingdom-based and 0.5 per cent of Brazilian newspapers were analysed, and thus conclusions can only be drawn from these papers.

This selection of papers might limit the findings described in this research. In spite of this limitation, in terms of daily circulation, all four newspapers are amongst the top most read newspapers in their respective countries and therefore, when applying findings from these studies to other research, countries or newsrooms, one has to pay due attention to possible differences. The analysis of different countries could, possibly, provide different findings and therefore different correlations.

All participating science journalists were from the chosen newspapers and due to scheduling divergences and limitations, no journalists from *The Guardian* were interviewed. It can be expected that this further limit the views on the uses of statistical information in the newsroom. Similar to the selection of newspapers, this study's findings might be constrained by the choice of journalists.

Considerations concerning the improvement of statistical studies and skill among science journalists

Due to the limitation of scope and time of this research, a solution or proposition for the development of mathematical training among journalists was not delivered. The aim of this study was to analyse the uses of statistics in the production of news stories

in the media. The point on the misunderstanding of information and the need for a better training of journalists in the area of statistics and quantitative methodologies were often touched, however, due to the research's restrictions as well as focus on its aims, the understanding of the improvement of statistical training presents a limitation of this investigation. A further study should be undertaken, with the aim of providing an answer to the general need for improvement in the understanding and usages of statistical information by journalists, especially those in the area of science. Further research is required to examine this gap in knowledge and propose improvements and quantitative methods research and presentation. One journalist provided some interesting suggestions for further improvement in the training of journalists in the area of statistical sourcing and understanding.

9.7. Further Research

This research is the beginning and the first step towards a better elucidation of numerical information in the news. Due to its innovative body of knowledge, this study opens doors for a number of future research possibilities. It is my commitment to developing further this area as well as to advocate a more considerate communication of scientific information in the news. Similarly, I hope to promote a better understanding and usage of numbers as a tool in the newsroom. This research produced crucial information and broadened the boundaries of the uses and representations of statistical data in the articulation of science news stories.

This research has the potential to be further developed in the following areas. Firstly, this study is correlational and therefore does not demonstrate any causal relation between specialist science journalists versus non-specialist ones and their notion of numbers. The analysis of specialist science reporters and non-specialists has the

causality in differing findings. For instance, the assumption would be that specialist science journalists have a better understanding of both raw scientific information as well as mathematical terms. Furthermore, it would possibly also recognise the subjectivity or at least limitations of numbers to guarantee objectivity, and transfer that crucial piece of information into the news article. In other words, it could provide a more realistic portrayal of statistical data in science news.

In addition, still with reference to this aspect, there is space to conduct further study in the ways in which graduated or scientifically and mathematically trained journalists use and articulate numbers in the construction of news discourses, especially in the news of science. The findings of such a study could potentially illuminate fundamental aspects as well as needs within the training of journalists and the relationship inside the newsroom. Furthermore, such study would make possible the adjustment in how numbers are taught as well as used in news articles. One of the major contributions of this study showed the need for better education and numerical training within the newsrooms. In terms of journalism practices, it identifies key problems that science journalists have in handling statistical data to write news –for example, their inability to critically access or challenge statistical information. Therefore it makes possible for both journalism schools, as well as work places, to address the lack of skills in handling statistics that lead to journalists' inability to deal with statistics. Another example regards their overdependence of certain sources. Therefore making a call for journalists to widen and diversify the sources they use in the construction of science news. Similarly, concerning science communication, it impacts the communication of science because it calls for a transparent, accountable, comprehensive, yet critical dissemination of science. And that process of educating the public, the better we will understand how journalists mediate scientific

information, the better science communication will have at the end.

As a result, it would be interesting to investigate the extensiveness of this need. Especially, it would be attractive to study whether it encompasses graduated, or previously trained, journalists or not. Similarly, further research could be conducted to determine if a better need for numeracy education and training of journalists can be observed in other areas of journalism or if it is exclusive to the communication of science news.

Secondly, a future research project could potentially look specifically at how journalists read and understand press releases. It could use these findings to scrutinise where numbers are lost in translation. Additionally, it could produce a better read in this process of science news production and the role of statistics in it. These findings may provide some useful intelligence in the general communication and understanding of scientific and statistical information. Similar to Sumner, et al. (2014), who provides some interesting suggestions for further research, it would be interesting to analyse the full circle: how statistical information is understood by the researcher, the journalist and the public. More research is needed in understanding how this progression works on the ways in which numbers are presented to writers, reported in the media, and ultimately the public's response to them.

Further, as a means to understand how scientific information is communicated through the medium of newspapers, the supplementary analysis would look at the whole "telephone" process. This research could shed light into this process. Furthermore, it could prove as suggested by Sumner, et al. (2014), that most press releases exaggerate scientific information, even before it reaches the journalist and newsrooms, or that the scientific data is firstly manipulated in the press release offices

or even by the researcher him or herself. This research could, in theory, improve the entire process.

Thirdly, it would be beneficial to expand the research to other countries, by looking at how developed and developing, west and east countries, etc. use statistics as a means to articulate news. If the study is extended, methodologically speaking, a larger data set should be collected encompassing more newspapers and interviews. This would result in a more representative view of how journalists use statistics to articulate and validate news stories.

In regards to the expansion of conceptual frameworks, a more extensive analysis of data points, such as different newspapers, countries and codes, could clarify points primarily provided in this study – data that were succinctly touched in this research. Moreover, it could be responsible for elucidating interesting dissimilarities between said frameworks and data points. That happens because, in spite of the conceptual differences between Brazil and the UK and its media systems, the two are considerably similar in its production, freedom of expression, etc. Thus, it would be interesting to look at these aspects in terms of different perspectives; to look at how different perspectives direct and influence the uses and representations of statistics in the articulation of science news.

The innovation of this research's debate is, therefore, extensive and multifaceted even within the national level. It presents an essential and unique view on the applications of statistical information in the news and how journalists understand it. This is crucial to produce achievable changes in the training and construction of statistical news discourses in the newsrooms. However, there is an existing need for building on a particular aspect of this research; the lack of training and understanding of numerical information as suggested by the in-depth interviews. There is a need for more case-

specific studies to allow for further inferences on the subject. Exploring the following aspects as further research strategies can facilitate the attainment of this goal; the development of a qualitatively focused methodological approach to the question, especially towards the use of supplementary interviews, increasing the number of qualitative points and in-depth interviews, as well as amplifying the range of journalists to include science graduated writers.

In terms of future studies from a more macro perspective, I would like further to establish the uses of statistical data by journalists and news media. The findings of this study point to a future research reference framework that should take into consideration the understanding of statistics as a decision-making tool for the study of human behaviour. Thus, I would like to explore its applications further as the interplay between news items, human behaviour and public opinion. Similarly, I would like to understand the processes within the collection, use and representation of statistical information by journalists and society. How do they interact with each other? What numerical skills do journalists and laymen citizens possess? Which ones ought to they further develop? The findings presented in this research suggest that reflection on the familiarity of mathematical information might improve the processes of decision-making, through an understanding of news, and its information and legitimising authority. It might be easier for numerically trained journalists to make sense of statistical data. It might be less complicated for the public at large to understand numbers and make a rational decision based on them when journalists are duly qualified.

This study is primarily of investigative relevance. It presents an innovative body of knowledge on the applications and representation of statistical information in the reporting of science news and how it is applied to legitimate journalistic narratives

and shape news discourses of science. It puts forward a foundation on the uses of statistics by journalists and news media. As Carl Sagan reasons, we live in a society widely reliant on science where only a small number of people understand it. In this case, this research offers an approach to seek out a better understanding of science and statistics in the news.

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