Who's For The Planets?

An Analysis of the "Public for Space Exploration" and Views of Practitioners of Science Communication on "Their Publics" and Public Communication in the UK

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DECLARATION

I, Marta Entradas, declare that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Para os meus pais e irmão, os pilares da minha vida…

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ABSTRACT

Over the last decade, there has been a fundamental revolution in how science should be communicated to the public. Science communication has been built around a changing preference for "dialogue" where the public, formerly conceived as having a passive role, is now seen as an active player in the communication process. However, there are fundamental questions arising from this revolution concerning the role of the public and the science communicator, and the practice of science communication itself. I take a look at the way in which this transformation has been reflected in the communication of astronomy and space exploration to the public from the perspective of social sciences by drawing on empirical qualitative and quantitative data.

I examine the characteristics of the "public for space exploration" and the views of those doing science communication on "this public" and public communication to provide as complete a picture as possible of the current meaning of science communication in the area of 'space' in the UK.

I show that practitioners who deal with "the public for space exploration" assume a *gatekeeper* role as they try to control public communication rather than simply pass on information. The science communication practice in the 'space' scene involves both one-way and two-way communication activities that serve different aims of public communication to target different audiences. I argue that rather than competing, both models should be seen as complementing paradigms in the practice of communication of 'space' with the public. Consequently, outreach activities can be characterized as "preaching to the converted" – they attract the "public for space exploration" who is more likely to be part of the "attentive/interested" publics and that bring with them less attentive/interested publics, which otherwise would be very difficult to reach through other means.

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CHAPTER 1

INTRODUCTION

"There are often two purposes of those engaged in the study of nature.
The first is to advance the knowledge of the wonderful truths that it contains,
the second is to put this knowledge in a way so that everyone can,
with some attention
participate in the wonders and utility that it can bring"

(Teodoro de Almeida, 1722-1804, my translation)

1.1 SUMMARY OF THE THESIS AND BACKGROUND

1.1.1 Summary of the thesis

This research was set up to explore "the public" and public communication in the area of astronomy and space exploration. In particular, this thesis will examine i) the British public attending astronomy and space outreach events -- people who have at least an interest in going to space-related activities, what for want of a better term I call "the public for space exploration", and ii) the views of practitioners of communication in the field of astronomy and space research on science communication and the publics they are meant to be addressing. By practitioners I mean people who conduct science communication and outreach activities, either as their main professional activity, which I term here professional science communicators, or as a requirement as part of their job or simply as a motivation; these groups are in 'powerful' and unique positions in the science communication arena since they have direct contact with the public what makes them an extremely important target of study in PUS research.

I first conducted surveys at two space outreach events in the UK to characterize "the public for space exploration" in terms of socio-demographic characteristics, rationales for exploration, beliefs in extraterrestrial life, attitude towards space exploration, space policy preferences (preferred means of exploration and support for government funding) and support for space exploration. These findings were then put to a selection of practitioners in a series of semi-structured interviews to understand how they anticipate their audiences and conceptualize "the public for space exploration" and public communication. An important dimension that this thesis explores is how the rhetoric on public engagement and participation in policymaking is reflected in the practice of this community. An aspect that I was particularly interested in investigating was the meaning of "dialogue" outside the policy context, which is under theorized and under researched; even though it is assumed to be of particular importance in science communication as a field of practice.

In interpreting the results of both the quantitative and qualitative studies, it should be borne in mind that: i) Given the locations at which the survey data were collected, this sample cannot provide a representative view of the general UK public at large. But it does provide important information about "the public for space exploration" as a group; ii) The qualitative study is not intended to show a representative sample of the practitioners' views in the area of 'space' (although I have tried to construct a sample as representative as possible), but rather to give a perspective of practitioners' ideas about publics and public communication.

Nevertheless, although related to the British astronomy and space related practice of science communication, the general issues about science communication dealt with in this thesis can be of use in other contexts; the practice of science communication is a global discussion, and therefore, these findings may also suggest general trends among publics of science and practitioners of science communication. I believe that understanding practices and publics can contribute to strengthening the relationship between communication and society, a relationship that has assumed a privileged role in modern societies. Therefore, my research aims at understanding such interaction to comprehend the contemporary meaning of science communication, which can ultimately serve to help science communicators and policy-makers develop effective approaches to public engagement in order to better reach their audiences. As such this thesis will treat not only the theory in PUS but also the practical application of the theory to the field of science communication.

1.1.2 Context and background of space exploration in PUS research

The political context for "public engagement with science"

In recent years, British science policy has seen a significant shift in conceptualizing the relationship between science and the public, which has moved from the language and methods of PUS towards “engagement”. This shift took place against the background of a series of policy crises and public controversies during the 1990’s such as the BSE crisis and the genetically modified (GM) crops and foods or the MMR controversies. All these controversies resulted in public suspicion and wariness towards scientists working in the government and scientific advice, and in a debate which has drawn in the government, scientific institutions, the media and industry about how best communicate science, scientific uncertainty, and risks to the public.

The idea that the relationship between science and the public was facing a ‘crisis of trust’ and needed improvement also gained support from STS scholars who criticized the way science was being communicated, arguing that a more ‘democratic’ approach to science policy and public debate would produce a more ‘socially robust’ science and policy (e.g. Irwin and Wynne, 1996; Wynne, 1992).

When the New Labour took over in 1997 the political climate for science was completely transformed, with research budgets rising to higher levels than they had ever been before and with science and innovation occupying a privileged place in the government's agenda. The ideas of participatory democracy in science gained ground in the government arena as they were key components of New Labour's ideological orientation (Gregory and Lock, 2008; Thorpe, 2010). Arguments that more direct contact with the public would legitimate the authority of governmental institutions were the basis of the institutionalization of public participation in science policy in the UK Government (Gregory and Lock, 2008; Thorpe and Gregory, 2010). In a recent paper, Thorpe shows how public participation was an element of Third Way political thought that influenced the development of New Labour (Thorpe, 2010). He argues that the receptivity of STS participation by the New Labour was a component of the Third Way, influenced by the London Thinktank Demos (founded in 1993) and the ideas of the British sociologist Anthony Giddens (Giddens, 1998), that had a direct impact in the early years of the Blair government (for an extended discussion on this political dimension of science policy see Thorpe, 2010).

The New Labour's idea of public participation is reflected in the publication of the influential House of Lords report in 2000, which put 'dialogue' on the agenda for science and technology policy within the UK Government. In contrast to the Bodmer report's concept of educating the public, the House of Lords report emphasized public values and a mutual understanding between groups that share their views, opinions and attitudes as an essential element in decision-making. Issues of public understanding were therefore replaced by rhetoric based on the need to address ethical and social questions in ways which 'command public confidence' (House of Lords, 2000). This idea of openness and transparency with the public was also emphasized in the first published science White Paper of the New Labour Government (DTI, 2000) through the use of terms such as 'engagement', dialogue, confidence and trust. As a result, signs of a more participatory conceptualization of the relationship between science and the public, both in reports and public consultations started to emerge (e.g. biosciences in 1998 (OST, 1998); GM Nation in 2001). Yet, despite this new approach to science communication with the public, some commentators have referred to the discrepancies between an 'ideal' public dialogue and the deliberation and consultation processes undertaken by the government (Irwin, 2001) which, while admirable, have not yet been proven sufficient (Wilsdom, Wynne and Stilgoe, 2005) and that participatory public communication as well as PUS communication can both be seen as a way of controlling and managing the public opinion. The way in which this rhetoric has been put into practice is an issue that assumes extreme importance in science communication, which I will be investigating in this thesis.

Calls for public engagement in space issues

Recent reports in the UK have called for the development of sustained programmes of public engagement with space science and the involvement of the public in policy decisions about the future of space exploration (RAS, 2004, Crawford, 2005; Global Exploration Strategy, 2007; BNSC, 2008; Space IGS, 2011). Space is a significant area of research that encompasses a broad range of academic disciplines including biology, geology, astrobiology, physics, astronomy, etc. and, one where public views regarding value and benefits are many times confused. There is evidence which shows that public awareness and support for government funding have increased in the last 30 years in Europe and the US (ESA 1998; NSB, 2002; Mori, 2004; Eurobarometer, 2005; Safwat et al., 2006). But, there is also increasing scepticism about exploring the outer space particularly amongst younger people (Ottavianelli, 2002; Mori, 2004, Safwat et al., 2006; Jones, 2007). Also, space exploration is somewhat controversial when talking about humans in space or microbial contamination for instance. These issues assume particular importance at a time when the UK has been changing its long-standing opposition to participating in human space flights, which might have been spurred in part by recent reports and experts' opinions stressing that the UK should fully participate in space programmes (Royal Astronomical Society, 2004; Crawford, 2005; Global Exploration Strategy, 2007; National Space Technology Strategy, 2011; Space IGS, 2011).

However, little effort has been made to develop a baseline understanding of public opinion about space exploration (Bell and Parker, 2009) and to understand what the views of those who deal directly with the public are about "the public", in particular about public participation in 'space' policy decisions. Yet, space exploration is an issue of public interest and an important aspect of science policy. And despite the rhetoric on public participation, as far as I have discovered, the public has not been asked to participate in such discussions. The only citizen jury aimed at understanding public's views about space long-term programmes that has taken place in the UK so far was commissioned by ESA in 2006 (Safwat et al., 2006), but nothing is known about whether any public contribution was incorporated into ESA's strategy.

There are fundamental questions arising from this transformation in the rhetoric of public engagement that should be addressed in the particular context of the communication of 'space', which were on the core of my research. First, who is the "public for space exploration", i.e., what are the characteristics of the audiences that practitioners of communication are addressing? Second, how do those responsible for communicating conceptualise the "public for space exploration" and public communication of space issues? Who do they think is the "right" public to contribute to the development of space programmes? And, finally, how can studies of audiences and practices of science communication contribute to a more accurate outreach strategy and public engagement with science?

Understanding the public and public communication

The paradox between the (lack of) public understanding of 'space' issues and the (increasing) recognition of public participation in space policy decisions, on the one hand, and the transformation in the way science should be communicated, on the other, leads to a conclusion that attempts to improve the public understanding of science should be complemented by attempts to improve scientific understanding of the publics and public communication (Levy-Leblond, 1992; Miller, 1992; Wynne, 2001).

Recent work has started to understand "scientific understanding of publics" and public communication alongside public understanding of science. Studies that have examined experts' views and assumptions of the public and public communication have found primarily deficit models of the public (see, for example, Young and Matthews, 2007; Davies, 2008) and public communication (Davies, 2008; Mori, 2000) where the practice of science communication is still confined to "transmission mode" with the aim of informing the public rather than engaging the public in science and technology. This is despite the revolution in science communication that calls for a shift from "deficit" models of communication to "dialogue" with the public, and demands that practitioners of science communication and other key players in engagement, including policy-makers, conceptualise public communication and "the public" in a more sophisticated way, knowing and recognising the importance of public opinions, values and attitudes.

There are substantial differences in the level of public understanding of space exploration (e.g. Miller, 1983a, 1992; Miller et al., 1997). Miller (1983a) distinguishes three types of issue-specific "publics" according to their knowledge level and science issue involvement: "attentive", "interested" and "residual" publics. And, although there is a strong interest in astronomy and space sciences, the number of people who consider themselves "attentive" to space issues is relatively small. In 2001 only 5% of the public in the United States could be considered "attentive to space exploration" (respondents who reported that they were very interested in space exploration and very well informed), while 21% were "interested" and 74% "residual" (NSB, 2002).

One of the main reasons given for the limited attentiveness to space issues is insufficient communication (Brown, 2007; Finarelli and Pryke, 2007; Lorenzen, 2007). As Lorenzen (2007) put it "Europe is doing great in astronomy and space exploration, but it has a hard time to communicate that". This cannot simply be a matter of quantity, however, particularly in the US, to which the NSF figures refer: NASA has a very active press and outreach programme, as do many other relevant bodies such as the Space Telescope Science Institute (STSI), responsible for the Hubble Space Telescope, whose images often make the front pages of newspapers and magazines, and top the programming of T.V. news bulletins. This raises the question of the nature, quality and comprehensibility of such communication. And, in order to understand these, it is necessary to first understand the public itself.

Moreover, it is crucial to go beyond the categorization of individuals by level of support as presented by general surveys, and seek to understand the relative influences of factors such as beliefs and expected cost/benefit considerations. As Nisbet and Scheufele (2009) emphasized "any science communication efforts need to be based on a systematic empirical understanding of an intended audience's existing values, knowledge, and attitudes, their interpersonal and social contexts, and their (…) preferred communication channels" (Nisbet and Scheufele, 2009, p. 1767). To date, however, almost no effort has been put into investigating the "space audience" and significant variables that may influence their support for space exploration.

My research builds upon this idea of understanding of publics and communication to provide as complete a picture as possible of the current meaning of science communication in the 'space arena' in the UK. The study that I present here is thus original and is offered as a contribution to fill the gap in the literature concerning both the characterization of the public for space issues and their support for space exploration, on the one hand; and constructions of social audiences which shape practitioners' communication, on the other. Understanding the way key-players in science outreach and engagement conceive public opinion, science communication and engagement informs the choice of science communication activities and the way they are to be conducted (Holliman and Jensen, 2009). I believe that developing an understanding of these two components, publics and public communication, may be useful to setting up outreach programmes according to public needs, rather than basing policies on assumptions about who/what "the public" might be, know or think.

The "should scientists be responsible for communication?" debate

The 'social movement' of PUS of mobilizing scientists and other resources to engage the public with science (Bodmer, 1985) has brought many discussions among scientists and academics about who should be responsible for communicating science. The communication of science by scientists has been claimed to be a responsibility of scientists by many reports and institutions in the UK and around the world, which recognize the importance of the role of scientists in the cause of public involvement in science, particularly those who are publicly funded (Bodmer, 1985; Gregory and Miller, 1998, Royal Society, 2006; Royal Society, 1990). In this regard, the profession of scientists seems to be evolving in a way that should make scientists respond more positively to science communication. Scientists should not only train themselves to communicate science but also become involved in public engagement (PE) activities (e.g. Royal Society, 1985).

However, despite the many initiatives in the UK designed specifically to encourage scientists to participate in science communication activities, and the practice of science communication seeming to be evolving among scientists in past years (Bauer and Jensen, 2010; Jensen, 2010), there are still many scientists reluctant to become involved in public engagement activities (Pearson et al., 1997; Bauer and Jensen, 2010). Little evidence exists to explain this reluctance, but research that has looked at what inspires scientists, and what encourages and motivates them to be involved in science communication has found that it is likely to be a mixture of factors (MORI, 2000; Royal Society, 2006). While scientists see science communication as important, it is not seen as part of their work, as it is not recognized and does not lead to progression in terms of a scientific career. Moreover, scientists are concerned about their colleagues' not viewing science communication activities favourably, and often simply do not feel sufficiently trained to do so (Pearson, et al., 1997; Royal Society, 2006). Also, findings have shown that scientists' perceptions on communication vary according to 'type of scientist' (funding and specialty). For example, while industry and other private funded scientists are less likely to think that they should be responsible to communicate their work with the public, scientists who recognize that their research does have social/ethical implications to society are more likely to think that is their responsibility to communication their research with the public (Pearson, et al., 1997; Royal Society, 2006; Mori, 2000).

The Mori survey (2000) that investigated a sample of British scientists working in higher education institutions (1,540) and research council-funded establishments (112) showed that most scientists interviewed considered communicating their work with the public as their duty and felt they were the most appropriate group to communicate the "social and ethical implications to policy-makers, and to the non-specialist public". However, fewer felt that "scientists are the people best equipped to do this" (p.21). Pearson's et al. (1997) found different results: the majority of the 168 scientists that took part in the UK's 1995 National Week of Science, Engineering and Technology, reported they did so because they were told to, and only 15% reported their sense of duty to communicate science. The Mori survey also showed that biomedical scientists and those dealing with patients, or those funded by a charity or conducting animal research are more likely to say that it is their duty to communicate their work because it has social and ethical implications either because their research is trying to "cure, treat or understand human illness", is looking for environmental impacts, or is involved with biotechnology (MORI, 2000). This suggests that different 'types' of scientists see their responsibilities differently, and brings questions not only about the role of different scientists but also about the type of science communication activities each group should be involved.

In addition, main reasons for participating in science communicating activities mentioned by scientists and other practitioners are the 'importance of raising scientific awareness and knowledge of the public who provide funding for science" (Pearson, et al., 1997). And, such participation most of the times does not result from scientists' own initiative, which reflects the lack of importance attributed to science communication activities. This is likely to affect the quality of communication, which will depend on the way in which scientists and other practitioners see science communication. An understanding of social demands and a more responsive attitude towards public engagement, and science and society, will inform the roles of practitioners and the type of science communication activities to be used in various social and scientific contexts, therefore, contributing to a more appropriate communication of science with the public which takes into account public's needs. I will be addressing these issues throughout this thesis, particularly in my discussion on whether 'deficit and dialogue completing or complementing paradigms' (Chapter 6).

1.2 RESEARCH QUESTIONS

In this thesis I will be addressing the following research questions regarding "the public for space exploration" and their support for space exploration (Chapter 4):

- How is the surveyed audience characterized in terms of socio-demographic variables, rationales for exploration, beliefs in extraterrestrial life, attitude towards space exploration, and space policy preferences?
- How do rationales, beliefs, age and gender influence public support for space exploration?
- Does support for space exploration vary among males and females?

I will also be looking at how practitioners of science communication in the field of astronomy and space science see their "publics" and public communication (Chapter 5). In particular I will be looking at:

- What are the strategies and models of science communication currently used to communicate astronomy and space research to the public?

- What types of science communication activities are used in the field? And what are they aimed at?

- To what extent have science communicators been following academic models of PUS?

- How does practitioners' discourse on "their publics" and public communication relate to their science communication practice?

- In what way has the revolution in science communication changed practitioners' conceptualisation of the public and practice of science communication? In particular, who do practitioners think is the 'right public' to take part in space policy decisions?

- How do science communication practitioners anticipate their audiences' characteristics and opinions about space science?

- How do practitioners respond to surveys on the publics they are meant to be addressing?

Finally, I believe that my study can make an important contribution to the social study of science and technology and PUS by looking at (Chapter 6):

- What is the meaning of "dialogue" in the contemporary practice of 'space' communication?

- Whether the 'deficit' and dialogue are competing or complementing paradigms in the communication of 'space' with the public?

1.3 Outline of the Thesis

After this introduction, there are four substantive chapters in this thesis. Chapter 2 introduces the relevant literature review on the problematic over the issue of science communication situating my study in the broad context of PUS research. The third chapter explains the methodology that I used to answer my research questions. Chapters 4 and 5 explore the empirical data providing an analytical approach to the discussion of science communication in the area of astronomy and space exploration, prior to drawing conclusions in the summative Chapter 6.

Chapter 2 – Literature Review

In this chapter I review some of the literature on the issue of public communication, and the development of the relationship between science and the public, which I consider relevant to my thesis. In particular I provide an overview of the main discussions around PUS and how it has evolved from a deficit model approach of the public and public communication to one that sees the public as active contributors to science and public communication as two-way process. I introduce this literature in order to later draw on the main concepts and theories surrounding the issue of science communication and conceptualizations of "the public". This literature also provides the context to the methodological approach that I used in this thesis. Other literature is drawn on more specifically in Chapter 4 and Chapter 5, in order to offer a deeper theoretical background to these chapters.

Chapter 3 - Methodology

In Chapter 3, *Methodology*, I offer a description of the methodological approach that I have used in this study. I refer to the main research questions of this thesis and describe the type of methodologies that I have used to investigate them. I explain the methods of data collection and the type of data analysis that I have conducted. The methodological approach that I have used here – mixed methods approach – is one of the strengths of my thesis due to its innovative character in science communication as an area of research. I have used both types of methodology, quantitative *(Phase 1)* and qualitative *(Phase 2),* in which the data derived from *Phase 1* was then used to produce 'new' data in *Phase 2*. In this chapter I explain how, in *Phase 1,* I investigated the "public for space exploration" through a quantitative survey, and how in *Phase 2,* using findings from *Phase 1* (the survey), I investigated practitioners' of science communication views on "their publics" (i.e. the "public for space exploration") and public communication.

CHAPTER 4 – WHO'S FOR THE PLANETS? CHARACTERIZATION OF THE "PUBLIC FOR SPACE EXPLORATION"

In Chapter 4, *Who's for the planets? Characterization of the "public for space exploration"*, I present the findings of the quantitative empirical data on the "public for space exploration". I first provide a background of previous studies on public opinion and attitudes towards space exploration. And although this thesis is focused on the UK context, when comparable data is available I draw on figures from the United States and Europe to provide as complete a picture as possible of the literature available. I then present the results of the statistical analysis offering a characterization of the public for space exploration in terms of the characteristics surveyed, and how those factors might influence public support for space exploration. I then present a summary of the main findings and a short discussion on the implications of the findings for science communication.

CHAPTER 5 – PRACTITIONERS' VIEWS ON "THEIR PUBLICS" AND PUBLIC COMMUNICATION

In this chapter I present a qualitative analysis of the views of practitioners of science communication on their publics and public communication. Prior to presenting the analysis, I introduce relevant literature on previous studies on experts' images of the public, public participation, and models of communication. I then present the analysis of interviews conducted with practitioners in order to provide answers to the research questions mentioned above. I finish the chapter with a discussion of the main ideas that came out of the qualitative data, in particular how dialogue is seen and used outside policy and academic contexts.

CHAPTER 6 – SUMMARY AND IMPLICATIONS FOR SCIENCE COMMUNICATION

This chapter provides a review of what I have accomplished in terms of my original purposes. I present a summary of the main findings of this thesis, and I tease out some implications for science communication and practitioners of science communication and key players in engagement, which may help them to better understand and address their audiences. I also address the issue of whether the deficit model and the new dialogical approach to science communication are competing or complementary paradigms in the 'space' arena, drawing not only on my empirical data, but also on other studies.

CHAPTER 2

Communicating Science to the Public – Literature Review

"Some years ago, as your Serene Highness well knows,
I discovered in the heavens
many things that had not been seen before our own age.
The novelty of these things,
as well as some consequences which followed from them
in contradiction to the physical notions commonly held among
academic philosophers, stirred up against me
no small number of professors – as if I had placed these things in the sky
with my own hands in order to upset nature and overturn the sciences.
They seemed to forget that the increase of known truths stimulates the investigation, establishment,
and growth of the arts, not their diminution or destruction".

In a letter from Galileo Galilei to
Madame Christina of Lorraine, Grand Duchess of Tuscany, 1615

2.1 Introduction

In this chapter I review a range of literature on the relationship between science and the public, which I feel appropriate to provide a comprehensive background for my research. Studies on the science/society relationship have come from several disciplines including Science and Technology Studies (STS), Sociology of Scientific Knowledge (SSK), Public Understanding of Science (PUS) and studies of science communication, which I have examined in order to provide context to the research questions I propose to investigate in this thesis. Some of the literature that I present here should be understood in a broad context; nevertheless it is essential for positioning my research in the general context of PUS studies.

I will offer a concise chronological picture of the main events that have been the origin of some of the most debated and, at many times most controversial, theories and research methodologies in the public understanding of science and science communication as areas of research and fields of practice, which my research will be addressing and contributing to. This will be particularly important to provide a more comprehensive contextualisation to the discussions that I will present during this thesis, in particular in Chapters 4, 5 and 6. Other literature will be drawn on more specifically throughout this thesis, specifically in Chapters 4 and 5, to offer a deeper theoretical background to these chapters. I believe this specific literature will be helpful to provide a more comprehensive understanding of the analyses dealt with in each of those chapters.

The first section of the literature review, *The Gap between Science and the Public*, is intended to give a general picture of the double-edged nature of science communication, which is seen as both contributing to, and the solution for the 'gap' between science and society. It begins with a brief account of the historical transformations shaping science popularisation and the separation of science from the lay people. It introduces the problem of the relationship between science and society and emphasizes how the traditional view of science popularization has, perhaps inevitably, contributed to it. Furthermore, it introduces the 'new wave' of research in PUS, which focus on studies of "the public", placing my research in the broad context of PUS research.

The second section of the literature review*, The Public Understanding of Science (PUS) and its measurements*, offers a general review of the discussion around PUS and PUS measurements. It starts with an overview of the public understanding of science movement in the UK in the 1980s and discusses how PUS has evolved as an area of research and practice and what has motivated it.

Next, I move on to a discussion of how the belief that more knowledge about science would generate more support resulted in extensive quantitative research on levels of public scientific literacy, and on analyses of the relationship between levels of knowledge and public support for science. I specifically refer to how academic discussions around this controversy showed that public support for science is a rather more complex issue than it was previously thought and when researching public support for science other factors such as values, beliefs, or social factors have to be considered. These criticisms of PUS measurements gave birth to what has become known as the "deficit model", which brought new methodologies such as ethnographic and discourse analysis to look closely at specific cases of (mis)understanding of science by "the public" in specific contexts. This discussion is important for contextualizing my survey methodology, but it will also serve as general background for Chapter 4 where I will be analysing factors that may relate to public support for space exploration.

The third section of the literature review, *Public Participation and Dialogue*, summarizes the main trends in the shift from the "deficit model" to a "mood of dialogue" in science communication. First, I explain what motivated a dialogic approach to science communication and public participation in policy-making. Next, I move on to a discussion of academic literature on the criticisms of public participation in policy-making giving special emphasis to what Collins and Evans (2002) called the "problem of extension". This literature is important in the broader context to understand the main theories in science communication and discussions going on around the topic, which I will be referring to during this thesis. In particular, this literature will be of particular importance for Chapter 5 in which I will analyse the discourse of practitioners of science communication concerning public participation in space policy decisions. At the same time, it is with this background in mind that I will be discussing the current practice of science communication in Chapter 6 (the general discussion of this thesis).

The last section of the literature review, *Dialogue Outside the Policy-making Context,* looks at what the rhetoric of dialogue in policy-making has produced outside the policy context. Although very little research has been done in this area, some recent work which has started to look at dialogue events that do not seek to influence policy-making has theorized that such events might have an important role to play in the relationship between science and society. This is an under-researched area, which my empirical study aims to contribute towards by analysing what the meaning of "dialogue", as described by practitioners of science communication, is and what forms it can take in the area of 'space'. I turn now to the literature review on these topics.

2.2 The 'Gap' between Science and the Public

In this section I give a brief perspective on the scientist/public relationship emphasising the emergence of the 'gap' between scientists and the public that is attributed to the 'traditional' view of science communication. This section is important in terms of setting up the broad context of my thesis as it presents the historical perspective of science communication introducing the roots of the problem around the communication of science with the public. The existing problem in science communication highlights the current challenges that it faces, which in the end justifies the need for a thesis like this one.

2.2.1 The popularization of science and the gap between science and the public that (inevitably) emerged from it

Although concerns about the relationship between science and the public date from the beginning of the seventeenth century, when science began to develop as central social institution, it was not until science started to separate from laypeople in the mid-ninetieth century that the interest in the relationship between science and the public gained more relevance (Gregory and Miller, 1998). However, attempts to popularize science seem to be older. There were many episodes in the history of science where scientists turned to the general public, and astronomy, one of the world's oldest sciences, was also one of the first to be popularized among the public. For instance, the publication in 1543 of Nicolaus Copernicus's (1473–1543) "De Revolutionibus orbium coelestium", which offered for the first time an heliocentric model with the Sun at the centre of the Universe, regarded by many as the start of the scientific revolution, was written for the general public (Gregory and Miller, 1998). However, it was not until Galileo Galilei (1564–1642) turned his 'perspicillum' to celestial observations, that astronomy developed into a modern science, and that the communication of new discoveries of astronomy gained more emphasis. Indeed, Galileo's works were written for the benefit of the layperson; his most important work "Dialogues concerning Two New Sciences", published in Italian, in 1632, was one of the first scientific books written for the lay public (Drake, 1957).

Many other opportunities for the popularization of science were created during the eighteenth and nineteenth centuries, and science began to have a place among the general public. However, it was not until the second half of the nineteenth century, alongside the professionalization of science, that the interest in promoting science to broader publics gained more momentum, reflecting the idea of democratization of the scientific knowledge. "Large scale" (Buchi, 1998) communication of science such as exhibitions, visits to museums and botanical gardens, and publications of books and journals of science, as well as general interest magazines devoting space to scientific information, became very popular among the general public. And, as scientific knowledge continued to expand throughout the twentieth century, the idea of communication of science became embedded all over the world.

Paradoxically, while initiatives to foster the public understanding of science have continued to increase through time, a gap between science and the public started to emerge in the mid-nineteenth century. And, the twentieth century saw this gap widen at an accelerating pace. Bensaude-Vincent (2001) argues that "rapid advances of scientific research, coupled with its increasing specialization and more technical language, deepen the gulf between the scientists and the lay public". Curiously, what at a first glance seems to be a simple process -- scientific knowledge is generated at scientific institutions and is then disseminated to the public -- is in fact a very complex one as it involves communication between very different spheres: those who produce science, those who consume it, and those who mediate it (science journalists, science communicators, etc).

The "canonical" account to science communication

In effect, when considering "communication of science to the public", arguments of the "canonical" account (Shapin, 1992) of the communicative relationships between science and society are likely to be encountered. Because science is seen as "too difficult for the lay people" there is a need for a "third person" (in general the science journalist) to simplify the messages in order to bring these two spheres closer together. This old tradition of science communication rests in the assumption of a "two-stage model", as Hilgartner (1990) defines it:

> "First, scientists develop genuine scientific knowledge; subsequently, popularisers disseminate simplified accounts to the public".

This dominant view of science popularization oversimplifies the process by assuming that this task of differentiating "scientific knowledge" from "popularized knowledge" is straightforward, and that any differences between genuine science and popularized science must be caused by "distortion" or "degradation", often attributed to the "third person" or to a public that misunderstands the message (scientists deny any involvement in the process).

Critical analysis of such traditional models of science communication present the gap between science and the public as an ideological entity created by science popularisers in order to position themselves as mediators (for some real cases, see for example, Hilgartner, 1990, for the controversy between diet and cancer; Lewenstein, 1992, 1995, for the cold fusion controversy; Mellor, 2010, for the controversy around negotiating uncertainty and risk of asteroids impact). For instance, Hilgartner (1990) critically analysed the old "culturally-dominant view" tradition of science communication by looking at the controversy between diet and cancer. He argued that the boundaries between "genuine" science and popularized science, and "appropriate simplification" and "distortion" are ambiguous, and that such boundaries have a political use: they serve scientists and others who derive their authority from science as a political tool in public discourse. As he claimed, this happens because scientific experts are entitled to define these boundaries, and non-experts are not:

> "non-experts remain forever vulnerable to having their understandings and representations of science derived as 'popularized' and distorted even if they accurately repeat statements made to them by scientists" (p.534)

Problematising the public and mediators

Thus, the existing image of the 'gap' in the relationship between science and the public has been constructed by problematising the public, leaving the scientists and other groups involved in the process of communication outside of the problem. Studies of science have, under the influence of the canonical account, showed the role of the public being at best, as Bucchi (1996) argues, that of "providing a passive environment in which knowledge could be spread". According to this traditional view, public discourse of science starts where the scientific discourse ends, drawing a clear boundary between experts and non-experts and reflecting an unproblematic view of the communication of science. As Bucchi (2008) put it:

> "it [the traditional model] incorporates a notion of communication as unproblematic one-way transfer, having no impact on the processes of knowledge production (popularization)".

The "diffusionist" model of science communication has dominated literature in the area of communication of science to the public (Bucchi, 1996). Until the mid-1970s science communication research focused mainly on the relationship between journalists and the public, analyzing the journalistic practice as well as how to improve the media coverage of science (see, for example, Friedman, et al., 1986). This focus has been suggested to have contributed to public misunderstandings of science, and consequently, to the insufficient public appreciation of science. Such traditional studies based on an "outdated" model of science communication led to concerns about accuracy and sensationalism in the media, but also relevance to the public (Lewenstein, 1995).

Understanding "the public" and public communication

Recently, studies of science have started to pay attention to public communication of science as an integral part of scientific discourse where scientists and other science communicators, as well as the public should be part of the process. Instead of two different spheres where distortion is inescapable, sociologists started emphasizing the way in which the various audiences that can make use of scientific knowledge shape that information.

My thesis is based on the premise that understanding contexts and actors involved in the process of science communication is crucial to reconceptualising what science communication currently means and how the relationship between science and society can evolve. Therefore, my research is intended to contribute to this "new" wave in science communication studies in which the public and the way science is communicated are at the core of research, by characterising the "public for space exploration" and identifying how practitioners of science communication conceptualize this public and public communication.

Summary

This section gives a short account of the traditional view of science communication. I have shown how scholars have argued that the 'gap' between science and society exists as a result of the prevailing means of science communication based on knowledge transmission, and how it has motivated research that examines "the public" and the practice of science communication including that presented here. At the same time, this first section of the literature review is of interest to contextualise the problem around the still ongoing debate over the relationship between science and the public, which I intend to address in this thesis and for which my empirical research aims to contribute.

2.3 The Public Understanding of Science (PUS) and Its Measurements

The way the public understands science or "public understanding of science" (PUS) has been a concern over the last three decades not only to the scientific community, and among political, economical and social groups that have recognised the rationale for involving the public more intimately in science, but also among the public who have increasingly demanded involvement in scientific issues. This corroborates the significant role that science and technology play in modern societies and in our everyday lives, and has led to various attempts to systematically place science within society.

In this section, *The Public Understanding of Science and its Measurements*, I review major trends in the public understanding of science "movement" in the 1980s in the UK and how, by the end of the twentieth-century, public engagement with science was a matter for science policy (Gregory and Miller, 1998; House of Lords, 2000; Gregory and Lock, 2008). I will specifically describe the arguments that called for an increase in public scientific literacy and its measurement. I will refer to the academic debate in favour of and against PUS measurements, in particular the evolution of survey design, and how PUS criticisms gave birth to a 'contextual' perspective in PUS favoured over a 'deficit' one. This is important not only to understand my Chapter 4, surveys of the "public for space exploration", but also to contextualise my mixed methodology approach, which I explain in Chapter 3.

What is more, this discussion on PUS measurements and criticisms also provides the differing points of view in academia concerning models of science communication and conceptualisations of "the public". This background is necessary to understand discussions in Chapters 5 and 6, where I will be analysing interviewees' views on science communication and publics, and whether the deficit model and the dialogical approach to science communication are competing or complementing paradigms in the practice of communication of 'space'.

2.3.1 Calls for Public Understanding of Science

In 1985, the Royal Society of London published a report "The Public Understanding of Science" on the problematic around the public understanding of science (Bodmer, 1985). This report, based on the belief that the more the people knew about science and technology the more they would love and support it, claimed that everyone should have some understanding of science and, as a result, placed PUS firmly on the UK agenda. This gave birth to what came to be known as the "public understanding of science movement" (Gregory and Miller, 1998). The report was clearly a call to action and probably the turning point for a new dimension in the science-society relationship. In effect, one of the purposes of the report was to mobilise the scientific community for public understanding of science and to engage the public with science (Miller, 2001; Bauer and Jensen, 2011). Consequently, a wide variety of activities devoted to enhance PUS have started to be implemented. Among others, was the establishment of COPUS (Committee for the Public Understanding of Science) in 1986, responsible for the PUS practical initiatives in Britain such as small grants for PUS activities, media training workshops for scientists and the creation of an annual prize for the most enthusiastic scientists or institutions in communicating science. Certainly, the "most direct and urgent message" of the Bodmer's report was for the scientific community itself to improve their communication skills and to consider communication with the public a responsibility. As the report put it:

> "[S]cientists must learn to communicate with the public, be willing to do so and consider it your duty to do so" (Bodmer, 1985, p.34).

The report also highlighted the need to conduct surveys of public attitudes towards science and technology. In particular, it recommended that the Economic and Social Research Council (ESRC) sponsor research into "ways of measuring the public understanding of science and of assessing the effects of improved understanding" because "they are a valuable guide to the improvement of understanding" (Bodmer, 1985, p.12 and p.15).

Beside the Bodmer's publication, other similar reports reinforcing Bodmer's idea of promoting science and scientists' "duty" to communicate their subject to a wider public were issued in the years following with the aim of increasing the public understanding of science or "scientific literacy" as the term was coined in the US (e.g. Miller, 1983b, 1998) (see, for example, COPUS, 1990; Wolfendale Committee Final Report, 1995).

Clearly, the Royal Society publication initiated a wave of interest in the way in which "the public" understands science. This resulted in the evolution of PUS not only as a field of activity but also as an area of social research. Indeed, funding for academic research into science communication and public attitudes towards science and technology also flourished after the Bodmer publication. However, this wave of interest in PUS also raised important discussions about 'why' and 'what' should the public understand science.

"In his biography of Einstein, Mr. H. Gordon Garbedian relates that an American newspaper man asked the great physicist for a definition of his theory of relativity in one sentence. Einstein replied that it would take him three days to give a short definition of relativity. He might well have added that unless his questioner had an intimate acquaintance with mathematics and physics, the definition would be incomprehensible" (in Introduction to Abridged Edition of "The World as I see it" by Albert Einstein, 2006). This is an interesting approach to the question of 'why' and 'what' science the public should know. How much science does the public need to understand Einstein's theory of relativity? Should the public understand it at all? In what way, if at all, might understanding Einstein's theory of relativity benefit the public? Questions like these originated one of the most prominent discussions on PUS research – the assumption of a deficient public whose origin relates to a lack of scientific knowledge and an adoption of a linear view of communication.

Providing an overview of how these questions have been answered by PUS scholars and how they have motivated PUS research, particularly regarding PUS measurements, is important in the context of this thesis to understand the origin of the discussion around "the deficit model" of PUS. PUS measurements through surveys, as presented by the traditional perspective of PUS, are based on the assumption that higher levels of knowledge lead to more positive attitudes towards science and technology. Whether this is the belief that drives science communicators when organising science communication activities is unclear. Thus, to fully capture the views of practitioners concerning the aims of science communication and their motivations, as provided by my interviews, it is important to understand the traditional perspective of PUS and assumptions related to it, as I present next. I will be making use of these concepts and ideas throughout this thesis.

Public understanding of science: traditional perspective

One of the responses to questions such as the ones asked above, what and why should the public understand science, has been the concept of scientific literacy. Drawing on the basic meaning of literacy, meaning to be able to read and write, Jon Miller's original *Daedalus* article (1983b) suggests that "civic scientific literacy" should comprise three related dimensions:

> (1) "a vocabulary of basic scientific constructs sufficient to read competing views in a newspaper or magazine; (2) an understanding of the process or nature of scientific inquiry, and (3) some level of understanding of the impact of science and technology on individuals and on society".

This level of understanding needed for scientific literacy, as defined by Miller (1983a, 1995, 1998, 2004) and generally agreed by other scholars (Miller and Pardo, 2000; Durant et al., 1989, 1993) has to be sufficient to read and comprehend the Tuesday science section of *The New York Times*. As Durant (1993) later suggested, scientific literacy must be understood as the development of cultural habits that allow the understanding of basic scientific knowledge and its interaction with other areas of culture.

There are many arguments in favour of increasing public understanding of science. Much of the existing literature on the subject (e.g. Thomas and Durant, 1987; Durant, 1993; Shortland and Gregory, 1991; Miller, 1998) identifies some or all of the following arguments for promoting the public understanding of science. Science is part of our culture and everyone has the right to scientific knowledge in the same way that everyone has the right to culture. Participating in the adventure of discovery of nature can be a great pleasure, and even those who are not scientists should be able to understand and solve specific problems based on science, to formulate opinions about scientific themes, and to participate in scientific discussions and decision-making about science and technology. The acquisition of a scientific attitude as a framework for learning at school or in informal contexts, is essential for making personal decisions such as, for instance, those about diet, vaccination, or prevention of influenza. As Haldane (1939) stated in his book "Science and Everyday Life" when describing the importance of bringing scientific facts into the realm of everyday life:

> "the ordinary man must know something about various branches of science, for the same reason that the astronomer, even if his eyes are fixed on higher things, must know about boots. The reason is that these matters affect his daily life" (Haldane, 1939, p.7).

Also, a society that depends on services based on science and technology needs not only scientists and engineers but also a public that supports the scientific enterprise. As the biochemist and great writer of popular science books, Isaac Asimov (1984) once said "without an informed public, scientists will not only be no longer supported financially, they will be actively persecuted". The difference between public understanding and non-understanding, as Asimov claimed, is "the difference between respect and admiration on the one side, and hate and fear on the other" (Asimov, 1984).

Furthermore, public understanding of science became more relevant when a problem of credibility in the scientific system started to arise from increased visibility of scientific controversies, close relationships with socioeconomic and political contexts and risks associated with industrial-technological development -- what Ulrich Beck called the "risk society" (Beck, 1992). This growing public distrust over the past years is associated with the demand for public participation in decisions on issues of public interest and concern (Wynne, 1996, Durant, 1999). From this perspective, citizens need to have basic levels of scientific literacy so that their policy preferences reflect an informed judgement of the policies under debate (Shen, 1975, Miller, 1983a, 1992, 1995, 1998, 2004; Durant et al., 1989, 1993).

Finally, and probably one of the most common arguments in favour of promoting the public understanding of science is the belief that greater public understanding of science will lead to higher levels of public support for science. This has generated a large academic interest in the relationship between knowledge and public attitudes towards science that continues today, which I will discuss next in this literature review. I turn now to look at the academic discussion around measurements of public scientific literacy and how those measurements have been improving with time as a result of the contributions from social studies.

2.3.2 PUS Measurements

What follows is a discussion that examines the existing debate in the literature around the relationships between variables that influence public attitudes and support for science and technology. This is important to understand the analysis presented in Chapter 4 of "the public for space exploration" and factors that may influence their support for space exploration.

In this sub-section I will also explain how PUS measurements have been used to characterise the public according to their level of knowledge and informedness as "attentive", "interested" or "residual" (Miller, 1983a). This is important to understand the assumptions I make in Chapter 4 about the composition of my sample in terms of individuals' attentiveness to 'space' -- I will be arguing that my sample is mainly composed of "attentive/interested" publics.

It should be borne in mind that my aim here is not to provide a description of the levels of public scientific literacy as provided by surveys, although I may refer to it in general terms whenever it is appropriate in the context. A detailed review of public attitudes towards astronomy and space exploration will be presented in Chapter 4, "Who's for the planets – an analysis of the "public for space exploration".

The measurement of public understanding of and attitudes towards science and technology

In order to improve the public understanding of science, governments attempted to measure the levels of public scientific knowledge as a way of assessing what the public already knew and what could be improved in future. The assessment of the public's understanding of science has been one of the most crucial questions in the public understanding of science research, and it is far from a mere academic question. It brings with it historical, social and political implications (Sturgis and Allum, 2004). It seems that little doubt exists in accepting that one of the primary reasons for recent government and industry initiatives to increase public understanding of science is the recognition that a non-supportive and suspicious public towards science and scientists can severely restrict the funding of scientific programmes (e.g. Bodmer, 1985; Nelkin, 1995; Miller, 2004; Sturgis and Allum, 2004). Critically, public levels of scientific knowledge, both in Europe and the US, have not been as high as governments would have expected them to be (NSB, 2002; 2010; Eurobarometer 2005, 2010).

Surveys generally measure three dimensions of the public relationship with scientific issues: interest, knowledge, and attitudes towards science. Knowledge has been measured in one or two dimensions: factual knowledge, which is measured with a "knowledge quiz" (true or false) in which respondents are asked to state, for example, whether it is true or false that the Earth goes around the sun; and methodological knowledge (understanding of scientific methods) where respondents are asked about probability reasoning and logic of scientific methods. The measurement of these three dimensions, interest, knowledge and attitudes, has improved considerably since the first surveys were conducted in the United States, as I turn to explain next.

Empirical surveys

The empirical study of the public understanding of science dates back to 1957 when the first national survey was conducted in America, only six months before the launch of Sputnik I. The study, which was sponsored by the National Foundation of Science Writers (NFSR) and the Rockefeller Foundation, focused primarily on public scientific attitudes rather than knowledge, and was essentially aimed at understanding people's reactions to the presentation of science in the mass media (Withey, 1959). The survey included items on interest in science, attitudes towards science and technology, media consumption means for science and technology issues, and a few items on knowledge. Curiously, perhaps, the survey included a definition of science, as the public was "by no means clear, nor was anyone else" about this "thing about which we have an opinion" (Withey, 1959). The definition was presented to respondents as follows:

> "It [science] includes everything scientists discover about nature – it could be the discoveries about the stars, or atoms, about the human body or the mind – any basic discovery about how things work and why. But science also includes the way in which this information is used for practical purposes – it might be a new way of curing a disease, or the invention of a new auto engine, or making a new fertilizer".

And, to gather public's understanding of the nature of scientific study, respondents were asked:

> "Some things are studied scientifically, some things are studied in other ways. From your point of view, what does it mean to study something scientifically?"

Despite the public's high expectations for future achievements in science and a sentiment in favour of science, the survey showed that only about 12 percent could be said to reasonably understand what was meant by the scientific approach, i.e. could talk about experimentation, scientific method or other rigorous study methods; and about half of the respondents reported that scientific study involved careful analysis but they could not define it more clearly. The survey also revealed a public "in relative ignorance about science" and that "popular attitudes are naive and unrealistic" (Withey, 1959).

Fifteen years passed before the National Science Foundation (NSF) started to conduct its surveys to gauge peoples' understanding of science and technology, and even then they were mainly focused on public attitudes towards science and technology rather than understanding (Miller, 1992). The NSF surveys, which are still carried out today, are conducted regularly (biannually) and have become known as *Science Indicators* where an entire chapter is dedicated to public attitudes towards science and technology. The first survey took place in 1972, which along with the 1974 and 1976 surveys incorporated a series of items on general attitudes towards science, government spending preferences and the status of scientists and engineers (NSB, 1972, 1974, 1976).

In comparison with the 1959 survey, the NSB surveys showed that, although the public retained high levels of appreciation for and expectations about science and technology, surprisingly, perhaps, there was also an almost unchanged percentage of Americans (14 percent) who understood what was meant by the scientific approach (Miller, 1992; Gregory and Miller, 1998). This characterised the first phase of the NSF surveys, which reflected the concerns of the foundation and the scientific community about scientists' prestige and funding. As Miller acknowledges in his article "Toward a scientific understanding of the public understanding of science and technology" published in 1992 in the first issue of the *Public Understanding of Science* journal, this series of surveys was "largely devoid of integrating constructs and ignored the relevant social science literature on attitudes and attitude formation". More recent data, however, revealed that over the last three decades, the percentage of individuals who were able to provide an acceptable explanation of the meaning of studying something scientifically has increased from 12 percent in 1979 to 21 percent in 1999 (NSB, 2000; Miller, 2004).

The second phase of the *Science Indicators* data series began with the 1979 survey and, as a result of the criticisms of sociologists concerning the way public understanding of science was being measured, this new series began to pay more attention to public attitudes, knowledge measures, and expected participation measures for specific issues and controversies, such as nuclear power (Miller, 1992). It began to include a satisfactory number of knowledge items -- not only general knowledge items but also knowledge items for specific areas of research -- such as open-ended items, several multi-part questions and a closed-ended true-false quiz (Miller and Pardo, 2000). New measures of political participation in science were introduced, as I show below, and socio-demographics measures were significantly expanded allowing a first analysis of the public's "scientific literacy" (Miller, 1992).

The attentive public for science and technology policy

The 1979 study marked the beginning of the use of the concept "attentiveness to science" (Miller, 1983a) as a "vehicle for understanding the differential roles of the public in the formulation of science and technology policy" (Miller, 1992). Jon Miller (1983a) using the pyramidal structure by Gabriel Almond (1950) of public participation in the formulation of foreign policy, introduced a classification of the public for science and technology policy as follows:

- The "attentive public" – is composed of individuals who declare themselves very interested in and very well informed about science and technology policy issues;

- The "interested public" – are those individuals who declare themselves very interested in science and technology policy issues but who do not classify themselves as being very well informed about those issues;

- The "residual public" – are those individuals who report that they are neither informed nor very interested in science and technology policy issues.

In that year (1979), only 20% of the population surveyed declared themselves to be "attentive" to science and technology policy, a further 20% were interested, and around 60% was neither informed nor interested in science and technology policy (residual public) (NSB, 1981; Miller, 1992). The 1979 and 1981 *Science Indicators* studies also showed that different levels of attentiveness corresponded to different attitudes to science. The "attentive" public, more interested and informed about science, was more likely to support science and to take an active role in society in discussing controversies than the "interested" or the "residual" publics. However, Miller has not explored differences within the "attentive" public to find out whether the more informed are in general more supportive of science than the less informed (Sturgis and Allum, 2004).

The measurement of scientific knowledge and attitudes was improved in the 1985, 1988 and 1990 *Science Indicators* surveys. These surveys paid special attention to overlap measures in order to allow comparisons of the data over time and cross-national studies of the public understanding of science and technology, and to knowledge measures. In fact, a collaboration between Jon Miller in the US and John Durant and colleagues in Britain in 1988 resulted in the development of what is called the "Oxford scale" – a series of factual quiz questions that tapped "textbook" knowledge about science, which allowed comparisons between attitudes of British and American publics.

Expanding surveys to the UK and Europe

The 1988 NSF survey of public literacy mentioned above was replicated in the UK in 1988, the first survey of the British population that ever took place.

Surveys of public understanding of science were then expanded to Europe in the late 1980s (Miller, 1978; Durant et al., 1989; Wynne, 1995) when the European Commission started to measure the levels of scientific literacy of the European community and publish dedicated reports (Eurobarometers).

The 1988 survey in the UK was an outcome of a major initiative funded by the Britain's Economic and Social Research Council (ESRC) to involve social scientists in research in this area (Ziman, 1991). In contrast with previous surveys in the US, the 1988 survey in the UK incorporated a range of new questions, which in combination with existing measures allowed the investigation of the public understanding of science (scientific understanding was measured on two main dimensions: understanding of the processes of scientific inquiry; and knowledge of the elementary findings of science) and science-based technologies (including medicine) rather than only levels of knowledge, attitudes and perceptions of science and technology (Durant, Evans and Thomas, 1989).

Overall, these two parallel national surveys showed that in both countries, notwithstanding the fact that the levels of public interest in science and technology were high and the public recognised the value of science in modern society, the levels of knowledge were far lower. For instance, only 34 percent of Britons and 46 percent of Americans knew that the Earth goes round the Sun once a year, and around 24 percent knew that the size of the Universe is expanding (Durant, Evans and Thomas, 1989). The survey also showed that, when asked about the processes of scientific inquiry – meaning study something scientifically – less than 18 percent of Britons referred either to theory construction and hypothesis testing or experimental method. These results were generally similar to the NSF survey. Furthermore, these surveys allowed for the first time analyses of relationships between interest, levels of informedness, and understanding, as I proceed to explain.

Relationships between interest and levels of public informedness and understanding

Interestingly, Durant, Evans and Thomas' analysis of the data revealed that no relationship existed between respondents' self-reported interest and levels of informedness. In fact, what appeared to be a direct relation between interest and informedness for sports, politics and films, did not prove to be true for science. The majority of those reporting that they were "very interested" also reported that they were not "very informed": only 9 percent of the 38 percent who reported themselves as "very interested" declared themselves as "very informed' (Durant, Evans and Thomas, 1989). In contrast, and consistent with the NSF surveys, a strong association between interest and understanding was found. These findings were confirmed by Evans and Durant (1995) in a later analysis of the same data. Respondents with lower levels of understanding tended to express less interest in science, which was justifiable by demographic variables – those with lower educational qualifications, those from the working class, females, and older respondents were more likely to score lower on levels of understanding.

Relationships between levels of understanding and public attitude to science

Perhaps the most problematic question resulting from the analysis of the data from the 1988 survey, concerned the relationship between public understanding and public attitude toward science and technology. Durant, Evans and Thomas (1989), based on their preliminary analysis of the results of the 1988 survey, were the first to present a formulation of this relationship. In their article published in *Nature*, they argued that "there are important relationships between public understanding and public attitudes, with a tendency for better informed respondents to have a more positive general attitude towards science and scientists" (Durant, Evans and Thomas, 1989). This linear relationship was critically revised and confirmed by Evans and Durant a few years later in their article "The relationship between knowledge and attitudes in the public understanding of science in Britain" published in 1995 in the *Public*

Understanding of Science journal. Such results reinforced the assumption behind the Royal Society Report (1985) that increased public understanding of science would further public support for science. But, these results also prompted many academic discussions around the relationship between public attitudes and public knowledge about science that continue today. For instance, in a recent article, Pardo and Calvo (2002) argued that empirical support for those conclusions presented by Durant and Evans was very limited as none of the studies mentioned above offered an analysis of the stated relationship.

Discussions around the contested relationship between understanding and attitude to science gained even more emphasis when surveys showed that, after a decade of PUS initiatives, few changes had occurred in the level of scientific understanding both in Europe and America (Miller, 2001). For instance, in the UK, a survey carried out in 1996 as a follow up to the 1988 survey showed that, when asked "what does it mean to study something scientifically" only 17 percent of the British population said experimentation or theory testing – the number remained statistically equal to the 1988 survey (18%). Moreover, not only was the level of public understanding of science not increasing but also the public was even more sceptical about science (Miller, 2001).

One of the major criticisms coming from these findings was directed at the premise that the more the public knew about science the more they would support it. Critics also maintained that the way in which science was being communicated to the public was not 'appropriate' as aims to raise scientific literacy were not being achieved (Irwin, 1996). However, these criticisms have been challenged by recent evidence showing that the level of public understanding of science has, overall, been increasing through the generations (Bauer, 2007, 2009; Claessens, 2008; Eurobarometer, 2000, 2005, 2010; NSB, 2002).

In a recent study about the evolution of public understanding of science through the generations in 12 EU countries from 1989 until 2005, Bauer (2009) using Eurobarometer data, showed that, for instance in the UK, the level of public scientific knowledge overall is increasing with successive generations. By contrast, interest in science has had ups and downs, but generally it has been kept high: the 'baby boom' generation (1950-62) was slightly more interested than the 'generation X' (1963-76), but the 'generation X' (1963-76) was slightly less interested in science than the 'new order' generation (>1977). As for attitudes towards science, in particular the expectation that "science makes our lives more comfortable, easier, and healthier" the same study showed a very small inter-generational difference, and rather positive attitudes. But the 'baby boomers' (1950-62) and the 'generation X' (1963-76) were the most positively inclined in their views towards science, while the 'new order' (>1977) was generally less positive. Given this, it seems that younger generations possess higher levels of knowledge and interest, but are also more sceptical about science.

These studies bring important issues into the discussion over the 'gap' between science and society described in the first section of this literature review, in particular to the question of whether that "gap" is real or existent. In fact, these studies seem to suggest that outreach activities have had an effect on the increase of the levels of public understanding of science. Therefore, it also raises questions about whether the deficit and the contextual models are competing or complementing paradigms, which I will be discussing later in Chapter 6.

I move on now to discuss the main arguments in the literature around the relationship between knowledge and attitudes towards science and technology. While it is not my intention here to describe the many existing points of view as this is beyond the scope of this thesis, I should allude briefly to the main scholarly positions over the discussion around this relationship, and how its criticisms have motivated analysis of other factors that might exert more important influences on public support for science and technology than knowledge.

The debate around relationships between knowledge and attitudes to science and technology

There has been no fiercer academic debate in the public understanding of science than that around the question of whether "to know science is to love it" and the assumption of a linear relationship between knowledge and attitudes toward science (see for e.g. Durant, Evans and Thomas, 1992; Evans and Durant, 1995; Bauer et al., 2000; Calvo and Pardo, 2002; Sturgis and Allum, 2004; Allum et al., 2008). But the results are diverse and not conclusive (Allum et al., 2008). As Allum et al. (2008) argued "there remain more puzzles than certainties; more disagreement than consensus".

In the existing list of works that have looked at this relationship, most relate to general attitudes towards science and technology and point to a weak correlation between knowledge and positive attitudes (see, for example, Bauer et al., 1994; Evans and Durant, 1995; Grimston, 1994; Miller et al., 2000; Sturgis and Allum, 2001, 2004). However, for attitudes towards specific fields of science or specific technologies the relationship has proved to vary significantly. Studies have shown that the correlation is weaker and may sometimes be negative for attitudes towards specific technologies or controversial issues such as for instance, energy technologies (e.g. Midden, 1989), human embryology (Evans and Durant, 1995), biotechnology (e.g. Bucchi and Neresini, 2002; Gaskell et al., 1999), nanotechnology (e.g. Brossard et al., 2008) or nuclear power (Hennen and Peters, 2000). For instance, Evans and Durant (1995) showed that although more knowledge of general science is positively correlated with a favourable attitude towards science in general, for specific technologies or scientific fields a variety of correlations showed up, and a negative relationship for morally contentious science such as human embryo research – the well informed were more strongly opposed to funding than were the less well informed. Similarly, a study by Bucchi and Neresini (2002) concerning public attitudes regarding biotechnologies showed a considerable level of scepticism among individuals most informed about biotechnological topics.

Studies that have deeply analysed this relationship have shown that it can be very "chaotic", particularly for issues involving risk as in the cases of biotechnology (Gaskell et al., 1999) or nuclear power (Hennen and Peters, 1991). For example Gaskell et al. (1999) showed that those less interested and knowledgeable about genetics had stronger perceptions of risk of medical applications of biotechnology than those more informed. By contrast, for agricultural biotechnology and genetically modified food, these relationships were not found.

In addition, a study by Hennen and Peters (1991), which analyzed the nuclear power debate that spread throughout Germany after the 1986 Chernobyl disaster, supports the same argument. The authors surveyed the general population's level of knowledge (knowledge questions) and attitudes (attitude items) towards nuclear power plants in West Germany. The findings showed that "respondents with the most positive attitude toward nuclear power had the highest level of knowledge about it, but the respondents with the second most negative attitude had the second highest level of knowledge about this technology" (Peters, 2000, p.269). Consistent with Evans and Durant's (1995) study, Hennen and Peters' study did not support the assumption of a linear relationship between the level of knowledge and attitudes towards specific areas of science and technology, but a rather complicated relationship.

Furthermore, this relationship varies across cultures. Many studies have shown that the dimensionality of knowledge varies across contexts, which makes this discussion even more challenging (e.g. Bauer, 1996, 2009). Comparisons of measures of public understanding of science across Europe, Canada, Japan and the US show interesting cross-national differences that have been explained in terms of cultural and structural differences (Bauer, 1996, 2009; Miller and Pardo, 2000; Einsiedel, 1991, 1994). For instance, Miller and Pardo (2000) using comprehensive national surveys from the European Union, the United States, Japan, and Canada, examined the levels of civic scientific literacy, interest in science and technology policy, and substantive attitudes towards public funding for basic scientific research showing substantive differences between cultures.

The results showed that the level of public interest in new scientific and medical discoveries, new inventions and technologies, and environmental issues was higher in Canada, the United States and the European Union than in Japan. The authors argued that the low level of scientific interest among the Japanese appeared to reflect a combination of cultural and political factors.

The importance of other factors in public attitude to science

However, recent research suggests that other factors might be more important than knowledge and understanding when it comes to explaining public attitudes towards technological innovations (e.g. Sturgis and Allum, 2004). For instance, studies that have focused on opinion formation about new technologies have shown that support for funding of the technology is influenced by religious beliefs (e.g. Gaskell, et al., 2005; Nisbet, 2005; Brossard et al., 2008), science media coverage (Nisbet et al., 2002; Bauer, 2005; Brossard et al., 2008); and emotional reactions such as fears and perceptions of risk and benefits (e.g. Lee et al, 2005; Brossard et al, 2008).

For instance, Brossard et al. (2008) have looked at the way in which religiosity, the mass media, and perceptions of nanotechnology related risks and benefits might impact attitudes. The study found a direct and negative relationship between the strength of religious beliefs and support for funding of the technology (stronger religious beliefs related to lower levels of support), and that media use had a positive effect on public perceptions mainly because the media, until now, has framed nanotechnology in terms of scientific progress and benefits to society (Brossard et al., 2008). As for perceptions of risks and benefits of nanotechnology, the study showed that a higher level of perceived risk was negatively related to support for nanotechnology and a higher level of perceived benefits was positively related to support for this technology. The authors also analysed how public understanding of nanotechnology and support for this technology might relate. Interestingly, the analysis showed that factual knowledge about nanotechnology relates to support, but religiosity can suppress positive effects of knowledge on support for nanotechnology. In fact, the relationship between knowledge and support for nanotechnology is weaker for higher levels of religious beliefs than it is for lower levels of religious beliefs (Brossard et al., 2008).

Summary

In this section I have presented a case for understanding the complexities inherent in public attitudes towards science and technology. Underlying this are studies that have investigated the relationship between knowledge and attitude to science, which tend to show that well-informed people have more positive attitudes towards science, however, for specific areas of research a positive linear relationship is generally not found. Research has shown that a well-informed person may also have lower support for research in controversial areas of research. Also, attitudes towards science vary across contexts and cultures, which makes the study of attitudes and comparisons between populations even more challenging.

In the next section, *Criticisms to PUS measurements*, I will show how criticisms to PUS measurements had been the origin of what became known as the "deficit model" of public understanding of science and science communication.

2.3.3 Criticisms to PUS Measurements

Prior to more detailed review of literature on the understanding of "the public" later in this thesis, I will provide here a short theoretical context describing ideas about "the public" and public communication put forward by the two perspectives – the "deficit model" and the "contextual model", which I will be making use during this thesis, in particular in the analysis of practitioners' discourse presented in Chapter 5. During the interviews conducted with practitioners of science communication, one of the most debated topics concerned their views on models of communication and "the public"; in order to understand the concepts and ideas that practitioners described it is necessary to introduce a comprehensive examination of the broader academic debate around models of science communication and what conceptualisations of the public are associated with them.

Knowledge measures and the "deficit" approach to PUS

Ziman and Wynne have criticized the basic idea of attempting to measure public understanding of science and the methods that have been used to measure scientific concepts and public attitudes towards science (Ziman, 1991; Wynne, 1991). An incisive argument is that this kind of analysis is based on a "deficit-model" (Ziman, 1991). The measurement of factual knowledge is the key problem of this paradigm. Critics have argued that the essence of science is methods and not facts. According to Ziman (1991) the deficiency model is an asymmetric model in which the science is "sufficient" and the public "deficient" (Gross, 1994), that is, science is seen as a well-defined body of knowledge and the public's level of knowledge is measured in comparison with that. This formulation does not take into consideration other knowledge domains that influence attitudes and isolates science from the contexts that give it public significance (the "third" dimension of knowledge – the context of scientific knowledge). According to some commentators there are other knowledges that can only be understood in their social context. As Ziman (1991) argued:

> "a simple 'deficit' model, which tries to interpret the situation solely in terms of public ignorance or scientific illiteracy, does not provide an adequate analytical framework for many of the results of our research. We have seen many everyday questions that cannot be addressed properly, let alone answered, simply in terms of a shortfall in potential understanding" (Ziman, 1991, p.101).

Durant, Evans and Thomas (1992) have provided a reflective answer to the criticism of the so-called "deficit" model of the public understanding of science as a means of measuring public knowledge:

> "[W]e accept that there are particular issues in our field that require different treatment. Nevertheless, we find hard to see that these qualifications provide good grounds for abandoning the deficit model altogether. Thus, while we have conceded that a great deal of science is problematic, it must be acknowledged in return that a great deal is not. Vast areas of scientific knowledge are relatively unproblematic, in the sense that all competent experts agree with them. This means that there is a reasonably stable body of knowledge against which levels of understanding of science may be measured". (Durant, Evans and Thomas, 1992, p.163)

Responding to Ziman's argument that the public is ignorant and the scientific community posses all the knowledge, and that scientists' knowledge is better than "local knowledge", the same authors commented:

> "[T]here remains the problem of stigmatization. Clearly, to measure levels of scientific understanding within a population is inevitably to assign higher scores to some individuals than to others. By analogy with the notoriously controversial issue of IQ testing, this may be seen as inherently normative. Surely, it may be said, by measuring scientific understanding we are automatically branding as inferior those who score badly? Not at all. It is worth remembering that the French psychologist Alfred Binet developed the IQ test in order to identify those pupils who were most in need of an educational assistance.... [he demonstrates] that there is nothing necessarily prejudicial about the wish to find out how individuals are doing in any

> particular area of educational or scientific attainment" (Durant, Evans and Thomas, 1992, p.164).

Knowledge measures and the "contextual" approach to PUS

Ziman argues in favour of a "contextual" approach to the public understanding of science in order to fully capture the other knowledge domains that influence attitudes towards science. This 'new' approach essentially asks "What do people want to know in particular circumstances?" rather than "what do people know about science?" This "contextualist" perspective (Sturgis and Allum, 2004) requires an understanding of the context of scientific knowledge and how people use it (Ziman, 1992). Brian Wynne, an incisive critic of the deficit model, defends that in order to capture the various knowledge domains that are relevant to attitudes towards science "three elements of public understanding of science have to be expressly related: the formal contents of scientific knowledge; the methods and processes of science; and its forms of institutional embedding, patronage, organisation, and control" (Wynne, 1995). Advocates of this approach argue that the "deficit model" fails to consider the third of these elements. Neglecting this third dimension of knowledge means neglecting the different forms of engagement that people might have with science in a variety of contexts. Furthermore, methodologically this dimension relies on qualitative case studies for empirical support (e.g. Wynne, 1991, 1996).

Despite the criticisms, work to measure quantitatively this third element of knowledge has been done by some scholars (see for example Bauer, et al., 2000; Yearley, 2000; Sturgis and Allum, 2004), and contested by others who say that surveys cannot serve to measure contextualizing forms of knowledge as they take individuals out of their social context (see for example Wynne, 1991, 1996).

An example of quantitative measures of contextual forms of knowledge is presented by Bauer et al. (2000). The authors have proposed alternative measures for measuring knowledge of scientific institutions, which were tested in different contexts, Britain and Bulgaria. Twelve items covered issues such as teamwork, peer review, funding, prestige, etc., in which respondents stated, for example, whether it is true or false (or Don't know) that "scientific research is mostly team work"; "scientists do not criticize each others work"; "the reward of science is recognition rather than money", etc. The authors argued that whether respondents answered the questionnaire in Bulgaria or in the UK makes a difference, as context vary, but that the 'new' instrument clearly discriminates the different contexts:

> "Our scales clearly covary with the country, age, sex, and level of education of respondents; their education in natural or social sciences; and their undergraduate or postgraduate status. The new instrument clearly has the power to discriminate these different contexts (…) The young are more knowledgeable than the old, and whether you are a member of the elite or of the general public, being in Britain or in Bulgaria alerts you to different facets of the institution of science" (p.42).

Despite these measures have proved to be reliable, the knowledge items that the authors proposed require careful calibration within the specific country context where the data are collected. This is in contrast to the knowledge quiz of scientific facts and methods in which correct answers can be assumed to be universal.

Sturgis and Allum (2004) have gone further in this discussion. They showed that both the cognitive deficit and the contextual models might be investigated using a survey-based approach, and that the relationship between scientific knowledge and attitudes is not positively linear, because "other knowledges" (the Wynne's third element of PUS) will influence public attitudes in an opposite way to the two first elements and, therefore, will always be "moderating factors" (Wynne, 1992; Sturgis and Allum, 2004). The authors concluded that both the deficit and contextual models provide insight on "how, why, and under what conditions" knowledge determines public attitudes to science, and that both models should be used instead of being criticized.

Similarly, Einsiedel (2000) maintains that both an ideographic/qualitative approach and quantitative/surveys based research "may be complementary rather than mutually exclusive" to understand "the public" and public attitudes (Einsiedel, 2000, p. 210). As Einsiedel (2000) argued:

> [surveys] "are certainly useful as one indicator of what people say, think, or know about science as an enterprise… they do tap one dimension of knowledge without necessarily negating the fact that there are many other ways to tap understanding" (Einsiedel, 2000, p. 211).

The "deficit" approach to science communication

A more trenchant criticism of the deficit model concerns the practice of science communication. Assumptions that the scientifically "illiterate" public, as shown by surveys, associated with the growing public distrust of science over the past decades in part due to controversies in the 1980s and the 1990s over issues such as BSE, GM food, cloning, gene technologies, nuclear power, or stem cell research, pointed to a "failure" of the efforts to increase the public understanding of science. Many have agreed that science was not being communicated as effectively as it could be (Nelkin, 1995; Ziman, 1992; Miller, 2001; Treise and Weigold, 2002). Not only were scientists communicating in an ineffective way (Royal Society, 2004) but also the scientific knowledge was being poorly disseminated through the media (Nelkin, 1995; Bucci, 1998).

The 'problem' with the communication of science to the public was seen to have its roots in the assumption that the public was in need of more scientific knowledge and the simplistic view of science as unproblematic and certain. Under these assumptions, knowledge dissemination was seen as key. This meant that attention was primarily focused on “knowledge” and “ignorance” (Durant, 1999) rather than on the way science was being (or should be) disseminated to the public. Some commentators argued that the way in which science communication was framed was essentially a simple one-way transmission of scientific facts from experts who possessed all the scientific knowledge to an “ignorant” public that needed to be fed with factual scientific knowledge (Wynne, 1991; Ziman, 1991; Gregory and Miller, 1998). As Stilgoe and Wilsdon (2009) have argued, the one-way communication model did not stimulate a “cordial relationship between science and its publics”. In fact, it proved to be inadequate especially in situations of disagreements between science and the public on particular issues involving risk and uncertainties (Durant, 1999).

A classic example of what is viewed by many as a failure of science communication (not only in the UK but also internationally) is the case of BSE (Irwin, 2009). In effect, the way in which the government handled the BSE case can be seen as an example of what has become known as the “deficit” approach to science communication (Wynne and Irwin, 1996, 2009). Government statements about risk portrayed a consistently confident position which did not match the scientific uncertainties of the case. However, the situation changed dramatically when a number of human deaths were associated with BSE and a large number of cows were slaughtered as a precaution. The government’s official report on the case of BSE “The BSE Inquiry - the report” (Phillips et al., 2009) – was, perhaps not surprisingly, highly criticized as being a communication strategy to “sedate” the public (Irwin, 2009) rather than to explain uncertainties. Although strongly criticised, the report seems to have brought to light important points that are crucial to the science communication process: openness, transparency, recognition of risk and uncertainties, and dialogue with the public, as I will explain further on in this section.

As critics see it, the “deficit” perspective of science communication, such as the BSE one mentioned here, characterizes the public in negative or “needful” terms, privileges scientists and emphasises one-way communication from experts to a passive audience which should trust the scientific institution. When the public opposes scientific and technological development, it is seen as the result of public lack of knowledge or misunderstanding, or insufficient knowledge dissemination. This process of transmission is based on the 'science' rather than explaining uncertainties or doubts.

The "contextual" approach to science communication

The "deficit" approach to science communication contrasts with the 'new' contextual model of communication defended by some commentators. This model emphasises the relationship between science and the public based on two-way communication, and intends to re-establish public trust in science and technology through greater public involvement in science. As Irwin and Wynne (1996) put forward, the two-way model of communication involves both "listening" and "speaking" and considers the role of science and technology within particular social contexts. The authors argue that not merely formal knowledge must be taken into consideration as in the deficit model, but also a broader range of contextual factors – cultural, social, political, economic, and ethical concerns that are many times at the origin of conflicts between science and society. According to these authors, lay people can also be informed and knowledgeable about the conditions of everyday life, and therefore, "local knowledge" or "lay expertise" should be part of public debates to allow a better understanding of social realities. And, to fully capture the contextual factors which are on the base of 'lay expertise', a genuine dialogue between experts and non-experts should exist.

The "lay expertise"

There are a number of case studies which have shown the development of "local knowledge" among the public and public participation (see Irwin and Wynne (1996) for a discussion of these critical perspectives). A classic example of what Brian Wynne called "lay expertise" is the case study of the effect of a radioactive cloud on hill sheep-farmers of the Lake District Cumbria, northern England (Wynne, 1996). Interviews with sheep farmers and others who received intensive expert advice, allowed an analysis of the farmers' understanding of science and reception of scientific expertise. Wynne's account of this case shows that experts, initially, expressed optimism based on a scientific model that later proved to be fundamentally wrong and which led the farmers to economic distress. By ignoring the farmers' local knowledge and farming practices, experts carried out failed field tests. The farmers perceived the experts to be engaged in a "conspiracy with government against hill farmers" due to lack of openness, which led to a situation of deep distrust that could have been avoided if scientific and local knowledge had been brought together.

Despite the strong criticisms of the deficit model by scholars, in practice elements of the deficit model, concerning both the image of the public and public communication, still remain, as shown by previous studies (e.g. Davies, 2008) and my own data will confirm. Furthermore, considering the increase in the level of public knowledge over time, as showed in previous sections of this literature review, it could be argued that the deficit model has some use. I will come back to this point in my general discussion of this thesis in Chapter 6.

Summary

In this section, *The Public Understanding of Science and its Measurements*, I have looked at the way in which public understanding of science has been measured and how critics have argued that measures of knowledge and public attitudes rely on a "deficit" approach to the public and public communication. This discussion about conceptualisations of "the public" (ignorant vs. knowledgeable) and public communication (deficit transfer of knowledge vs. contextual) raises important issues for debate around the question of 'what is PUS for?' My interview data provide information relevant to this debate, which I will look at in Chapter 5, when discussing the aims of science communication as described by its practitioners.

In the next section I extend the discussion to dialogue and public participation in policy-making referring to the main trends these have taken in academic literature.

In order to understand practitioners' discourse on public participation in 'space' related policy issues, which I will be presenting in Chapter 5, it is necessary to understand the broader debates over public participation in science and technology, as I address below.

2.4 Public Participation and Dialogue

2.4.1 The rhetoric of dialogue in policy-making

Public participation has frequently been referred to as the involvement of the public in science policy. Rowe and Frewer (2005) provided a general definition of public participation as the "practice of involving members of the public in the agenda setting, decision-making, and policy forming activities of organisations/institutions responsible for policy development", recognising that the public can be involved in policy formation in a number of different ways with the highest level of involvement being public "input" into decisions that affect them.

The methods used to obtain public participation can range from public opinion surveys, to citizen's jury (e.g. Crosby, 1995) and consensus conferences (see, for example, Joss and Durant (1995) for an extended approach to a consensus conference held in the UK in the field of plant biotechnology; Einsiedel et al. (2001) for a cross-national comparative analysis of consensus conference in Denmark, Canada, and Australia on food biotechnology). Each of these modalities seek to incorporate the results of such discussions into the policy and decision making process. However, they differ from each other in terms of the number of participants, the scientific issue discussed or even the degree of scientific controversy, the method by which public input is gathered, and the extent to which public opinion will be a part of policy-making. These dimensions have been the focus of many attempts to categorize the different participatory models (for extended discussions on models of public participation proposed see, for example, Bucchi and Neresini, 2008; Rowe and Frewer 2000, 2004, 2005; Smith, 1997).

In effect, public participation and dialogue have been the science communication approaches advocated by governments to combat what they thought to be a "public crisis of confidence" in science when faced with increased public scepticism and distrust of science and scientists generated by the many public controversies around science (e.g. BSE, GM foods, cloning, gene technologies, Chernobyl, nuclear power, waste incinerators and many other issues of importance in the public domain). Furthermore, the issue of public participation has been made even more pressing by increasing public demand for involvement in scientific issues and reluctance to uncritically accept experts' decisions (e.g Beck, 1995; Durant, 1999; Fisher, 1999; Goncalves, 2000; Bucchi, 2008). And, the fact that many of the issues involving science are indeed public issues in various aspects and that scientific research depends on public money makes it difficult to argue against public participation in scientific decisions (Fisher, 1999).

Calls for public participation and dialogue

As a consequence, numerous international documents have specified the need for public dialogue and participation in policy issues involving science and technology. In May 2000, the House of Lords published an internationally influential report "Science and Technology", which marked the transition from the "deficit model" of communication to a "mood for dialogue" (House of Lords Select Committee on Science and Technology, 2000). The report argued boldly for the need for public engagement and discussion around scientific issues, and that it should become a fundamental part of the policy-making process. The committee recommended a change in the culture of institutions involved in S&T arguing that:

> "[D]irect dialogue with the public should move from being an optional add-on to science-based policy-making and to the

> activities of research organisations and learned institutions, and should become a normal and integral part of the process of science based policy-making" (House of Lords Select Committee on Science and Technology, 2000, pp. 43).

This idea was enhanced by the publication in July 2000 of the government's science White Paper "Excellence and Opportunity". It stated that the new emphasis in science communication should be focused on dialogue between the scientific community and the general public and that dialogue should be based on greater transparency in order to restore the public's trust and confidence in science (DTI, 2000).

The notion that public opinion can assist decision making in S&T was also put forward in the "Open channels – Public dialogue in science and technology" report published a year after the White Paper. The report resulted from the commission by the House of Lords Science and Technology Committee to the Parliamentary Office of Science and Technology (POST) to keep a "watching brief on the development of public consultation and dialogue on science-related issues, and to keep members of both Houses of Parliament informed". The report identified "rapid growth" in the deliberative activities practiced by S&T institutions and a growing interest in involving the public more directly in policy (POST, 2001). However, it also recognized that there is still a long way to go and to learn from other policy areas to develop good practices in dialogue.

The UK vision for public dialogue was also mirrored in Europe. In 2002, the European Commission published an action plan that "marks the beginning of a long process, the objective of which is to change the relationship between science and society". The action plan argued that "a true dialogue must then be instituted between science and society" (European Commission, 2002, pp. 27).

This "rhetorical shift towards a style of scientific governance based on public dialogue, transparency and democratic engagement" (Irwin, 2006) gave rise to a new paradigm, which Bauer et al. (2007) called the "Science in Society paradigm". This shift places understanding of "the public" as the focus of attention, and public opinion among the scientific community and policy-makers. Hence, public deliberation and participation are the hub of this new "paradigm" (Bauer et al., 2007). As a consequence of this new approach to science communication and conceptualisation of the public, the question which seems to emerge is "How is non-expert knowledge to be positioned within the policy-process? How can the broad rhetoric be translated into practice?"

Many differing and conflicting points of view have been presented. The most prominent one is the democratic model of public understanding of science. According to Durant (1999) "mechanisms should be put in place to facilitate informed public debate as the basis for democratic policy-making" (Durant, 1999, p. 315). This emphasises the participation of different social groups in policy-making – experts and non-experts, including "the lay public" – that are allowed to contribute to the policy-making process in order to establish socially sustainable policies that lead to public confidence in science. This implies that on matters that have significant impact on public policy, it is no longer sufficient that the public trust in scientific institutions and scientists. Instead, the public should be engaged and consulted over matters of scientific and societal concern. However, this idea of democratic participation has been the "target" of many criticisms, as I will attempt to show later in this literature review.

2.4.2 The practice of dialogue in the policy context

Alongside the many PUS initiatives of science communication such as lecturing, exhibitions and museum organisation among others, a number of new forms of science communication have started to emerge based on the idea of a dialogue between experts and non-experts. One important example was when the government tried to put the rhetoric of dialogue into practice regarding a contentious issue in the public domain concerning the British *GM Nation?* The

GM Nation? was an important national public debate in 2003 in the UK over the commercialisation of genetically modified (GM) crops. Not surprisingly, given all the controversy around the subject at the time, the final *GM Nation?* report showed an "uneasy" public towards GM and the more they were engaged, the more suspicious they were concerning the growth of GM crops (GM Nation?, 2003).

Even though it was considered a "very well developed dialogue exercise" by some (see for instance Irwin (2006) for an extended discussion), it was also largely criticised (House of Commons, Environment, Food, and Rural Affairs Committee, 2003) (for a deeper discussion on this see for example Wilsdon and Willis, 2004). One of the biggest criticisms of the *GM Nation?* was that it took place too late, when the decisions on GM technologies had already been taken. As Wilsdon et al. (2005) argued afterwards, efforts to involve the public should be made in the early stages of the scientific development, when technologies are not yet in use – this idea has become known as "upstream engagement" (Wilsdon, et al., 2005).

Upstream engagement

The idea of involving the public in the early stages of technology development has already been put into practice in areas involving risk and uncertainties such as nanoscience and nanotechnologies (see for example the RS/RAE report, 2004; Kearnes, Macnaghten and Wilsdon, 2004; BMRB Report, 2008). For instance, the EPSRC (Engineering and Physical Sciences Research Council) commissioned a public debate to identify public concerns and priorities in relation to the development of nanotechnology for healthcare. The study showed that healthcare applications were greatly valued, but participants showed concerns about the safety and reliability of such applications (BMRB, 2008).

Despite many commentators arguing in favour of upstream engagement, it is still a fairly new way of discussing science. As such, it brings many questions about its value and impact. Questions around whether earlier engagement is better, whether it is considered a means of predicting and managing public opinion

(Wynne 2006), or who the relevant public is and what its role should be, have been topics of much discussion with arguments against and in favour of upstream engagement (for a more detailed discussion on this see for example the works by Stirling (2005), Irwin (2006), Wynne (2006) and Wilsdon, et al., 2005). Advocates of this model have made it clear that upstream engagement is about creating the opportunities to empower the public to discuss the uncertainties and benefits of science, and at the same time, to allow scientists and policy-makers to receive social reflection on issues involving science (Stilgoe and Wilsdon, 2009; Wildsdon et al., 2005). For its critics, upstream engagement does not seem to be the solution for the "problem" of rescuing the good image of science (see, for example, Taverne (2004)) but rather a "fashionable demand by a group of sociologists for more democratic science" (Taverne, 2004).

2.4.3 Criticisms to the rhetoric of dialogue

More generally, while rhetoric about dialogue, trust, and openness in policy-making has been strongly incorporated into governments' agendas, and some dialogic events about science and technology have been designed in recent years, numerous questions about the practicality of dialogue have been raised. Commonly asked questions are whether this is only simple rhetoric or something to be taken seriously; whether processes involving only small groups can be representative of general public opinion; whether the means justify the costs; who should decide or which issues should be discussed; how effective are these exercises; whether the outcomes of these dialogue exercises will be incorporated into the policy decisions (for extended discussions on these see, for example, Wynne, 2006; Irwin, 2009; Stilgoe and Wilsdon, 2009; Neresini and Giuseppe, 2008). Another question, and perhaps one of the most discussed among scholars, concerns the potential of the public to participate in such discussions, for which many differing theoretical approaches have been presented; yet no consensus has been reached. Due to the importance of the latter to this thesis I will explore it in greater detail next. The potential for the public to participate in policy issues about science and technology was one of the most predominant topics during my interviews with practitioners when discussing public participation in space policy issues.

The public deficiency

As seen in previous sections of this literature review, research has demonstrated the legitimacy of the value of "local knowledge" (e.g. Irwin and Wynne, 1996) or "lay expertise" (often cited in medical sociology literature, see for example Kerr et al, 1998a; 1998b; Kerr et al., 2007) as important contributions to science. However, the public's ability to participate in the making of complex decisions has been one of the most prominent discussions among scholars concerning the issue of public participation. Here the question seems to be: Who should and should not be contributing to decision-making?

An example of the most extreme view on public participation can be found in Shamos' book "The Myth of scientific literacy" (1995). He insists that the true scientific literacy is only achieved when an individual understands integrally the third law of thermodynamics as a physicist and that science policy should be abolished from the democratic process. The public could never have the scientific knowledge to participate effectively in the decision-making process.

This idea of the public being unable to participate in policy-making decisions is not new. In 1922, Lippmann in *Public Opinion*, his effort to deal with the problems of representative and democratic government, maintained that the public deficiency in knowledge was an obstacle to public participation in policy issues. He believed that an expert organization should exist for making unknown facts understandable to those who have to make decisions. The key problem, as Lippman saw it, was that facts could be distorted. What people take as fact is not what it is, but what they perceive. And that distortion occurs due to emotional factors and stereotypes (the images we have of things). Consequently, citizens were seen as not competent enough to determine government policy. Competent opinions could come only from specialists. He continues the discussion on the problem of representative democracy and public participation in policy making in his *The Phantom Public* (1925) and his last major work, *The Public Philosophy* (1955). In *The Phantom Public* he wrote:

> "The public will arrive in the middle of the third act and will leave before the last curtain, having stayed just long enough perhaps to decide who is the hero and who is the villain of the piece".

The "problem of extension"

Most recently, Collins and Evans (2002) showed their concerns about public participation in their critique of the notion of "lay expertise". Much of their critique was around what they called the "problem of extension": public participation should exist, but limits should be defined. This is clearly opposed to the "democratic model" discussed above, which tries to solve the "problem of legitimacy" through increased participation by the public. Collins and Evans argue that the role of expertise should be separate from the role of democratic rights. According to them, "lay expertise" is not to be found among the public. There is, instead, "experienced-based expertise", and the appropriate way to incorporate public opinion into policy processes depends on the nature of that expertise in science and technology. According to these authors, there are three types of public expertise: *Interactional Expertise*, which means "enough expertise to interact interestingly with participants and carry out a sociological analysis" (learning the language of the relevant science); *Contributory Expertise* that means "enough expertise to contribute to the science of the field being analysed"; and *Referred Expertise* that means "expertise in one field that can be applied to another" (Collins and Evans, 2002, p. 254, p. 257). Public participation should be by virtue of the type of expertise possessed and only those with relevant expertise may participate. The authors acknowledge that these are ideal types, and that the boundaries between them depend on the different actors involved in the process.

Moreover, if public expertise is insufficient to make a contribution, then public participation should be decreased. In their critique of the notion of ‘lay expertise’, they wrote:

> “The romantic and reckless extension of expertise has many well-known dangers – the public can be wrong”. (Collins and Evans, 2002, p.271)

While in Wynne’s approach to public participation in decision-making there are no boundaries between scientists and the public and both have the ‘right to participate’, Collins and Evans argue in favour of a distinction between political and expertise roles and boundaries between groups of specialists and non-specialists. Specialists that can contribute to the process of decision-making can be certified or non-certified to be part of the “scientific core” but at least have to have *interactional expertise* (see Collins and Evans discussion paper for an extended analysis of their theory of the inter-relationship of types of expertise and how different parts should interact). This means that the scientific community as a whole no longer plays a special role in the decision-making process, and that the wider scientific community is indistinguishable from general citizens.

Jasanoff (2003) and Wynne (2003) have strongly criticised Collins and Evans’ ideas. Among other criticisms, they commented on Collins and Evans’ ideas of public expertise and understanding of public domain processes involving science. Contrary to Collins and Evans’ idea of participation of ‘sub-populations’ according to level of expertise, and the idea that the public as a whole cannot be experts, Wynne (2003) argued that “the proper participants are every democratic citizen”. Also, Jasanoff (2003) argued that Collins and Evans’ notions of expertise have a “reductionist quality to their analysis”, which falls under “(1) a misleading characterisation of the relevant science studies literature; (2) a misconception of the foundations of expertise in the public domain; and (3) a misunderstanding of the purposes of public participation in contemporary democratic societies”

(Jasanoff, 2003, p. 391). Concerning this last point on which I have focused in this literature, Jasanoff stated:

> "In general, Western states have accepted the notion that democratic publics are adult enough to determine how intensely and in what manner they wish to engage with decision-making, subject only to the constraints of time and other resources. In US regulatory decision-making, for example, all federal agencies are required by law to engage the public at least by offering notice of their proposed rules and seeking comment. It is understood that any 'interested and affected' party has the right to participate in such processes". (Jasanoff, 2003, p.397)

Kerr et al. (2007) have recently analysed lay and expert positions in public debate about new genetic research challenging Wynne's and Jasanoff's arguments in this debate. They analysed three public dialogue processes: a multi-stakeholder workshop, a *Café Scientifique* event, and a one-day public meeting, to explore the dynamics of expertise and their implications for the demarcation between lay and experts (participants alternated between technical experts with formal or related professional experience and non-experts chosen by virtue of their life experience). The study showed that, despite the "hybrid" expert-lay positioning, scientific knowledge persisted, i.e. there was a dominance of experts and lack of lay contributions. Non-experts were not able to challenge technical expertise, instead they were often complicit with it. The authors argued that the events they analysed are far from the ideal type of participative democracy that supporters of public participation such as Wynne and Jasanoff may have in mind. Their study also acknowledged that the events they analysed did not result in any significant contribution to decision-making about genetic research or service provision. The authors wrote "our findings nevertheless lead us to query Jasanoff's and Wynne's apparent optimism about the public's potential impact on decision-making" (p.408).

Summary

In this section I have shown that the aim of greater public involvement in policy issues is far from uncontested and that this disagreement relates to the way in which the "the public" is conceptualised. Moreover, I have provided some examples in the existing literature of criticisms around public participation and defenders' responses to them. While some scholars argue for a deliberative democracy, which values equality between scientists and non-scientists and informed public debate, others argue that the role of the public in policy arguments represents a more complex issue than that put forward by defenders of the democratic view. Opponents to public participation question the potential of the public to take informed decisions, and argue that the public has too much say in the application of science what may be dangerous in determining its direction.

In the next section, I will discuss how the policy rhetoric of "dialogue" has been used outside the policy context, albeit very little existing research that has explored this issue. My research aims to contribute to filling this gap in the literature and is therefore original in this aspect. In Chapter 5 of this thesis I will look at how this rhetoric of science communication has been put into practice by those who are asked to do so: I will examine how this discourse is translated into particular situations of science communication of astronomy and space exploration to the public.

2.5 Dialogue Outside the Policy-Making Context

As previously stated in this thesis, one particular issue that I will be looking is the meaning of "dialogue" outside the policy context. To do so, I will analyse practitioners' discourse on "dialogue" and "engagement". As discussed before, dialogue has been advocated as the means to engage the public in science. However, there is no consistency regarding what "dialogue" means (Davies et al., 2009) and what forms "dialogue" should take. And, despite informal science institutions (ISI) such as museums and science centres having been increasingly promoting public engagement and dialogue with the public, as far as I am aware, no research has looked at the 'real' meaning of "dialogue" in the contemporary practice of science communication, i.e. how practitioners of science communication are responding to the rhetoric of dialogue from policy contexts.

2.5.1 The rhetoric of dialogue and engagement outside the policy context

Recent work that has started to discuss and theorize the role of dialogue outside the policy context (Van der Sande and Meijman, 2008; Davies et al., 2009; Lehr et al., 2007) has proposed some preliminary typologies. For instance, Davies et al. (2008) defined two main types of dialogue that can occur between science and society: "dialogue events that seek to influence policy and those that do not" – a simple typology, but a distinction that according to the authors "is an important one and fruitful way of analysing 'dialogue'" (Davies, et al., 2008, p.339).

While works such as the ones referred to above argue that dialogue has a role to play outside the policy context, other authors have presented different typologies of the science-society relationship that challenge this idea. For instance, Rowe and Frewer (2001, 2005) have, based on the flow of information between participants and sponsors, distinguished between *participation* and *communication*; the key difference being that "information of some sort flows from the public to the exercise sponsors in the former, rather than solely from the 'sponsors' to the public in the latter" (Rowe and Frewer, 2005, p.254). In their most recent typology, the authors proposed three types of public engagement as follows (Rowe and Frewer, 2005):

- *Public communication*: the "information is conveyed from the sponsors of the initiative to the public… information flow is one-way: there is no involvement of the public per se in the sense that public feedback is not required or specifically sought" (pp.254, 255).

- *Public consultation:* the "information is conveyed from members of the public to the sponsors of the initiative, following a process initiated by the sponsor" (p.255). Also here information flow is one-way.

- *Public participation*: the "information is exchanged between members of the public and the sponsors. That is, there is some degree of dialogue in the process that takes place" (p.255).

Rowe and Frewer's classification makes a clear distinction between *participation* and *communication* in which the latter is only concerned with a one-way communication. This classification has, however, been criticised by some scholars. In a recent study, Bucchi and Neresini (2008b), among other criticisms to Rowe and Frewer's typology, argued that this typology "anchors public engagement to a notion of information flow" which "seems largely to reprise the limits of the deficit model and traditional communication paradigms, the main difference being that it envisages the possibility of two-way transfer" (p. 460). My own data will show that communication, as described by its practitioners, is framed according to the aims of communication and not to the flow of information, and it may involve both one-way and two-way communication.

Van der Sande and Meijman (2008) have also challenged Rowe and Frewer's ideas by presenting a typology based on aims of communication as follows: "public awareness of science, public engagement with science, public participation in science, and public understanding of science". The authors' main argument is that dialogue has a role to play not only in public participation but also in public awareness of science and public understanding of science. As they argue, the public understanding goal is "just as open to dialogue as the public awareness goal of science communication". The authors also maintain that science communication goals, as they defined them, science communication modalities (science promotion, science education, and 'prevention of knowledge deprivation'), and the use of (science) communication instruments such as dialogue, are not clearly distinguished in form and function at present". My empirical data on the views of practitioners support Van der Sande and Meijman's (2008) hypothesis that there are different types and aims of dialogue which can serve public understanding of science, public awareness of science and public participation in science, as I will show in my Chapter 5.

2.5.2 The practice of dialogue outside the policy context

In terms of the practice of dialogue outside the policy context, "dialogue events" between experts and the public have, in the past five years, become a component of many informal science institutions in the UK such as the Science Museum's Dana centre. They are usually "adult-focused, face-to-face forums that bring scientific and technical experts, social scientists, and policy-makers into discussion with members of the public about contemporary scientific and socio-scientific issues related to the development and applications of science and technology" (Lehr, et al., 2007, p.1467). The main aim of these discussions is to produce dialogue with the public. As the Science Museum's Dana Centre, a site where these events take place, website states:

> "The Science Museum's Dana Centre is an adult-only venue that lets you explore issues in contemporary science through dialogue, interaction, performance and art".

Scholars who have theorized about the value of these events have suggested that they are important "sites of learning" and that it "may be productive to research and evaluate such events" (Lehr, et al., 2007; Davies et al., 2008). For instance, Davies et al. (2008) argued that these events "should be viewed as having learning outcomes at the level of individuals rather than influencing policy-making at the level of the institutions". The same authors also argued that such events might be more effective in producing a culture of science than actual public participation in policy:

> [D]ialogue events that do not seek to influence policy are spaces enabling individuals from potentially diverse cultures to come together, articulate positions and views, and interact in a context of genuine equality. It could even be argued that this could – theoretically – be a far more effective way of affecting the culture of science to become more personally relevant and democratically accountable than through public participation in policy" (Davies et al., 2008, p.347).

The shift towards dialogue within informal scientific institutions has taken place within the broader context of cultural change towards increased public engagement with science, and as a reaction to visitor requests for scientific and technological topics to be addressed in an intelligible way for non-experts (Simonsson, 2005, 2006). Science centres and museums understand their role as "being able to respond rapidly to new developments in science, which can be achieved by hosting and supporting debates rather than only by creating new exhibitions" (British Association for the Advancement of Science, 2005, p. 70). In addition, these "dialogue events" are seen as opportunities to attract other audiences, i.e. to move beyond the family visitors to other groups who would not otherwise visit these centres (Simonsson, 2005, 2006). Nevertheless, although dialogue events outside the policy context seem to be a promising way of getting people engaged in science and reach beyond the "attentive/interested" audiences, very little is known about what formats dialogue can take and what use are practitioners making of it (if any).

Summary

I have provided a brief overview of the discussions around the value of dialogue outside the policy context. Despite the recognition of the value of public engagement, its real meaning is far from being resolved. There is a need for critical thought with respect to what dialogue means to the ones who practice it, and what forms it can take. Of interest to my thesis is taking this idea further and asking what types of dialogue exist in the context of science communication of 'space' with the public. I will argue that there are different types of dialogue that have been adapted from policy discourse by practitioners of science communication who use them according to their needs and particular contexts.

2.6 SUMMARY AND CONCLUSIONS

In this chapter I have reviewed a range of literature showing the historical development of the debates around the relationship between science and the public, which I feel is relevant to approaching the study of "publics" and public communication that I present in the following chapters. In order to show the complexity of the issues around public understanding of, public engagement and public participation, I have given a short account of how communication of science has evolved as a field of practice and a contested field of research over the last 25 years in the UK. Specifically, I have shown how models of science communication have changed as a way to answer the exigent demands of the public and society. My general approach focused on the way in which PUS research methodologies have evolved from public understanding of science to the "scientific understanding of the public", which I believe provides the background for understanding the discussions throughout this thesis over the meaning of the public and mechanisms to communicate with "the public". Furthermore, this background will help in understanding my methodology strategy (combination of quantitative and qualitative research) and also the analyses and discussions presented in Chapters 4, 5 and 6. At the same time, it also provides some initial thoughts on the problems of the relationship between science and society that this thesis will look into.

More specifically, I showed that the “public understanding of science (PUS) movement” was characterised by a “deficit” model of the public and a “deficit” model of public communication. The most prominent “problem” that came out of this paradigm was the belief that a more knowledgeable public would be more supportive of science. This idea resulted in a number of PUS activities which aimed at persuading people of the value of science. However, the findings of the many surveys investigating what “the public” knows about science, showed an ‘illiterate’ public, sceptical about science and technology. PUS research under this paradigm was essentially characterised by quantitative research on the way the public understands science, and analysis of the relationships between public knowledge and public support for science.

Contrary to what was expected, such analysis revealed more complicated relationships between knowledge and public attitudes towards science in general and specific areas of science in particular. While in some scientific areas weak relationships between knowledge and attitudes towards science showed up, in others no relationship or even negative relationships appeared. Furthermore, other individual or social factors might also have a role to play in public support for science. This part of the literature review places the discussion on public understanding of science and attitudes in contemporary PUS research, highlighting the importance that different variables might have in determining public support for science and providing the background to my Chapter 4, where I will be analysing variables that might influence public support for space exploration.

The “deficit” model has come under continuing criticism on a number of grounds essentially by social scientists. Critiques mainly concern the way in which PUS is being approached via quantitative research arguing that such an approach does not show all knowledge domains that influence public attitudes towards science, which according to opponents of the deficit model are only possible to measure through qualitative research. This gave birth to another important episode in PUS history, characterised by a change in rhetoric by scientific and governmental organisations, which came to highlight the importance of a dialogical approach to the public and public participation in policy-making. However, the potential for public participation in decision-making has become the focus of many criticisms for which many differing views have been presented. I have also shown how, more recently, dialogue has been adapted for situations outside the policy context, however, this is still an under-theorized and under-researched area of study. This piece of literature provides the essential background to understand the discussions in Chapters 5 and 6.

Before moving on to the analytical chapters of this thesis, I first describe the methodology that I used to investigate my research questions, which is explained in the next chapter.

CHAPTER 3

METHODOLOGY

Our discussion will be adequate if
it has as much clearness as the subject-matter admits of,
for precision is not to be sought for alike in all discussions,
any more than in all the products of the crafts. . . .
We must be content, then, in speaking of such subjects and with such premises
to indicate the truth roughly and in outline . . .
for it is the mark of an educated man to look for precision in each class of things
just so far as the nature of the subject admits;
it is evidently equally foolish to accept probable reasoning from a mathematician
and to demand from a rhetorician scientific proofs.

-- Aristotle, Nicomachean Ethics

3.1 INTRODUCTION

This thesis aims to contribute to the study of publics and public communication using a mixed-methods approach (Tashakkori and Teddlie, 1998). In particular, I attempt to characterize the "public for space exploration" and the views of practitioners of space science communication on their "publics" and public communication using both quantitative and qualitative methodologies.

This approach involved two phases of research: *Phase 1*, which consisted of a quantitative survey, and *Phase 2*, which consisted of interviews conducted with practitioners of science communication. This research approach is innovative in the sense that I used *Phase 1* data to generate responses in *Phase 2*, as I explain further in this chapter.

This methodology is one of the strengths of my thesis as it allows the study of a variety of aspects and dimensions related to the understanding of publics and science communication, providing a strong kit to build as complete a picture as possible of the current understanding of science communication in the 'space' arena. This would not be possible using only one single methodology.

In what follows, I explain the selection of the methodological approach. Next, I describe the quantitative methodology used, which includes the survey aims and purposes, the design of the questionnaire, and data collection. I then describe the survey data analysis approach: theoretical assumptions, types of variables used in this study, and the type of analysis performed to examine public support for space exploration. The last section of this chapter describes the qualitative methodology: the sample selection criteria, the interview procedure, and the analysis of the interview data.

3.2 Selection of Methodological Design

3.2.1 Mixed-methods approach

Mixed methods research implies the use of a number of different research strategies related to a complex range of research aims (Brannen, 2005). As stated above, this research follows a combination of quantitative and qualitative methods: *Phase 1* -- a survey of the "public for space exploration" in the UK, and *Phase 2* -- semi-structured interviews conducted with practitioners of science communication in the area of astronomy and space sciences.

A review of relevant literature has been presented in chapter 2, the *Literature Review*, in order to contextualize the aims and to frame the findings of the thesis. In my literature review I have provided a chronological overview of the main events related to my topic giving particular emphasis to the debate around the use of methodologies in PUS research, which in a way, I thought would also be useful to understand my approach to research methodology. The debate around PUS methodologies is part of a wider debate within the social sciences methodologies, regarding the superiority of which is the best method; a debate that has been alive for, at least, the past three decades. Although many of the intellectual arguments for the use of qualitative research are linked to perceived weaknesses in quantitative research, I believe that both qualitative and quantitative research methods deliver useful and informative data, with each method serving rather different research objectives (Davies, 2007). Therefore, I was interested in both types of data – words which would allow an inductive approach and generation of PUS theory (interviews); and, numbers that would allow a deductive approach and testing of hypothesis (surveys) (Brewer and Hunter, 2006).

To provide a brief history, the mixed-methods approach resulted from the "paradigm wars" (Creswell, 1995) between the value of the positivist paradigm (quantitative research) and the constructivist paradigm (qualitative research), stating that qualitative and quantitative methods are, indeed, compatible (Tashakkori and Teddlie, 1998). This has come to be known as the third methodological movement in social research or the "pragmatists paradigm", as presented by "pragmatists", particularly as this applies to PUS approaches (Tashakkori and Teddlie, 1998; Brewe and Hunter, 2006; Bauer, Allan and Miller, 2007). Pragmatists argue that because mixed methods research may produce a substantial amount of empirical work, theoretical work becomes more comprehensive. As Brannen (2005) put it, mixed methods research "may foster thinking outside the box" (p.5). Furthermore, the purpose of the research methods may also be different (Hammersley, 1996; Tashakkori and Teddlie, 2003). As Hammersley (1996) maintains, the second method is not used to check or verify the first; both complement each other. This research strategy has been increasingly employed in the social and behavioral sciences (Brannen, 2005)[1].

Complementary methodologies in science communication research

I consider this type of research methodology to be of particular importance in the multidisciplinary field of science communication, which brings together researchers from many different disciplines, and many different aims and targets of study. Consequently, I chose a mixed methodology for the reason of "complementarity" (Tashakkori and Teddlie, 1998). As Brannen (2005) argued "qualitative and quantitative results are treated as different beasts. Each type of data analysis enhances the other. Together the data analysis from the two methods are juxtaposed and generate complementary insights that together create a bigger picture" (Brannen, 2005). I believe that this mixed approach provides a more "comprehensive picture" (Tashakkori and Teddlie, 2003) of the complex study of "publics" and public communication, which would not be as rich using one single method.

Nevertheless, this form of research also proved very challenging within the timeframe of this thesis. It included not only extensive data collection but also a considerable amount of time analyzing both text and numeric data (744 respondents in the survey and fifteen semi-structured interviews). In addition, it required being familiar with both types of methodology, which is a time-consuming process.

[1] A Sage Handbook of Mixed Methods Research was recently published (Tashakorri and Teddlie 2003a); numerous UK and international seminars and workshops have been held in the recent past; and a journal of mixed methods research by Sage emerged in 2007 (Brannen, 2005; Creswell and Plano Clark, 2007).

3.2.2 Mixed methods research design

I collected the data in separate phases, in what Creswell (1995) called “two-phase studies”, which began with the quantitative phase *(Phase 1)*. The analysis of the quantitative data and its results were then subsequently used in the second phase, during the data collection *(Phase 2)*. First, I conducted the surveys in order to characterize “the public for space exploration” and support for space exploration. Second, I conducted the interviews with practitioners of science communication where I examined, among other issues (such as public participation in science policy or the meaning of dialogue), how well practitioners ‘know’ their publics by showing them results from *Phase 1*. That is, data from *Phase 1* became a source of data in *Phase 2*. This meant that my quantitative and qualitative data were “connected” during the research (Crewswell, 2009). Overall, I used a “sequential explanatory strategy” to mixed methods research design (Creswell, 2009), which is “characterized by the collection and analysis of quantitative data in a first phase of research followed by the collection and analysis of qualitative data in a second phase that builds on the results of the initial quantitative results” (Creswell, 2009). Thus, the two methods are separated but “connected”.

Given this, I used both types of data collection -- quantitative and qualitative; and both types of data analysis – statistical analysis and qualitative analysis (Tashakkori and Teddlie, 2003), as I explain further in this chapter. For the quantitative data collection I designed a questionnaire, which I analyzed entirely quantitatively through both *descriptive* and *inferential* statistics (Field, 2005). The interviews I conducted are qualitative and were analyzed only qualitatively.

3.3 QUANTITATIVE SURVEY

3.3.1 The survey design

As I explained in the introduction of the thesis, little research has been conducted to understand this group which takes the time to go to space science exhibitions, and to explore what factors might influence their support for space research. Thus, my survey had two main aims: a) to characterize the "the public for space exploration" in terms of socio-demographic factors, rationales for exploration, beliefs in extraterrestrial life, attitude towards space exploration, and space policy preferences; and b) to analyze how those characteristics influence public support for space exploration. Particular emphasis was given to the understanding of gender differences in support for space exploration. Males and females are often found to have divergent attitudes towards science. Most studies that investigated gender differences in attitudes towards science concluded that males are more supportive of science than females (e.g. Barke et al., 1997; Trankina, 1993; Simon, 2010). Therefore it would also be interesting in this survey to understand the gender pattern in the survey sample. Within the context of these broad research objectives, this analysis focused on three main research questions:

- *Research Question 1*: How is the "public for space exploration" characterized in terms of socio-demographic variables, rationales for exploration, beliefs in extraterrestrial life, attitude towards space exploration, and space policy preferences?

- *Research Question 2*: How do rationales, beliefs, age and gender influence public support for space exploration?

- *Research Question 3*: Does support for space exploration vary among males and females?

The basic purpose of the survey research was to generalize from a sample to a "population" so that inferences could be made about characteristics of the "public for space exploration" (Creswell, 2009). As Busha and Harter (1980) stated "a population is any set of persons or objects that possesses at least one common characteristic." As the "public for space exploration" may be quite large, studying only a sample (i.e. a small proportion) is one big advantage of a survey methodology.

Furthermore, recognising that space outreach exhibitions and centres are usually busy locations, a survey was the preferred type of data collection in terms of surveying as many visitors as possible as it allows collecting considerable amount of data in a short time. Also, it was the most appropriate type of data collection to investigate several characteristics of this group, covering as many people's views as possible. In addition, a survey would allow comparison of characteristics among individuals, such as for instance, whether gender differences existed among this group of individuals. Finally, a survey would allow me to address the question of public support for space exploration: by combining individuals' characteristics it would be possible to test how the surveyed factors might influence public support for space exploration.

3.3.2 Sampling strategy

The form of data collection that I used was a self-administered questionnaire (Jenkins and Dillman, 1995; Wright et al., 1975, Wright et al., 1978). Recognising that visitors usually do not want to spend much of their time filling in long forms a questionnaire in the form of a postcard to be self-administrated and completed in about 5 to 10 minutes seemed to be the most appropriate sampling strategy. Furthermore, it would have the advantage of getting even less motivated people to participate. By comparison, asking people to complete the survey after going home would certainly generate lower response rates, unless respondents were particularly interested in the research (Herberlein and Baumgartner, 1978). The questionnaire was also a compromise between cost and convenience (Fink, 2003). Finally, it was the quickest way of getting a form of data collection done in the short period of time that I had available for designing the questionnaire (see the limitations section further).

3.3.3 The sample

The sample was taken from space science events as these tend to self-select people who at least have an interest in going to space science-related activities (NSB, 2008). In fact, as I will argue in Chapter 5, people who come to science events are more likely to be part of the "attentive" and "interested" publics for science (Miller, 1983a; NSB, 2008). The two locations for sampling were: the Royal Society Summer Science Exhibition in London and the National Space Centre (NSC) in Leicester. The locations were a compromise between convenience and accessibility.

The opportunity for sampling at the Royal Society Summer Exhibition in 2008 came from a connection with the University of Leicester, which had also shown an interest in surveying visitors' opinion about space exploration. My participation at this event enabled the development of relationships with the Communication and Outreach team at the National Space Centre, which was also participating in the exhibition. These contacts made possible the distribution of the postcards at the National Space Centre that summer (2008) after the Royal Society Exhibition has finished.

The Royal Society sub-sample

The Royal Society Summer Science Exhibition is one of the most important and famous public science exhibitions in the UK. It takes place at the Royal Society in London every summer, and lasts for four days. It attracts thousands of visitors every day from all around the UK. The exhibition is aimed at showing the British public top science achievements in various scientific areas from top universities and scientific institutions in the UK.

I distributed the postcards at the exhibit "Exploring the Solar System, Mankind, machine or both?" during the four days of the exhibition -- from 31st of May to 3rd of June 2008. From the 500 postcards distributed, 295 were returned by visitors.

The exhibit was a cooperation between the University of Leicester, the Mullard Space Science Laboratory (UCL), the Aberystwyth University, the National Space Centre and the Astrium Ltd. The exhibition displayed an "ExoMars" robot prototype (2018 ESA's mission to Mars), a BepiColombo model (ESA's spacecraft to Mercury to set up in 2014), video clips and hands-on-activities on the theme of the exhibit.

The National Space Centre sub-sample

The National Space Centre is located in Leicester. It has been one of the most successful visitor centres in the UK. This location appeared to be of particular importance for data collection of a sample of people interested in space science as they had to travel with the purpose of visiting the centre.

I left the postcards at the centre with the Communications and Outreach team who kindly offered to distribute the postcards to the visitors. The postcards were left at the centre at the beginning of August 2008 and collected at the beginning of September 2008. From the 750 postcards distributed, 449 were returned by the visitors.

At both locations, the postcards were handed to respondents individually while they were walking around the exhibits and returned after the visit. All the questionnaires were anonymous. The sample size was 744 respondents; about two-thirds from the NSC sub-sample and one-third from the Royal Society Exhibition sub-sample. The sample represented a response rate of 62% at the Royal Society Exhibition, and 71% at the National Space Centre. The high response rate at both survey locations proved that the self-administered questionnaire was an appropriate form of data collection.

3.3.4 The questionnaire

Designing the questionnaire

In designing the questionnaire (Converse and Presser, 1986; Davies, 2007; Groves et al., 2009; Busha and Harter, 1980) there were important issues that I had to take into consideration in order to ensure that, as far as possible, the findings of the survey could be relied upon by those who would use the results. Among other considerations, I had to ensure that: the questions measured the characteristics of the group that I wanted to investigate (I develop this point further in this section); the questionnaire was not too long (exclusion of unessential questions) so that it would not take much time to complete; the structure of the questions was elegant and comprehensible (I tested it with a few colleagues and friends in order to make sure that the language was understandable); the questionnaire offered "don't know" and neutral options (such as "neither agree nor disagree") as a response option for questions which people may not have an opinion on or may never have thought about (Bauer, 1996; Converse and Presser, 1986); the instructions to fill in the questionnaire were clear (this was challenging, as I explain further in this section); the layout looked professional – for this reason I included the logotypes of the universities and laboratories which participated in the exhibit where the postcards were distributed).

I also had some exploratory discussions with relevant experts: I contacted Professor Martin Bauer, who is professor of social psychology and research methodology at London School of Economics, and Jon Bridges, the organiser of the exhibit, to discuss the construction of the questionnaire. However, its creation is entirely my responsibility (The questionnaire is included in Appendix I).

Socio-demographic characteristics

Demographic factors are widely used in sociology to characterize audiences. Commonly examined demographic factors include gender and age, employment status, social class, ethnicity, education and occupational class. In order to define a demographic profile of a population or a group, social scientists often combine a number of demographic factors, which provide enough information about a representative member of the group. While the most used factors in the social sciences are social class, gender and age, the choice of socio-demographic factors depends on the aims of the study.

In the social sciences, social class is often discussed in terms of 'social stratification', i.e. classification of individuals according to their socio-demographic status. There are different social classifications systems used in the UK: the SOC (1990 Standard Occupational Classification), the NRS National Readership Survey, the NS-SEC (National Statistics Socio-economic Classification). The NS-SEC is the most used in the UK (first used in 2001 census) (Rose, 1995; Rose and O'Reilly, 1997; Hall, 2005)[2]. For example, NRS classification classifies individuals as follows: A – Upper middle class; B – Middle class; C1 – Lower middle class; C2 – Skilled working class; D – Working class; and E – Subsistence. Allocating people to social classes, involves mapping occupation and employment status to class categories using 'raw' data collected for example from the Census or government social surveys (for more detailed information on how individuals are assigned to social classes please see Rose, 1995).

As for social class, ages of individuals can also be subdivided into 'age groups'. The specific age groups will depend on other data the study is to be compared with. Examples of age groups used are the Target Group Index [TGI] (<15; 15-24; 25-44; 45-64; 65 and upwards) or those used by the Office of National Statistics

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[2] The full version of NS-Sec has 17 main categories, and is collapsible down to three categories, but the version used for most users has eight categories. Rose, D. (1995); Rose, D. and O'Reilly, (1997).

National Census data (see ONS, 2010). However, age groups may vary and may be combined according to research aims. In fact, these large-scale data sets use slightly different age ranges as their basis. For instance, one of the groups I was particularly interested in was ‘middle-aged people’, the generation born after the Apollo missions, as such I used age bands 40-54, and 55 and over.

For the research aims of this study I did not study social classes, however, it could be a demographic factor of interest for future research. I analyzed gender and age, which are likely to influence visitors’ attendance at science learning events (e.g. NSF, 2002) (Please see Chapter 4 for a detailed explanation of the literature and assumptions about the characteristics of the ‘attentive’ public for space exploration’). I have also questioned respondents about their ‘professional activity’ in order to understand whether an existing professional relationship with education would be likely to affect visitors’ attendance at outreach events. Professional activity classes included: ‘secondary school student’, ‘undergraduate’, ‘post-graduate’, ‘academic researcher’, ‘other’. However, due to the way in which this ‘professional classes’ were constructed, as explained further in this chapter, this factor was not used in the statistical analysis presented in this thesis.

Concepts and indicators in the questionnaire

As for relevant measurements, as the survey was concerned with rationales for space exploration, beliefs, attitudes and space policy preferences, in drawing up the questionnaire, a set of questions was designed as indicators of the concepts rationales for space exploration, beliefs in extraterrestrial life, attitude towards space exploration, and space policy preferences. The latter two concepts (a) attitude towards space exploration and (b) space policy preferences were considered as measures of support for space exploration.

Attitude towards space exploration was measured by four “Likert items” (Bainbridge, 1989) where respondents were asked to agree or disagree on risk, value for money for the UK economy, priority of the UK positioning in space exploration, and importance of space exploration when compared with solving problems on Earth. Space policy preferences were a measure of individuals' preferred means of exploration and support for government spending.

Beliefs in extraterrestrial life were included as relevant beliefs because the possibility of extraterrestrial life, friendly or hostile, has always been a prominent topic in science fiction books and movies making it a familiar and involving subject for almost everyone.

These concepts were compiled into six closed questions. For some questions I have drawn on ideas of Neal (1994). Country of residence was also included to allow exclusion of non-UK residents, which I thought would ensure the "efficiency of the sample" (Fowler, 2009). As for socio-demographic characteristics respondents were asked about their gender, age and professional activity.

Below I present the questions by the order they appeared in the questionnaire:

In ***Question 1***, respondents were asked for the means of exploration that they thought should be used to explore the Solar System. The question read: "Do you think we should explore the Solar System with:"

- Observation from Earth
- Observation from spacecraft
- Robotic landing and exploration
- All of these
- None of these: we should stop exploring the Solar System

Respondents who answered "all of these" to this question were then asked to specify which 'means' they preferred "Most" and "Least", as a way of getting as detailed information as possible from this question. This question was also the ‘excluding’ question for the ‘non-explorers’ (respondents who did not agree with space exploration, responding “none of these”).

‘Non-explorers’ were then asked ‘why’ they did not agree with space exploration in ***Question 2A***. This question was intended to understand ‘non-explorers’ attitudes towards space exploration. ***Question 2A*** read: “What is the MOST important reason why we shouldn’t explore the Solar System?” The answers given were:

- Space exploration is very risky
- Space exploration is very costly
- Space exploration will only be carried out by a rich scientific elite
- Space exploration is not good value for money
- Space exploration is much less important than solving problems on Earth

Explorers were directed to answer ***Question 2B***, which read: “What do you think is the MOST important reason to explore the Solar System?” The answers were:

- To generate new scientific knowledge and advance human culture
- To return value to the UK economy through technological progress
- To create international cooperation
- To inspire new generations of scientists and engineers
- To engage British society in the full excitement of space exploration

Question 3B and ***Question 4B*** measured beliefs in extraterrestrial life. ***Question 3B*** read: “Do you think life has ever existed on other planets in our Solar System?” for which answers provided were:

- No
- Probably primitive life
- Higher forms of life
- Don’t know

Question 4B read: “Where do you think we should explore for any traces of life?

- Mars
- Moon
- Other planets in the Solar System
- Beyond the Solar System
- All of these
- None of these

Respondents who answered “all of these” to this question were then asked to mark with (1) the ‘Most’ important ‘target’ and with (0) the ‘Least’ important in order to get a more concrete idea of respondent’s beliefs in case they opted for all targets.

Question 5B measured *Attitude towards space exploration* asking respondents to rate their agreement or disagreement on two positive and two negative attitudes. The question read: “To what extent do you agree or disagree with the following statements about space exploration?” Statements were as follows:

- Space exploration is very risky
- It is important that the UK is at the forefront of space activity
- Space exploration is good value for money

- Space exploration is much less important than solving problems on Earth

Question 6B asked respondents about government spending on space activities: "How much of the national budget do you think should be spent on space exploration?" Because enquiring about space exploration funding without a reference point may be misleading – space exploration may be popular but not in comparison with other areas of public policy spending – two comparative values were given: UK spending on Health Services, which at the time of the survey was approximately 9.2% GDP, as well as the value of the then government budget spent on space activities (0.04% GDP). Answers to this question were as follows:

- None: It should be financed with private money
- Less than 0.04%
- Between 0.04 and 0.5%
- More than 0.5%
- Don't Know

The concepts beliefs, rationales for exploration, attitude towards space exploration and space policy preferences are shown in Table 1, which also shows the name of the variables[3] used in this study. Question 4B was not included in the analysis because it measured the same belief of question 3, and due to the way in which it was framed, as I explain further in this section in the "limitations of the survey".

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[3] Variable is a "characteristic or attribute of an individual or an organization that can be measured or observed and that varies among the people or organization being studied. A variable can vary in two or more categories or on a continuum of scores, and it can be measured or accessed on a scale "(Creswell, 2008). Examples of variables measured in social studies are gender, age, attitudes or beliefs.

CONCEPTS	*INDICATORS*	*VARIABLE NAME*
Beliefs	***(Q3B) Do you think life has ever existed on other planets in our Solar System?***	*Belief in extraterrestrial life*
Attitude towards Space exploration	***(Q5B) To what extent do you agree or disagree with the following statements about space exploration:*** - Space exploration is very risky - It is important that the UK is at the forefront of space activity - Space exploration is good value for money - Space exploration is much less important than solving problems on Earth	*Attitude 'risk'* *Attitude 'UK positioning'* *Attitude 'value for money'* *Attitude 'priority'*
Rationales for exploration	***(Q2B) What do you think is the MOST important reason to explore the Solar System?***	*Rationale for exploration*
Political preferences	***(Q1) Do you think we should explore the Solar System with…*** ***(Q6) How much of the national budget should be spent on space exploration?***	*Preferred means* *Government spending*

Table 1 – Operationalisation of key-concepts, indicators and variable name to survey questions.

3.3.5 Data analysis

In this section I will describe the steps involved in analysing the data. I will explain the assumptions that were made and how the variables used in this study were measured (at the nominal, ordinal or interval level)[4].

[4] Variables can be classified in three different types according to level of measurement: *nominal variables* if the variable has two or more categories but no ordering. An example is the gender. Gender has two categories with no order; a respondent is either a male or a female. *Ordinal variables* are similar to nominal variables but there is a clear ordering of the variables, however the values of the variable (name of the variable) they are not equally spaced. Age is an example of an ordinal variable, if the age groups defined are not equally spaced. Lastly, *interval variables* are similar to ordinal variables but the intervals between the values of the interval variable are equally spaced. An example can also be age if the age groups defined are have the same intervals between each other. In this study, all the variables were either nominal or ordinal.

Assumptions

Although it is not possible to determine the direction of the effects between variables with a single survey, I distinguish between *independent* and *dependent*[5] variables on the basis of theoretical assumptions. In my model (see Figure 1 below), belief in extraterrestrial life, rationales for space exploration, age and gender were defined as *independent variables*, i.e. the variables I thought could predict support for space exploration, while attitude towards space exploration and political preferences were defined as *dependent variables* as measures of support, i.e. the variables whose values would be dependent on its predictors.

Furthermore, I assumed that it is more likely that attitudes would influence space policy preferences than the opposite. However, reverse effects cannot be ruled out. Thus, it is reasonable to expect that individuals with a more positive attitude towards space exploration would be more likely to support higher levels of government funding and more "complex" means of exploration such as robotic landing and human space missions. For example, individuals who are more concerned about the risk of space exploration or do not see value for money in these activities would be less likely to support significant government funding and more "complex" (and thus expensive) means of exploration such as manned space flights. Similarly, it is reasonable to expect that individuals' rationale for exploration and beliefs in extraterrestrial life influence both their attitudes and their space policy preferences. In addition, while individuals' preferred means of exploration would be expected to influence their preferences for government spending, the reverse is also possible. Also, as previously hypothesised, gender differences in support for space exploration were also expected. Current literature does not highlight any information on these relationships so this work is

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[5] *Dependent variable* or *outcome variable*, is the variable that is not manipulated, i.e. its values depends on the variable that has been manipulated. *Independent variable* or *predictor variable*, is the variable that is manipulated, i.e. the variable that is used to try to predict values of another variable (the dependent variable). The dependent variables are dependent on the independent variables (Field, 2005).

exploratory. The relationships between the variables analyzed are illustrated in the conceptualization model below (Figure 1).

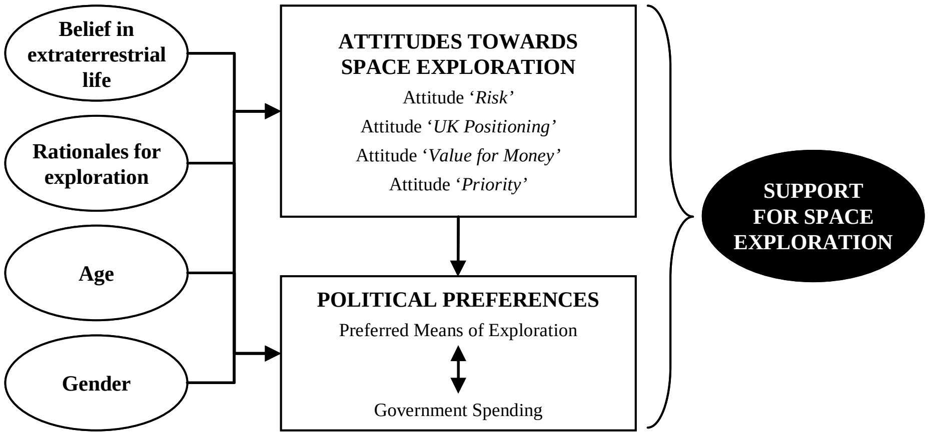

Figure 1 - Conceptualization model that illustrates the interpretation of relationships between the variables analysed to predict support for space exploration. The arrows represent the relationships expected (i.e. arrows lead from the determining variables to the variables dependent on it).

Next I describe in further detail the measurement of the *dependent* and *independent* variables used in this study.

3.3.6 Dependent variables

Attitude towards space exploration (Risk, UK positioning, Value for money, Priority)

Attitude towards space exploration was measured using four items to which respondents could respond on a five-step rating scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). Respondents were asked “to what extent do they agree with the following statements”: (1) “Space exploration is very risky” (attitude item ‘risk’); (2) “It is important for the UK to be at the forefront of space activity” (attitude item ‘UK positioning’); (3) “Space exploration is good value for money” (attitude item ‘value for money’) and (4) “Space exploration is much less important than solving problems on Earth” (attitude item ‘priority’). Items (1) and (4) are negatively phrased (i.e. agreement to the statements implies a negative evaluation of space exploration) while items (2) and (3) are positively phrased.

A Likert scale based on the summation of the appropriately recoded values of the four mentioned items was provisionally created to measure attitude towards space exploration. As this scale only showed a poor reliability (Cronbach’s Alpha= 0.43) I did not use the aggregate scale but rather decided to use the four individual (attitude) items as ordinal measures of evaluation of different aspects of space exploration. Retrospectively, I explain the low internal consistency with inter-individually very different cognitive frames in which respondents develop their evaluation of space activities and a variation of the meaning of some of the items dependent on the frame applied. The cognitive frames may include business-like cost-benefit analyses of public investment in innovation, perceptions of adventures related to space flight proliferated by science fiction, as well as images of national prestige and international competition. The meaning of risk, for example, may have different evaluative connotations if considered in the semantic context of "adventure" or in the context of "profitable investment of public money". As for all four items, the associations with support of government spending for science exploration and means of exploration show the expected signs, as I will show in the analysis between indicators of support in Chapter 4 (see Table 12 in Chapter 4), it seems justified to use them as separate attitudinal items, i.e. as measures of evaluation of space exploration.

Space policy preferences

Two measures of space policy preferences were used: “government spending” and “means of exploration”. Space policy preferences regarding government spending were measured by asking respondents “How much of the national budget do you think should be spent on space exploration?” Ordinal response categories were

"None: financed with private money", "Less than 0.04%", "Between 0.04% and 0.5%" and "More than 0.5%". The variable means of exploration was considered nominal, and respondents were asked whether they thought that the Solar System should be explored with "Observation from Earth"; "Observation from Spacecraft"; "Robotic landing and exploration", "Human space missions", 'All of these' and "None of these".

3.3.7 Independent variables

Rationale for space exploration

Rationale for exploration was treated as a nominal variable, and it was assessed by asking respondents "What is the most important reason why we should explore the Solar System?" Possible answers were "To generate new scientific knowledge and advance human culture", "To return value to the UK economy", "To create international cooperation", "To inspire new generations of scientists and engineers", and "To engage the British society in the full excitement of space exploration".

Belief in extraterrestrial life

As explained before, views on the existence of extraterrestrial life were included as potentially influential beliefs. Respondents were asked "Do you think life has ever existed on other planets in our solar system?" with response categories "No", "Probably primitive life" and "Higher forms of life". "Don't know" answers were excluded from the analysis. This variable was treated as nominal.

Demographics

In this analysis two demographic variables were considered: age and gender. Age was measured by using five categories: "≤15," "16–24," "25–39," "40–54," and "≥55."[6].

3.3.8 Analytical procedure

Data analysis was done using SPSS (statistical package for the social sciences). Variables were defined according to name, labels (description of the variable – for example the variable named "gender" has the labels 1=female, 2=male), missing values, and level of measurement (nominal, ordinal or interval). Statistical tests depended on the level of measurement of the variables. As all my variables were either nominal or ordinal, it was then appropriate to use contingency tables[7] to represent the cross-classification of the variables, and chi-square tests (χ^2), Cramer's V and Gamma to determine relationships among nominal or between nominal and ordinal data, as I proceed to explain.

χ^2 tests were run to test for independence of variables, i.e. to determine whether relationships between variables were likely to have occurred simply by chance. Because tests of significance are influenced not only by the strength of the apparent relationships but also by the size of the sample, it may happen that even a small effect can be statistically significant if it is observed in a very large sample as this one (a larger sample is more likely to produce a statistically significant relationship). This said, a significant relationship between two variables does not

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[6] Professional activity was not included in the analysis because the scale of measurement used was not the most appropriate for this study (see limitations of the survey).

[7] *Contingency table*, also refereed *as cross tabulation* or *cross tab*, is a table usually showing frequencies of two variables, displayed in rows and columns respectively. The levels of each variable are arranged in a grid, and the number of observations (frequencies) falling into each category is noted in the cells of the table.

mean that a strong relationship exists, or that the relationship is important. Therefore, it was appropriate, that the outcome of significance tests (χ^2) were accompanied by measures of the *effect size*.

Effect size is then a measure of the magnitude of an observed effect between variables. In order to test the size of the significant effects between variables I calculated: *Gamma* to measure the strength of associations between ordinal variables (variables measured at the ordinal level such as age, government spending or attitude towards space exploration); and *Cramer's V coefficient* to measure the strength between two nominal variables (for variables measured at the nominal level such as for example beliefs and rationales) (See appendix II for a summary of the meaning of these tests).

In all cases, a significance value of p=0.05 was used as the critical value to reject the null hypothesis and accept the hypothesis being tested. The p-value (probability value) is a numerical measure of the statistical significance of a hypothesis test. It tells how likely it is that the results obtained have occurred by chance. A smaller probability means greater confidence that the experimental hypotheses are actually correct. By convention, if the p-value is less than 0.05 ($p<0.05$), the null hypothesis is rejected and therefore the results are statistically significant. In contrary, if the p-value is higher than 0.05 ($p>0.05$), the null hypothesis is accepted and the hypothesis being tested is rejected, meaning that the results are not statistically significant[8].

As I explained previously in this chapter, the survey aimed at characterizing the "public for space exploration" and at measuring variables that influence public

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[8] Fisher (1925) suggested that only when there is a 95% certain that a result is genuine (not a chance finding), should it be accepted as being true, i.e. if there is only a 5% or less probability of something occurring by chance then it is said to be statistically significant. This criterion of 95% confidence is the basis of modern statistics. (see: http://www.economics.soton.ac.uk/staff/aldrich/fisherguide/rafreader.htm. Last accessed in 1 June 2011).

support for it. Therefore the first step of this analysis was to describe the sample -- *descriptive analysis*, followed by an *inferential analysis* based on the testing of relationships as I presented in Figure 1. The *inferential analysis* was conducted in two steps: In the first step I looked at the relationships among the three indicators of support of space exploration – attitude items, government funding and means of exploration – (dependent variables). In the second step I analysed the relationships between the independent and dependent variables. Special emphasis was given to possible gender-specific differences in support for space exploration. I will come back to this point in Chapter 4, where I will present the interpretation of the data.

Within the limitations of the survey (time, financial resources as I explain below), in interpreting the results, it should be remembered that both groups were surveyed with the personnel and financial resources available, and that clearly results should not be used to make generalizations about the current general British attitudes to space exploration as the sample does not represent the general population. However, it is still a useful and valid piece of social research, which provides information about this group which takes the time to go to space outreach events.

3.4 Limitations of the Survey and Personal Reflections

Planning and constructing a survey is a complex task that most of the time involves a skilled work team for the different phases of the survey. Constructing the questionnaire, collecting the sample, and analyzing the data of a sample as large as this one, appeared to be a significant challenge in the timeframe of my research. The whole process took much more time to complete than I initially expected, and brought some unexpected challenges along the way. The largest challenge I faced during the survey process concerned the short time I had for developing the questionnaire. When the opportunity for participating at the Royal

Society Summer Exhibition came up, there was very little time before the exhibition started. This meant that in a short period I had to decide on the sampling strategy, design the questionnaire, and discuss it with other experts as already mentioned. Thus, it did not leave time to test the survey with as full a sample as I would have liked. However, I did test it with some colleagues from my department and friends, mainly to verify the clarity of the language used.

Having a self-administered questionnaire offered many advantages as already stated above, but it also brought some disadvantages. In fact, designing a self-administered questionnaire is a hard task that involves a large number of decisions to be taken, and where some minor imperfections concerning language used or the way information is arranged spatially, what Wright and Barnard (1978) called "graphic language", may sometimes be impossible to envisage.

In my questionnaire there were some minor problems with two of the questions. Question 1 ("Do you think we should explore the Solar System with (1) Observation from Earth; (2) Observation from spacecraft; (3) Robotic landing and exploration; (4) Human space missions; (5) All of these; (6) None of these") and Question 4 ("Where do you think we should explore for any traces of life? (1) Mars; (2) Moon; (3) Other planets in the Solar System; (4) Beyond the Solar System; (5) All of these; (6) None of these") asked respondents to mark with 1 the "Most" and with 0 the "Least" preferred choices when selecting the option "All of these". The majority of respondents were not able to make such distinction, which was reflected in the low response rates for this requested distinction.

There are two possible explanations for this. One possible explanation is that it might have been a problem of graphic language: although respondents might have understood the language, the fact that the sentence was written in brackets just below the possible answer choices for the question might have not been easily visible to participants, and therefore they missed it or they did not see it as an important part of the question. This is particularly understandable in busy locations where people to do want to spend much time filling out a questionnaire and tend to go through it as quickly as they can. Another possible explanation is the language used. The way the questions were put might have not been clear to respondents. The low response rate to those questions might actually show some lack of comprehension by respondents. As Jenkins & Dillman (1995) maintained "when respondents are asked to complete a self-administered questionnaire, they are being asked to perform a task that from their perspective may be different from the task we wish them to perform". A way of improving the design of the questionnaire would be to have two separate questions, which would allow the use of a different language and a different arrangement.

Consequently, when entering the data in SPSS, I had to make some decisions: a) I created six dichotomous variables (2-category), one for each of the possible answers (i.e. yes/no 'values') to make sure that all responses were counted; and b) a nominal variable as I explained before for the variable "means of exploration" (i.e. 1=exploration from Earth; 2=exploration from spacecraft; 3=robotic landing and exploration; 4=human space missions; 5=all of these; 6=none of these 'values'). The dichotomous variables allowed counting of all responses given by respondents, and for which I conducted a separate analysis, as I will explain in Chapter 4. The nominal variable included only those respondents who gave a single answer. The dichotomous variables were only used in *the descriptive analysis*; while the nominal variable was used as measure of support of preferred means of exploration in the *inferential analysis*. This decision was based on the fact that the percentage of respondents who gave more than one answer was extremely small (5%) and therefore could be excluded from the main analysis.

These are the type of problems that may arise in a self-administered survey, particularly when the researcher is not present. There are indeed difficulties that can be minimized if the researcher is around. A good example of the benefit of the presence of the researcher is the large number of questionnaires returned at the Royal Society during only four days of the exhibition. This was probably due in part to my presence at the event where I took the time to explain the aim of the study and give respondents instructions on how to complete it.

Lastly, I would like to discuss the extent to which the choice of UK spending on health services as a comparator for the 'government-spending' question might have affected the answers of respondents. Although questions placing government spending on science in the context of what the government spends on other areas of public funding are useful comparators, it should be taken into account that variations in answers may occur on the basis of comparators used. Thus, while the use of health spending as a comparator certainly has advantages such as being a familiar topic for almost everyone, it also has some disadvantages.

One finding from this question was strong public support for an increase in government spending on space activities. However, it might be likely that the use of health as a comparator increased this support: health spending (9.2%) when compared with space exploration spending (0.04%) might have generated a tendency to agree with higher levels of support. Therefore, comparisons might also be needed to other relevant comparators. While I cannot be certain of what the impact would have been of using other comparators, it might be possible that providing respondents with other comparators such as secondary education (0.82% GDP), police services (0.16% GDP) or community development (0.03% GDP), or even spending on specific areas of scientific research such as health research (0.04%)[9] or environmental protection research (0.02% GDP) where government spending is noticeably lower than health services would have reduced support. On the other hand, it might also be possible that if respondents were asked to rate levels of space spending against a comparator that is seen negatively such as UK government expenditure on the wars in Afghanistan and Iraq (0.2% GDP between 2001-2010) or UK spending on prisons (0.3% GDP) this would have generated higher levels of public support for government spending on space exploration as the contrast to a negatively perceived use of government funds might increase support for something that is comparably seen as more positive.

Despite the minor problems mentioned with the questionnaire, the sampling strategy proved to be very efficient as many respondents returned the postcards

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[9] Source: www.uk publicspending.co.uk

and response rates were high at both locations. Furthermore, because of the surprisingly considerable sample size, this survey appeared to be a great chance to study the "public for space exploration" in some detail, which may be of particular interest to social sciences literature where no efforts to understand this public have been made, but also to the study of science communication in general, as I will explain later in this thesis.

3.5 Interview Methodology

As stated above, the interview methodology was employed in *Phase 2* of data collection. During the interviews conducted with practitioners, I showed them main findings of the surveys of "the public for space exploration" in order to understand how well they anticipate the audiences they are meant to be addressing and how they would use such information for planning science communication activities. The interviews also involved other topics related to public communication and practices. The research questions I proposed to answer were:

- *Research question 1*: What are the strategies and models of science communication currently used to communicate astronomy and space research to the public?

- *Research question 2*: What types of science communication activities are used in the field? And what are they aimed at?

- *Research question 3*: To what extent have science communicators been following academic models of PUS?

- *Research question 4:* How does practitioners' discourse on "their publics" and public communication relate to their practice of science communication?

- *Research question 5*: In what way has the revolution in science communication changed practitioners' conceptualisation of the public and practice of science communication? In particular, who do practitioners think is the 'right public' to take part in space policy decisions?

- *Research question 6*: How do science communication practitioners anticipate their audiences' characteristics and opinions about space science?
- *Research question 7*: How do practitioners respond to surveys on the publics they are meant to be addressing?

3.5.1 Semi – structured interview

I chose to use a semi-structured interview approach as I felt that it would be the most appropriate way of getting practitioners' views on and attitudes towards their audiences and public communication. As interviewees would be mainly describing their practice, experience, and science communication activities in which they had been involved recently, having exact questions and wording determined in advance would not provide interviewees the flexibility to relate their experiences in particular situations and circumstances. Thus, in contrast with a structured interview, a semi-structured interview was flexible enough to allow new questions to be explored as the interview developed as a result of interviewees' participation and opinions.

Therefore, I felt that this type of interview would be more suitable to explore the themes I wanted the interviewees to talk about as I could lead the interview in the direction I wanted, but it would also allow room for the interviewees to direct the discussion or suggest alternative lines of inquiry by bringing other points to the discussion that I might not have thought of when planning the interview.

Furthermore, because a semi-structured interview is more dynamic and interactive, I thought that it would be a more efficient way of getting interviewees to describe personal experiences and views using their own language and terminology about public engagement with science. Indeed, one of my preoccupations was to ensure that I did not introduce any terminology of the policy discourse, as one of my research aims was to understand how it has been used by the community that is asked to put it into practice. Finally, the semi-structured approach also allowed me to compare the views of the interviewees, which would not be possible with structured interviews (Greenfield, 2002).

I prepared an interview guide in advance, which consisted of four main topics and groups of questions. These could be asked in different orders, according to how interviewees responded. In fact, this freedom allowed interviewees to express their opinions and experiences according to the context of the conversation, which helped direct the discussions (Fontana and Frey, 2005).

I decided to conduct face-to-face, one-on-one in person interviews because more intimate and personal contact with the interviewees would be most appropriate for achieving fruitful responses as interviewees were reporting real examples of their work. All the interviews were recorded in full with the consent of the interviewees. Despite my offering anonymity prior to commencing the interviews, all interviewees gave me permission to use their details. However, due to data protection issues, as well as it not being necessary to provide names for research purposes, I kept their details anonymous. I have, however, stated gender and 'type of practitioner' as I intended to analyze whether different types of practitioners would have different views and opinions concerning publics and public communication. There were occasions were I took notes during the interviews, although those were limited as I wanted to concentrate fully on what participants were saying (Berg, 2001).

3.5.2 *Pilot case*

At an early stage of my PhD I conducted a few informal conversational interviews (Patton, 1990) with science communicators in the field of astronomy and space exploration. In those informal conversational interviews, I did not predetermine the questions but rather allowed them to emerge from the circumstances which occurred and natural course of the conversation.

Two of these interviews were conducted during a visit to the Public Outreach Department (ePOD) of ESO (European Southern Observatory) in Munich, Germany. This opportunity resulted from a cooperation with the International Year of Astronomy (IYA) coordinator in organizing a workshop in science communication for the IYA national nodes. ESO is one of the biggest scientific astronomy institutions in Europe, which posses a considerable outreach department which produces daily outreach products to the public. For instance, ESO is responsible for the Hubble telescope outreach activities in Europe. Therefore, I saw this visit to ESO as an excellent chance to interview people from the Public Outreach Department. Around the same time, I conducted another interview at the National Space Centre in Leicester. These informal interviews were great opportunities to get familiar with outreach departments at both international scientific institutions and national science centres, namely to get insight on the way they are organized and work in practice. But, essentially, these 'pilot' interviews were very effective for refining and tightening the focus of my research (Greenfield, 2002).

3.5.3 *The sample*

I conducted fifteen interviews between March and May 2010 (I had to limit the number of interviews within the confines of this PhD research as I had already a quite significant sample from the survey). All interviews lasted between an hour and one and a half hours, except one interview which lasted half an hour with a policy maker who I interviewed during a coffee-break at a conference. Apart from this case, in no other situation did interviewees asked me to stop the interview because of time constraints. They were very involved in the interviews and happy to participate and share their experiences. This sample provided a large amount of material for subsequent analysis.

The interviewees were chosen according to three different criteria. Firstly, I only wanted to interview practitioners who were involved in the communication of science in the field of astronomy and/or space sciences due to the scope of this thesis. Although science communication practice in many aspects might be similar, it might also happen that different areas of research involve different strategies of communication and therefore need a different approach to their study.

Secondly, I chose to interview 'active' people in the field, i.e., practitioners who had been involved in science communication and engagement projects or activities recently, and that were, to an extent, known in the field. My main source for finding the interviewees was meetings and conferences in the area of astronomy and space, either scientific meetings which usually incorporate 'outreach' or 'science and society' sessions in their programmes (see, for example, Entradas and Miller, 2009), or science communication-related conferences. After attending a few meetings in the area of 'space' was easy to network with the community, which is actually small. Furthermore, having an understanding of the outreach activities which were being carried out in the UK during the IYA also helped in building familiarity with the most 'active' names in science communication in this field. In fact, the practitioners I contacted were either involved in outreach activities in the context of the IYA or were practitioners working for big institutions in the UK such as government departments, universities, space centres, museums or planetariums. These two aspects were almost sufficient to narrow down the selection of the sample.

Finally, since I was interested in understanding whether different practitioners would hold different views, a third aspect was to ensure that I would get a diverse spectrum of people. Therefore, in order to achieve a roughly representative mix of practitioners in the area, the sample included scientists, professional science communicators and policy-makers from the UK. Based on these aspects, I drew up an initial list of eleven practitioners, while the other four resulted from contacts in meetings that I attended.

3.5.4 Data collection

I conducted the majority of the interviews at meetings or conferences on astronomy and space science and/or astronomy and space communication. This strategy proved to be very efficient at gathering data: first, because conferences attract the "active community"; second, because people are more available for interviews, particularly at meetings that last a few days; and third, it is also easier to develop relationships with the interviewees before conducting the interview, and not to leave the interviewees feeling that they have been used for my own needs (Davies, 2007).

Five interviews were conducted at the CAP conference (Communicating Astronomy with the Public), which took place in Cape Town, South Africa, from the 15th to 19th March 2010. The CAP conference is an annual international conference attended mainly by practitioners of science communication in the field of astronomy and space exploration. It was an excellent occasion to conduct some of the interviews with practitioners from the UK who attended the conference, and who otherwise might have not been easy to reach (as in the case of one policy-maker from Edinburgh where I would have had to travel to conduct interview). Four other interviews were conducted at the "She is an Astronomer" meeting which took place at the Royal Astronomical Society in London on the 22 and 23 April 2010. This was a project developed during the IYA, aimed at attracting women to science, which was attended mainly by scientists and practitioners of science communication. The other six interviews were conducted at practitioners' places of work, usually respondent's offices.

I contacted all the interviewees by email where I briefly explained the aims of the research and the type of interview I intended to conduct. For the interviews that I conducted in meetings or conferences, I sent emails to the interviewees a couple weeks before the meeting asking for their cooperation. Another email with a reminder was sent a couple days before the meeting took place in order to arrange the last details (time of the interview, etc.). As for the interviews that were not conducted in conferences, I sent the same first email, however, asking interviewees themselves to arrange a time according to their availability. Of the practitioners initially contacted, all responded positively, which suggests interest in the research. After each interview an email was always sent thanking the interviewees for their participation.

3.5.5 The interviews

The interviews focused on practitioners' views on: publics and public communication; the role of the public in policymaking; characteristics of audiences; strategies, content of communication and motivations of practitioners for conducting outreach activities; value of and response to surveys of public opinion. I started the interviews by asking practitioners about outreach activities for the general public they had been involved recently as a way to put the interviewees at ease by letting them talk about their own work and establish a closer relationship with the interviewer to reduce tension. This worked very well as interviewees always described activities they had organized themselves or were in charge of. So, the interviews tended to flow easily. Then, in order to understand how well they anticipate their audiences, I used some key findings of the results of my surveys from *Phase 1* to ask their views about the audiences they are addressing. For instance, I asked them specifically about the socio-demographic factors of "their audiences" such as gender and age; what they thought were the preferred means of space exploration of their audiences as well as how supportive in terms of government funding they thought their audiences would be; whether they would expect gender differences to exist in support for space exploration; whether gender differences would be expected in attitudes towards space exploration, such as for example risk perceptions and benefit perceptions, and so on.

3.5.6 Analyzing the data

The process of data analysis involved making sense out of what participants said. This required various steps such as preparing the data for analysis, conducting the analysis and, finally, interpreting the meaning of the data. The interviews were transcribed in the 'smart' format, which is a smoothed-out transcript excluding all 'erms" and 'ahs', unnecessary use of verbiage and repeated words and short phrases, thereby making the transcripts more readable. I sent my tapes to transcribers, which meant that I had to check the transcripts against the tapes and add any detail that was missing or that I was interested in (e.g. pause, stress, etc). I re-listened and re-read the transcripts as many times as necessary.

The qualitative data analysis followed a general analytical procedure (Creswell, 2009) and data were analyzed using a stage-by-stage process (Burnard, 1991). Because the fifteen interviews were manageable to treat manually, I chose not to code the interviews in any software program. First, I read through all the interviews and listened to the transcripts, which allowed me to get a general sense of the "interactional work" with the interviewees (Rapley, 2004) and to reflect on the data's overall meaning (Creswell, 2007). I then coded the interviews using different colours for the different topics that emerged from the data. I identified three main themes within practitioners' talk: i) views on "the public" and public communication; ii) views on public involvement in policy-making; iii) views on audiences and responses to surveys of public opinion. Within these three main themes, I was able to identify sub-themes, as I will show in the interpretation of the data in Chapter 5.

The major weakness of this type of data collection is that it provides indirect information selected by the interviewees and filtered through their views (Creswell, 2009). Despite this, I consider it to have been a very useful piece of research, which provided me an in-depth perspective on science communicators' views about their practice of science communication and "their publics".

3.6 SUMMARY

In this chapter I described my overall methodology approach set up to research "the public" and public communication in the field of space and astronomy research. I explained my interest in using both text and numerical data, and how the mixed-methods research approach employed was used to answer my research questions. I described how I used a mixed-methods research approach to serve my different purposes of research: Quantitative methodology was aimed at analysing "the public for space exploration"; Qualitative methodology was aimed at examining practitioners' views on "their publics" and public communication. I also refereed to the innovative character of this methodology in science communication research. Essentially, I used a mixed approach for the reason of complementarity in order to provide as complete a picture as possible of the practice of science communication in the area of 'space' in the UK. I explained the research design, data collection and data analysis for both my quantitative and qualitative research, as well as the rationale on which I based my decisions about choosing to conduct a survey and the interviews. In addition, I also discussed the limitations of each of the research designs utilized.

In Chapter 4 and Chapter 5, I will describe the results of my mixed methods research approach, where I will present the findings and interpretation of the survey and the interview data. In Chapter 6, I will make use of both results from the qualitative and quantitative data to develop an in-depth analysis and discussion about the contemporary practice of science communication in the UK.

CHAPTER 4

WHO'S FOR THE PLANETS? – AN ANALYSIS OF THE 'PUBLIC FOR SPACE EXPLORATION'

"(...) I believe that this nation should commit itself to achieving the goal,
before this decade is out,
of landing a man on the moon and returning him safely to the earth.
No single space project in this period will be more impressive to mankind,
or more important for the long-range exploration of space;
and none will be so difficult or expensive to accomplish"

(President John Kennedy's May 25, 1961 Speech before a Joint Session of Congress).

4.1 INTRODUCTION

The monitoring of public attitudes towards science has grown substantially over the past 20 years (see, for example, Durant et al, 1992; Bauer, et al., 1994; Miller et al., 1997; NSF surveys, Eurobarometer surveys) as numerous bodies have recommended the development of sustained programmes of public engagement (e.g. Royal Society, 1985; EC, 2002; EC, 2007) and public opinion has progressively been seen as relevant in the context of public policy (Nelkin, 1997; Gregory and Miller, 1998; Durant, 1999; House of Lords, 2000; Gregory and Lock, 2008; Petersen, Heinrichs and Peters, 2010). According to Durant et al.

(1999), public policy is an important “expression of public aspirations, attitudes and values”. In the UK, the monitoring of public opinion gained stronger emphasis when in 1985 the Royal Society recommended appropriate bodies “to devise methods of monitoring attitudes to science in the UK”, arguing that “the public should be seen not as merely consumers of science but as individuals with opinions that are worth valuing and so should be taken into consideration” (Royal Society, 1985).

Areas such as nuclear power (e.g., Rothman and Lichter, 1982; Gamson and Modigliani, 1989; Mazur, 1990), biotechnology (e.g., Gaskell et al., 1999; Bauer, 2005; Brossard et al., 2007; Peters et al., 2007), nanotechnologies (e.g., Lee et al., 2005; Scheufele and Lewenstein, 2005; Brossard et al., 2009), climate change (e.g., Peters and Heinrichs, 2008; Roser-Renouf and Nisbet, 2008), and stem cell research (e.g., Nisbet, 2005; Liu and Priest, 2009; Jung, 2011) have been the focus of many studies of public attitudes and opinion formation. But, the social scientific literature on public attitudes towards space exploration is still relatively limited (Bell and Parker, 2009) in the UK or Europe. Yet, very often, in space policy debates the general public has acquired the “reputation” of being supportive of space activities when, actually, there is little evidence supporting such statements (Safwat et al., 2006).

The analysis of the “public for space exploration” presented in this chapter is intended to contribute to fill this gap in the literature. I begin this chapter with a review of the available literature on general studies on public attitudes towards space and astronomy in Europe and in the UK. Inevitably, reference is made to the United States, which has a long history in the exploration of the outer space and in surveying Americans opinion about the American space programme. Although comparable international data are not available most of the time, when it exists, and whenever appropriate, comparisons between European, UK and American public opinion are drawn here. Furthermore, figures from the most recent data available are always presented.

Next, I describe the research focus of my analysis i.e. the assumptions and hypotheses that I will be testing in this study. Then I present the main findings of my surveys on the "public for space exploration" in two main steps: first, I present a *descriptive analysis* of the main characteristics of my sample of the "public for space exploration"; second, I present the results of the *inferential analysis* to conclude about what factors influence support for space exploration. Lastly, I summarize the main findings of the survey analysis. The analysis presented in this chapter has been published in two peer-reviewed journals (Entradas and Miller, 2010; and Entradas, Miller and Peters, 2011).

4.2 Previous Studies on Public Opinion about Space and Astronomy

4.2.1 Public interest in astronomy and space

Public opinion about space related issues has usually been surveyed in general surveys of public attitudes towards science and technology through knowledge and interest questions. For instance, in Europe, only two items related to astronomy and space have been included in the surveys conducted by the European Commission (Eurobarometer, 2001, 2005) as part of questions regarding "interest in science and technology" and "image and knowledge of science and technology". In the "interest in science and technology" question, those respondents who described themselves as "very interested" or "moderately interested" in either "new inventions and technologies" or "scientific discoveries" were then asked to specify in which science and technology developments they were most interested. In the most recent survey in 2005 only one in four respondents mentioned astronomy and space (23%), and this interest had grown from 17% in 2001 (Entradas and Miller, 2009)[10]. In the "image and knowledge of science and technology" question, those surveyed were asked on a scale from 1 to 5 how scientific they considered different subjects. 70% regarded "astronomy" as being scientific (sum of responses "4" and "5"), but 41% regarded "astrology" as being scientific as well. However, when "astrology" was replaced by "horoscope", the number dropped from 41% to 13%[11].

Recent studies to investigate what people in the UK think about space exploration indicate that there is general support and strong public interest in space research (MORI, 2004; Safwat et al., 2006). For example, in a Mori opinion poll conducted in 2004, 70% of the respondents questioned agreed that space is exciting, 65% thought that the UK should be involved in "exploring the Universe with robots and telescopes", and 55% of the respondents were in favour of human space missions. In the same survey, fully 60% of those questioned agreed that "Britain should be involved in the human exploration of Mars and not just the robotic aspects". Despite this general support, there is also increasing scepticism about exploring outer space, in particular amongst younger people. Surveys have shown that the young generation has little knowledge about space issues, especially of European space programmes and achievements (Ottavianelli, 2002; Mori, 2004, Safwat et al., 2006; Jones, 2007). For instance, Harriet Jones (2007) showed that, when asked to list space exploration organisations, less than 0.5% of 13-15 year old British school students involved in the study listed the European Space Agency (ESA). This also appears to be true in the US where the 18-25 year old

[10] These numbers refer to the average for EU15 in 2001 and in 2005. There has been no recent survey including questions regarding astronomy issues.

[11] Compared to the 2001 survey there was a small decrease in the numbers of respondents who regarded "Astronomy" as scientific (70% vs. 78%) but the number of respondents considering "Astrology" as being scientific has dropped from 53% in 2001 to 41% in 2005. However, these figures might not be totally conclusive as comparable data for the EU15 average are not available for this question.

generation has revealed considerable apathy towards NASA's space programme with the exception of Mars Rovers (Dittmar, 2006).

A citizen's jury on space exploration was recently commissioned by the European Space Agency (ESA) in the UK to engage the new generation of the public born after the Apollo missions (under 35 years old) in the creation of ESA's long-term space exploration programme. This citizen jury found that, although participants generally supported the idea of exploring space, they valued space exploration in a rather complex way that reflected concerns regarding the risks and the costs of human spaceflights (Safwat et al., 2006). The jurors felt that "funding should not be increased before the public at large had the opportunity to consider the issues", and they were "generally unconvinced by justifications that did not relate to more immediately tangible public priorities" (p.14).

This is in line with the RCUK (Research Councils UK) national survey on public attitudes towards science conducted in 2008, where areas such as "understanding more about space, planets and stars" were about equally likely to be rated "not beneficial" (27%) as "very beneficial" (26%), while the largest group rated these areas as "fairly beneficial" (46%). This contrasts with areas such as "research into new drugs to cure human diseases", for example, which were rated "very beneficial" by 82% of the respondents (People Science & Policy, 2008)[12].

The RCUK survey (2008) also asked respondents how "worried about science and scientific research" they were. Regarding the statement "understanding more about space, planets and stars", 14% said they were "very or fairly worried", and 84% said they were "not very worried or worried at all". Women and those aged

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[12] This survey is part of a three series survey on public opinion towards science and technology carried out in the UK by The Office of Science and Technology (OST). The first survey "Science and the Public" was published in 2000 and was sponsored jointly by the OST and The Wellcome Trust. The second "Science in Society" took place in 2005 and was commissioned by MORI for the OST, Department of Trade and Industry. And the third survey "Public attitudes to Science" was conducted in 2008 and was carried out for the Research Councils UK (RCUK) and DIUS (Department for Innovation, Universities and Skills) by People Science & Policy.

60 and over were more likely to be worried about it. Also in this question, respondents were asked to indicate how beneficial they thought each type of research was. Level of worry was then combined with perceived benefit to conclude that because “people were not worried and did not see it as beneficial”, they were said to have a “lack of interest” in space issues (People Science & Policy, 2008, p. 28). This contrasted, for instance, with areas such as “understanding the causes of climate change” or “research into using stem cells” which were seen as “very beneficial and people were not worried”, so the survey concluded that the public “positively supported” these areas.

Interestingly, the classification of the public as “not interested” in “understanding more about space, planets and stars” in the RCUK 2008 survey contradicts a survey from the same series conducted a few years before (OST and The Wellcome Trust, 2000). The survey “Science and the Public” (2000) asked respondents about their interest in eleven areas of research, including “space research and astronomy”. Of the respondents surveyed, 58% manifested an interested in “space research and astronomy” while 41% did not. The same survey showed that 73% of respondents considered “space research and astronomy” beneficial, while only 22% considered it not beneficial. A strong correlation between perceived benefits and declared interest was found and, when both variables were plotted on a graph, “space and astronomy research” appeared to have a middle level of interest and perceived benefits when compared with other sciences. Areas such as “cloning”, “genetic testing” and ‘fertility” were plotted below “space research”, but areas such as “medicines”, “transports”, or climate change” were plotted above (OST and The Wellcome Trust, 2000, p. 28).

In addition, the numbers of visits to science-related activities shown by the “Science and Society” survey in 2005 (part of the same series of surveys of public opinion towards science in the UK) also seems to suggest a public interest in astronomy and space research, contradicting the disinterested public shown by the UKRC survey quoted above. When asked about which science centres they have visited in the last five years, The Science Museum in London was ranked second

(19% of respondents) and the National Space Centre was ranked eighth (2% of respondents) (Mori, 2005, p. 50). Moreover, of those science-related activities and attractions that people have not visited over the last twelve months but would like to visit in future, Britons reported having the highest interest in visiting a planetarium: one in five (20%) said they would be interested in visiting a planetarium which contrasted with 12% who expressed an interest in visiting a museum or a science centre (Mori, 2005, p. 52).

This contradictory data provided by surveys bring questions about the way in which surveys are designed and how questions are asked to respondents. Pardo and Calvo (2002) presented a detailed critique of the way in which specific statistical methods have been utilized and scales have been built to study public attitudes towards science and technology. Despite recognising the contribution that such surveys might have to understanding publics' opinion towards science, the authors argued that "more theoretical effort should be devoted to the design of questionnaires and to the combined use of statistical exploratory techniques and qualitative analysis in the interpretation of the data" (Pardo and Calvo, 2002). The limited surveying of public opinion in Europe and in the UK, contrasts with the strong, continuous polling in the United States over the last three decades. For instance, the National Science Board's Series *Science and Engineering Indicators* (NSB, 2002) has been gathering Americans' opinion on space exploration since 1981[13]. Similarly, The Gallup Organization has been carrying out surveys on what

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[13] The National Science Foundation Science' series *Science and Engineering Indicators*, started surveying Americans' opinion on science and technology in 1979, however, it was not until 1981 that the NSF introduced questions on attentiveness to space exploration (see appendix table 7-7, National Science Foundation, Division of Science Resources Statistics (NSF/SRS), NSF Survey of Public Attitudes Toward and Understanding of Science and Technology, various years; Science and Engineering Indicators, 2002). Moreover, in 1985 the NSF started asking public assessment of space exploration, as given by the perception of the cost-benefit ratio. See figure 7.12 and appendix table 7-25 of the public assessment of space exploration since 1985-2001). For the space program, questions were as follows: (1) In your opinion, have the costs of space exploration exceeded its benefits, or have the benefits of space exploration exceeded its costs? (2) Would you say that the benefits have substantially exceeded the costs, or only slightly exceeded the costs? (3) Would you say that the costs have substantially exceeded the benefits or only slightly exceeded the benefits?

Americans think about NASA's performance since 1980. Comparisons of data from various years show that the number of people who declared themselves to be "very interested or moderately interested" in space exploration was relatively stable till 2000, but dropped in the last decade. For instance, while in 1988, 78% of the Americans surveyed reported they were "very interested or moderately interested" in space exploration (NSB, 2002), in 2008 only 68% reported that they were "very interested or moderately interested" in space exploration (NSB, 2010). Despite data which seems to show that public interest in space exploration has decreased in the last decade (NSB, 2010), public interest in space exploration in the United States is still considerably high (e.g. Gallup, 2009; Miller, 2004).

4.2.2 Public awareness of space programme

Despite evidence that interest among young generations has decreased in the last few years, the long-term perspective shows that public awareness of space exploration has been increasing (Withey, 1959; Michael, 1960; Eurobarometer, 2001, 2005; NSB 2002, 2010). Compared with a survey carried out in 1957 in the US by the National Association of Science Writers (NASR) and the Rockefeller Foundation, immediately before and after the launch of Sputnik 1 – the only existing survey on public understanding of science before the beginning of the era of space exploration – results of later surveys show that, with the launching of the first satellites, space exploration became known to the great majority of the public. This may have been in great part due to the publicity given to it by the media as the space devoted to science in newspapers after the launching had materially increased, with some editors reporting increases of around 50 per cent (Withey, 1959). However, at the same time, there was only a modest increase in the number who had some understanding of the scientific purpose of space activities (Withey, 1959). The same study also revealed that most of the new advances in space were not seen as positive contributions, but rather people saw space much more as an international race with Russia, within the overall context of the “cold war”, rather than seeing space as advancing science per se (Withey, 1959).

4.2.3 Public support for space exploration

Regarding public support for space exploration, as measured by the perception of its cost-to-benefit ratio, surveys from several individual years show that it has been high in the United States: on average, nearly half of the adults surveyed in surveys carried out till 2002 said the benefits of space exploration “strongly outweighed or slightly out weighted the costs” (NSB, 2002).

However, a closer look at the aggregate patterns of public support over the past decades in the US shows a slight decrease in public support for space exploration over time. This was marked by a change in the number of people who argued that the benefits of space exploration exceeded its costs between the end of the 1980s and the beginning of 21st century: for instance, in 1985, 54% of Americans said that the benefits of space exploration “strongly outweighed the costs” or “slightly outweighed the costs”, but in 2001 only 45% agreed with these statements. Similarly, a change also occurred in the number who said that the “costs strongly outweighed benefits of space” or “costs slightly outweighed benefits”: in 1985, 39% agreed with this statement while in 2001 agreement rose to 43% (NSB, 2002). According to the *Science and Engineering Indicators 2002*, Americans were having difficulties in recognising the benefits of the space program, when the most dramatic drop in public support occurred in the late 1990’s (NSB, 2002). This might have been in part due to the Challenger disaster, which occurred in 1986. Even though a survey conducted in 1986 just after the disaster showed that the public at that time was still supportive of space exploration (I refer to the findings of the 1986 survey further in this section).

Despite there having been ups and downs in the number of supporters over time, public support has stayed high in the United States (NSB, 2002). In 2009 58% of the Americans surveyed said that the space program costs are justified and ranked NASA's performance high (58% said NASA is doing an excellent/good job) (Gallup, 2009). That said, support for space exploration ranks relatively low compared with other areas of science, technology and medicine. The most recent *Science and Technology Indicators* data (2010) showed that support for increased spending in space exploration is 14%, which contrasts with areas such as, for instance, health care (75%) or environment protection (66%)[14].

Nevertheless, in the 20 years following Sputnik, public acceptance of the space programme had increased and support for government funding spending had improved steadily in the decade following the Apollo Missions (Miller, 1994). A comparison of the results of the major survey of attitudes towards the space programme and the US Challenger shuttle accident - before the explosion (1985), immediately afterwards (1986) and five months later (1986) - showed that the public was fairly positive about space exploration and, contrary to what was expected, the Challenger accident in 1986 resulted in a shift towards a "more positive assessment of the benefits and costs of space exploration and positive attitudes to funding increased even more markedly" (Miller, 1987).

In Europe and in the UK, particularly, there has been a notable increase in support for government spending. For instance, in 1988, in the first survey of public opinion towards science ever conducted in the UK, 43% of the British surveyed thought that the government was spending "too much" on space exploration while 34% thought that the government was spending "about the right amount" (Evans and Durant, 1995). In 1998, a study conducted by ESA in fourteen different European countries about the importance of space activities, showed that about 64% of the general public agreed that their governments should fund space activities because they consider it important (ESA, 1998). Although more recent

[14] Support for increased spending in space exploration rose from 11% in 2001 (NSF, 2002) to 14% in 2006 (NSF, 2008). This figure was kept the same (14%) in 2008 (NSF, 2010), when other areas generated higher increase in public support.

comparable data are not available, public support for government spending seems to have been rather stable in the UK: 65% of British surveyed by Mori in 2004 disagreed that space research was a waste of money, while only 28% agreed with the statement. Similarly, 64% of the respondents disagreed that "joining the Aurora Programme was probably a waste of tax payers money" (Mori, 2004).

What the existing body of research over the last 30 years then suggests is that while the public is interested in and generally has a positive view of space exploration, the level of science "literacy" and number of "attentives" about space exploration continue to be low (NSF, 2002). Public awareness and support for government funding seems to have increased, but the question about to what extent space exploration, its benefits and applications, and risks are really understood by the public still remains unanswered. To date, however, almost no effort has been put into investigating the characteristics of "the public for space exploration" and significant variables that may influence public support of space exploration. This research is offered as a contribution to fill this gap in the literature by examining "the public for space exploration" in the UK, and how variables such as beliefs, rationales, gender and age might impact public support for space exploration. A careful analysis of survey data, like the one I will present here, might provide a useful framework for thinking about appropriate communication strategies for reaching different audiences and therefore inform effective public engagement in space issues (I will discuss this in deeper detail later in Chapter 6). I turn now to describe the research focus of this study, i.e. the assumptions and hypotheses, which I have used this study to test.

4.3 Research focus

4.3.1 Implicit assumptions

As showed in the conceptualization model presented on page 101, assumptions about dependent and independent factors were made based on theoretical inferences. Thus, in my model, belief in extraterrestrial life, rationales for space exploration, age and gender were defined as *independent variables*, while attitudes towards space exploration and political preferences were defined as *dependent variables*. For instance, I assumed that it is more likely that individual rationales for exploration and beliefs in extraterrestrial life would influence their attitudes and their space policy preferences. Moreover, I also assumed that it would be more likely that attitudes would influence space policy preferences than the opposite. In addition, while individuals' preferred means of exploration would be expected to influence their preferences for government spending, the reverse is also possible. Furthermore, I hypothesised that the "public for space exploration" is more likely to be part of the "attentive/interested" publics for space exploration, and to be composed of males, as I proceed to explain.

4.3.2 Gender differences and support for space exploration

Previous studies have shown that attitudes towards science and technology very often vary with gender; particularly women, on average, hold greater reservations about science and technology (e.g. Trankina, 1993; Miller et al., 1997; Miller and Kimmel, 2001; von Roten, 2004; Eurobarometer 2001, 2005, 2010). For instance, the 2010 Eurobarometer survey showed that men were more likely than women to be "very interested/interested" in "New scientific discoveries and technological developments" (82% men vs 75% women) and more likely to consider themselves "very well/moderately informed" about "New scientific discoveries and technological developments" (66% men vs 56% women) (Eurobarometer, 2010). This disinterest of women was also found to be true for space exploration issues. In Europe, men reported themselves to be more interested in "Astronomy and space" nearly twice as frequently as women (30% vs 16%), while women were more interested in "medicine" (73% vs. 50%) and "the environment" (50% vs. 45%) (Eurobarometer, 2005).

Figures on public attentiveness to space exploration in the US showed a four-times larger male “attentive public” (8% man vs. 2% women) and a two-times larger male “interested public” (28% men vs. 14% women) (see Appendix table 7-8 ‘Public attentiveness to science and technology issues, NSB, 2002). In addition, the largest survey ever conducted about Americans’ attitudes towards the space program in general, and the Shuttle accident in particular, had found similar correlations (Miller, 1987). The study showed that “attentives” to the space program, which were mainly composed of males as seen above, had significantly higher perceptions of the benefit-cost ratio: over 70% of the “attentive public” to space exploration reported that they thought the benefits from the space programme exceeded its costs, which contrasted with the 46% of the “residual public” who agreed with the same statement.

Therefore, in this study it is reasonable to expect a more positive attitude and stronger support for space policy among male than female respondents. For example, I might expect that male respondents would be more likely than female respondents to agree that space exploration is good value for money and that more money should be allocated to space exploration, while female respondents would be more likely to agree than male respondents that space exploration is less important than solving problems on Earth and that less than the current government budget should be allocated to space activities.

In the Miller’s survey (1987) quoted above, “attentives” also had stronger beliefs in human exploration of outer space in the coming future. When asked about what they thought would be the “likelihood of the placement of a colony on the Moon in the next 25 years”, 41% of the attentive public was “very likely” to believe in the placement of a colony on Mars compared with 34% of the interested public and 30% of the residual public. Also, when asked what they thought would be the “likelihood of landing a manned mission on Mars in the next 25 years”, 32% of the attentives agreed with the statement, 31% of the interested; and 25% of the residual (Miller, 1987). Therefore, I hypothesized that – overall – males in my sample would be stronger supporters of space exploration, i.e. males would have a more positive attitude towards space exploration, and would support higher amounts of government funding for space activities and more complex means of space exploration.

4.3.3 Attentive/interested public and support

Furthermore, I assumed that my sample would over-represent people particularly interested in space exploration, i.e., it would be more likely to be composed of members the "interested" and the "attentive" publics (Miller, 1983a): the sample members were at least sufficiently interested to actively attend a space outreach event or science centre, or to accompany family members, teachers or friends who are. According to the National Science Foundation's (NSF) series *Science and Engineering Indicators* (2008) "involvement with S&T in informal, voluntary, and self-directed settings such as museums, science centres, zoos, and aquariums is an indicator of interest in S&T" (NSB, 2008). The *Science and Engineering Indicators* survey (2002) showed that, in 2001, 75% of the "attentive public", 68% of the "interested' public", and 62% of the "residual' public", made visits to science museums one or more times per year. Analysis of these statistics shows that attendees to science-related events could be classified as follows: attentive public 14%, interested public 49%, and residual public 37%. As such, the combined 'attentive/interested' group represents 63% of the attendees, while the residual represents 37%. This indicates that, while the attentive public represents only a small percentage of attendees, the combined 'attentive/interested' groups represents a majority. Therefore, although my sample certainly comprises some members of the residual public, it is reasonable to assume that it is comprised by a majority of individuals who are 'attentive/interested' in space related issues.

However, in Europe the numbers of "attentive/interested" groups might be even higher. According to the National Science Foundation surveys, Americans are more likely to attend informal science institutions than Europeans (NSB, 2002; NSB, 2010). One of the possible explanations for differences in attendance to science-related events between Americans and Europeans is that adult leisure patterns reflect patterns that developed in childhood, a time when, especially for the older Europeans, informal science institutions were less readily available than in the United States (NSB, 2002). So it may be that the percentages of attendees at informal science institutions in Europe comprise a higher number of "attentive" and "interested" individuals than in the United States: Europeans would have to be at least interested in science issues to visit these places, while for Americans it is part of their leisure patterns. In summary, while males are generally more positive about space exploration, women may be more concerned about environmental issues. Consequently, I will be arguing that males would be more likely to belong to the "attentive/interested" publics for space exploration. I turn now to describe the main findings of this study that examines the "public for space exploration".

4.4 Characterization of the Sample: The "Public For Space Exploration"

This section looks at the findings related to the characterisation of the British public attending astronomy and space outreach events. First, I present a *descriptive analysis* of this audience in terms of socio-demographic factors such as age, gender and professional activity, rationales for exploration, beliefs in extraterrestrial life, attitude toward space exploration and space policy preferences. Next, I present an *inferential analysis* to determine public support for space exploration – as already mentioned, I will analyse how rationales for exploration, beliefs in extraterrestrial life, gender and age impact public support for space exploration.

4.4.1 Socio-demographic characteristics

The sample size is 744 respondents: 249 respondents from the Royal Society and 495 from the National Space Centre. The National Space Centre sub sample was twice as large as the Royal Society sub sample, with each group representing 66.7% and 33.3% of the whole sample respectively. Both sub samples were equally characterized in terms of gender, age and professional activity, i.e. there were no significant differences in the distribution of individuals among the gender, age and background classes defined. Table 2 below shows the profile of the demographic characteristics of the respondents to the survey.

Respondents			Sub-sample			
	Total		Royal Society		National Space Centre	
	n	%	n	%	n	%
Gender						
Male	408	55.5%	140	57.1%	268	54.7%
Female	327	44.5%	105	42.9%	222	45.3%
Total	735	100%	245	100%	490	100%
Age						
≤15	170	23.2%	55	22.4%	115	23.6%
16-24	68	9.3%	26	10.6%	42	8.6%
25-39	208	28.4%	72	29.4%	136	27.9%
40-54	182	24.8%	57	23.3%	125	25.6%
≥55	105	14.3%	35	14.3%	70	14.3%
Total	733	100%	245	100%	488	100%
Professional activity						
Secondary student	127	18.8%	36	15.9%	91	20.3%
Undergraduate	36	5.3%	12	5.3%	12	5.3%
Post-Graduate	113	16.7%	41	18.1%	72	16%
Researcher	15	2.2%	5	2.2%	10	2.2%
Other*	384	56.9%	132	58.4%	252	56.1%
Total	675	100%	226	100%	449	100%

Table 2 – Demographic profile of the respondents.

As Table 2 shows, a majority of the public attending space exploration outreach events was male (55.5%, *n=408* males; and 44.5% females, *n=327*). 23% of the surveyed visitors were children (younger than 16 years), 9% were young adults

(16-24 years), 29% were between 25-39 years, 24% between 40-45 years, and 14% were 55 years old or above. Furthermore, at least 43% were either students or had a professional connection to science. However, this percentage might be slightly higher as some of the children aged <15 or under, if not a secondary student yet, might have considered themselves under “others” as no other option was provided.

	Respondents at Space Outreach Events (%)	UK Profile (%)	Ratio of respondents to UK population
Under 16	23.2	18.3	1.27
16-24	9.3	12.9	0.72
25-39	28.4	19.4	1.46
40-54	24.8	20.6	1.20
55 and over	14.3	28.8	0.50
Males	55.5	49	1.13
Female	44.5	51	0.87

Table 3 – Comparison of respondents at space outreach events versus UK profile.

When compared with the demographics of the UK population[15] (Table 3), the attendance at space outreach events has a slightly different profile, with a slightly higher proportion being male and a lower proportion female. This suggests a higher interest in space outreach events by the male public.

As for age groups, when compared with the UK national profile, the attendants of space outreach events have a substantially younger age profile with the exception of the 16-24 age group. While the 25-39 and 40-54 age groups are most likely to come to such events, the 55 and older age group are the least likely.

[15] Source: ONS, 2010 (Last accessed 15 October: http://www.ons.gov.uk/ons/publications/re-referencetables.html?edition=tcm%3A77-230167

This should come as no surprise because younger age groups, schools and families are more likely to attend science and outreach events than young adults or older age groups by themselves. When people visit science-outreach events they are quite likely to come in groups or accompanied by family members or friends.

In addition, the frequency distribution of the socio-demographic factors in both sub-samples was largely the same, which suggests that these characteristics should be quite typical for the audience of space exploration outreach events in general. Moreover, the distribution of responses to survey questions by respondents at both survey locations was quite similar ($p>0.05$). To test the similarity of distribution of answers in both sub-samples, I used χ^2 for each question. This finding indicates that the location did not influence the distribution of answers in both sub-samples reinforcing the idea that not only socio-demographic characteristics, but also beliefs, motives and space policy preferences should be typical of the "public for space exploration". Due to the similarity between the two sub-samples ($p>0.05$), I did not distinguish between the two sub-samples in the statistical analysis and I present an aggregated data analysis here.

Statistical Reliability

The sample of 744 respondents provides robust overall findings about the "public for space exploration". The sample tolerances for overall results are shown below. The table shows the possible variation that might be anticipated because a sample, rather than the entire population, was surveyed. For example, on a question where 50% of the people in a sample of 744 respond with a particular answer, the chances are (95 in 100) that this result would not vary more than 3.6 percentage points, plus or minus, from a complete coverage of the entire "public for space exploration" population[16].

[16] Population sizes were taken from the Committee on Science and Technology Report (2007) http://www.publications.parliament.uk/pa/cm200607/cmselect/cmsctech/66/66we96.htm (last accessed 9 October 2011).

Approximate sampling tolerance applicable to percentages at or near these levels (95% confidence level)			
	10% or 90%	**30% or 70%**	**50%**
Sample (744)	+/- 2.2	+/- 3.3	+/- 3.6

Table 4 – Approximate sample tolerance

4.4.2 Rationales for space exploration

When asked what they thought was the most important reason to explore the Solar System, the most common reason given by respondents was "generating new scientific knowledge and advancing human culture" (69%). "Inspiring new generations" was ranked the second most common reason (16%), while "creating international cooperation", "engaging the British society in the full excitement of space exploration", and "returning value to the UK economy" did not appear to be strong preferences for the justification of space exploration (see Table 5).

Question (Q2) What do you think is the MOST important reason to explore the Solar System?	Respondents (n=680)	Percentage (%)
Generate new scientific knowledge and advance human culture	470	69
Return value to the UK economy through technological progress	40	6
Create international cooperation	18	3
Inspire new generations of scientists and engineers	110	16
Engage British society in the full excitement of space exploration	42	6

Table 5 – Respondents' rationales for space exploration.

4.4.3 Beliefs in extraterrestrial life

When asked about whether they thought life has ever existed outside Earth, the majority believed that life has existed outside of Earth (63%), either primitive (47%) or higher forms (16%). However, around a quarter of the respondents said "don't know" (24%). A further 12% did not believe that other planets in the Solar System have held life (see Table 6).

Question (Q3) Do you think life has ever existed on other planets in our Solar System?		
	Respondents (n=718)	Percentage (%)
No	87	12
Primitive life	339	47
Higher forms of life	118	16
Don't know	174	24

Table 6 – Respondents' beliefs in the existence of life on other planets.

Regarding targets for exploration for extraterrestrial life, although the most common response was "all of these" (chosen by almost a third of the respondents), the results indicate that the majority of respondents showed particularly strong expectations of existence of life "beyond the Solar System" (56%) and on "Mars" (52%), while the Moon was almost disregarded as a possible host to life (33%). Respondents were also supportive of searching for life on other planets in our Solar System (49%) (see Table 7).

Question (Q4) Where do you think we should explore for any traces of life?		
	Respondents (n=739)	Percentage (%)
Mars	159	21
Moon	17	2
Other planets in our Solar System	135	18
Beyond our Solar System	195	25
All of these	236	31
None of these	27	4

Table 7 – Respondents' preferred targets for exploring for traces of life.

Note: A sum up of the responses "all of these" with each of the four preferred targets for exploration for any traces of life should read as: 52% agreed with exploration on Mars; 33% agreed with exploration on the Moon; 49% agreed with exploration on other planets in our Solar System; and 56% agreed with exploration beyond our Solar System.

Respondents who agreed with “all of these” targets for exploration (236 respondents) were then asked to specify which target of exploration of extraterrestrial life they thought was the “most” important and which target they considered the “least” important. A more detailed analysis of this group revealed that respondents who made such distinction viewed Mars as the most important target for exploration (38 respondents of the total sample) and the Moon as the least important target for exploration[17].

4.4.4 Space policy preferences

Means of exploration

When asked about which means of exploration they thought should be used to explore the Solar System, respondents showed considerable enthusiasm: 98% said that the Solar System should be explored, although they held differing views on the preferred means of exploration. Over 55% preferred using multiple means (“all of these”) i.e. “observation from Earth”, “observation from spacecraft”, “robotic landing and exploration”, and “human space missions”, while 43% had varying opinions on favoured means, with robotic and manned missions ranking higher than observation from spacecraft and observation from Earth (see Table 8). The remaining 2% did not agree with the exploration of outer space.

[17] Because it is difficult to know the exact number of respondents that made the distinction as some respondents marked the ‘most’ but did not mark the least or vice-versa, I considered the number of responses instead. Therefore, of the 185 responses (sum of all ‘least’ and ‘most’) the number of responses for each target of exploration were as follows: *Target ‘Mars’* - 11 respondents considered it the ‘least’ and 38 respondents considered it the ‘most’ important target of exploration. *Target ‘Moon’* - 48 respondents considered it the ‘least’ and 5 the ‘most’ important target of exploration. *Target ‘Other planets in the Solar System’* - 8 respondents considered it the ‘least’ important target of exploration, while 30 considered it the ‘most’. *Target ‘Beyond the Solar System’* - 17 respondents considered it the ‘least’ and 28 respondents the ‘most’ important target of exploration.

Question (Q1) Do you think we should explore the Solar System with		
	Responses (n=725)	Percentage (%)
Observation from Earth	43	6
Observation from Spacecraft	72	9
Robotic landing and Exploration	125	16
Human space missions	91	12
All of these	426	55
None of these	13	2

Table 8 – Respondents' preferred means of space exploration[18]**.**

Note: A sum up of the responses 'all of these' with each of the four preferred means of space exploration should read as: 71% agreed with robotic landing and exploration; 67% agreed with human space missions; 64% observation from spacecraft; and 61% observation from Earth.

These findings are in line with previous findings by the Mori poll mentioned before (2004) that showed a great level of agreement with exploration of space by both mankind (68%) and machine (72%). For instance, the same poll showed that when asked what activities the UK should be involved, 65% said exploring the Universe with robots and telescopes and 55% said exploring the Universe with human space missions (Mori, 2004).

As I discussed in the methodology chapter, respondents who said "all means of exploration" (55%) were then asked to identify which mean of exploration they considered the 'most' important and which mean of exploration they considered the 'least' important. Only about a half of those respondents was able to specify: 28% and 25% out of 55%, for 'Most' and 'Least' respectively (corresponding to a

[18] In this question some respondents gave more than one answer as they were allowed to do so (5.3% of the total respondents). Therefore, this table presents the number of responses rather than the number of respondents (as explained in the Methodology Chapter). The data in the graph represents values out of 100%.

total of 377 responses)[19]. Despite the small percentage, a more detailed analysis (separate analysis) with those who made the distinction was conducted. Results showed that "robotic landing and exploration" was the 'most' preferred means (13% out of 28%), while observation from Earth was the 'least' preferred means (13% out of 25%). Human space missions were seen as the top priority methods to explore space by 9% (out of 28%) of those respondents. This contrasted with the 7% (out of 25%) who, although agreeing with human space missions, saw them as the lowest priority.

Because this question also allowed respondents to tick more than one answer, I ran a separate analysis to look in more detail at this portion of the sample. However, as only a small number of respondents ticked more than one answer (5.3% -- 38 of total respondents), I examined this portion here but excluded them from the main analysis.

As one of the main discussions around space exploration in the UK is whether space exploration should involve humans, I would expect that those individuals who did not agree with "all means of exploration" and chose more than one answer would be more likely to had some concerns about human space missions. Indeed, the first and most salient characteristic revealed by the separate analysis was that this group did appear to have some concerns about manned space missions: a majority (3.5% out of 5.3%) chose the three options that did not involve human exploration (i.e. "observation from Earth", "observation from spacecraft" and "robotic landing and exploration"). This confirms their

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[19] In this sub-question considered the number of responses rather than the number of respondents because not all respondents distinguished both 'the most' and 'the least'. Of the 426 respondents who agreed with 'all means of exploration', responses for each means of exploration were as follows: 'observation from Earth': - 91 respondents considered it the 'least' and 22 respondents considered it the 'most' important mean of exploration. 'Observation from spacecraft' - 20 respondents considered it the 'least' and 25 the 'most' important mean of exploration. 'Robotic landing and exploration' - 13 respondents considered it the 'least' important mean of exploration, while 90 considered it the 'most'. 'Human space missions' - 53 respondents considered it the 'least' and 63 respondents the 'most' important mean of exploration.

disagreement with manned space flights but agreement with exploration by other means. The further 1.8% (out of 5.3%) ticked either “observation from Earth” or “observation from spacecraft” or both.

In contrast to this general feeling that the Solar System should be explored (98% of respondents), 2% of the sample -- the “non-explorers” – disagreed with exploring the Solar System. When asked about reasons, responses were largely because it is “much less important than solving problems on Earth” (9 out of 13 respondents, 69%), and it is “very risky” (3 out of 13 respondents, 23%). Cost and value for money did not seem to be a primary concern for “non-explorers”.

Government spending

As Table 13 shows, even though there was a general feeling that government should finance space activities, about a half of the respondents (50%) agreed that the current budget should be maintained or increased, while 11% agreed that the UK was spending to much in space activities and 9% that it should be funded by private bodies.

Question (Q6) How much of the national budget should be spent on space exploration?		
	Respondents (n=710)	Percentage (%)
None: Private money	62	9
Less than 0.04%	81	11
Between 0.04% and 0.5%	250	35
More than 0.5%	108	15
Don't know	209	29

Table 9 – Respondents’ preferences for government spending in space exploration.

In this question, 29% of respondents answered “don’t know”. The high number of ‘ambivalent’ answers might have been due to the very small percentages used in the question -- people tend to be more familiar with day-to-day concepts than percentages. Another possible explanation is that people did not have a preference. As it is difficult to know what the case is, “don't know”’ respondents were analysed separately to see whether their answers presented any different patterns from respondents who stated a preference. Since no specific patterns were found, it was decided to deal only with those respondents who manifested a preference. Therefore, those who responded “don’t know” were excluded from the analysis.

4.4.5 Attitude towards space exploration

In order to investigate respondents’ attitude towards space exploration, respondents were asked agreement or disagreement with the following attitude items:

Attitude item ‘risk’ -- “Space exploration is very risky”;

Attitude item ‘UK positioning’ -- “It is important that the UK is at the forefront of space activity”;

Attitude item ‘value for money’ -- “Space exploration is good value for money”;

Attitude item ‘priority’ -- “Space exploration is much less important than solving problems on Earth”.

Results to this question are shown in Figure 2.

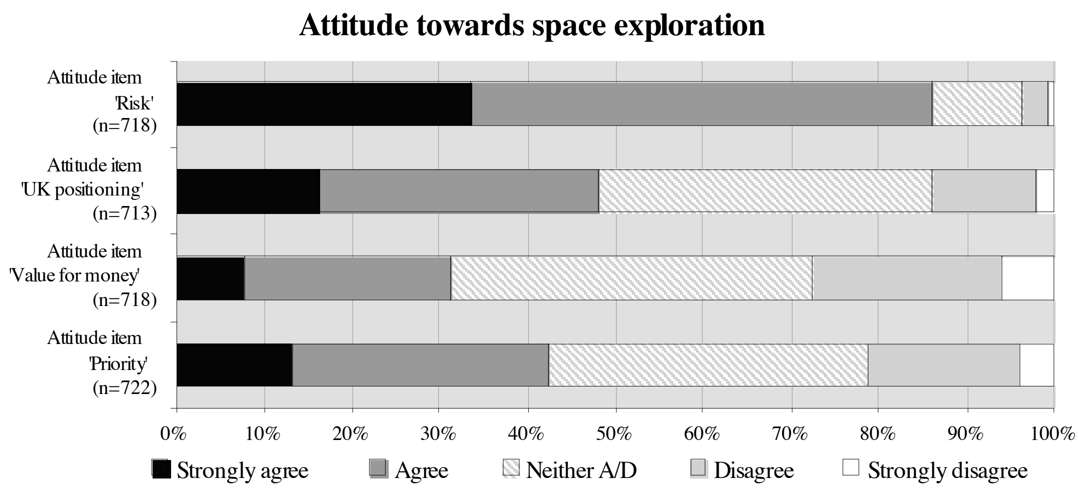

Figure 2 - Respondents’ attitude towards space exploration: attitude item ‘risk’, attitude item ‘UK positioning’, attitude item ‘value for money’, and attitude item ‘priority of space activities’. *Note:* NA/D, neither agree nor disagree.

Generally speaking, people saw space activities as very risky -- more than 8 in 10 (86%) perceived space exploration as very risky, and only 4% opposed to this idea. Respondents shared the same opinion concerning the importance of space exploration if compared with solving problems on Earth -- 42% agreed with the statement while 21% disagreed. When considering value for money, fewer more than a quarter agreed that space is a good value for money (31%), but another quarter did not (28%). Moreover, almost half of respondents were "ambivalent" regarding this issue (41%). For the importance of UK positioning, half of respondents agreed that it is important for the UK to be at the forefront of space exploration. The opposite feeling was held by a 14% who disagreed, and 38% were did not express a clear opinion (neither agreed nor disagreed).

4.5 Relationships Between Belief in Extraterrestrial Life, Rationales for Space Exploration, Gender and Age, and Support

I proceed now to address the central issue of this analysis: the interrelationship between rationales for exploration, beliefs in extraterrestrial life, gender and age, and attitude towards space exploration and political preferences, to determine which factors are better predictors of public support for space exploration. As I previously described in the methodology chapter, support is a measurement of two principal measures: (a) attitude towards space exploration and (b) space policy preferences (preferred means of exploration and government spending).

The results of the analysis that follows will be presented in two steps. *Step 1* will look at the relationships between indicators of support (relationships between *dependent variables*) and comprises a two-stage analysis: the relationship between preferred means of exploration and government funding, and the relationship between attitude items and space policy preferences. *Step 2* will describe the results of the relationship of rationales for exploration, belief in extraterrestrial life, age and gender with support (relationships between *dependent* and *independent variables*). The relationships between the *dependent variables* were explored by crosstabulating the four individual attitude items with government spending and with means of exploration, resulting in nine pairs of variables. The relationships among *independent* and *dependent variables* were analyzed by crosstabulating each *independent variable* with the four-attitude items, means of exploration and government spending, which resulted in 24 pairs of variables. All the relationships tested in this analysis are shown in the charts available in Appendix III.

4.5.1 Step 1: Relationships between indicators of support

Relationships between preferred means of exploration and government funding (space policy preferences)

First, I analyzed how the public's preferred means of exploration related to public preferences for government spending. As expected, preferred means of exploration were strongly related to support for government spending ($p<0.001$). People who supported more 'expensive' and 'adventurous' ways of exploring space such as robotic landing and manned space missions were also more likely to agree that the government should spend more than current funding levels on space exploration. In contrast, people who preferred less 'adventurous' means of exploration such as observation from Earth and observation from spacecraft supported lower levels of government funding (Figure 3).

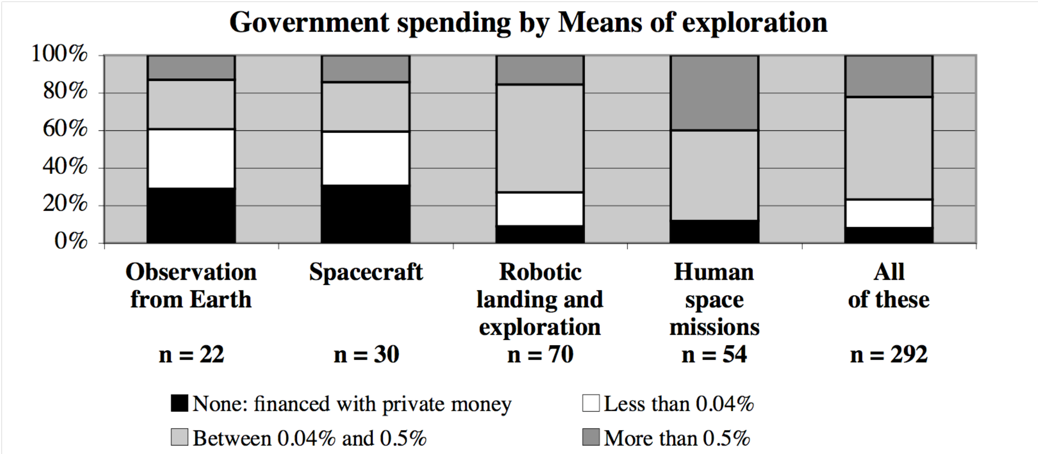

Figure 3 - Relationship between preferred means of exploration and government spending.

Although this relationship was expected, it may not be straightforward. People could be very enthusiastic about human space missions and yet disagree with increased government funding or even agree that space exploration should be funded by private money. In fact, the frequencies showed that the majority of respondents advocating private money (56% of a total 35 respondents) were strong supporters of human space missions. However, whether respondents had in mind space research or space tourism, it cannot be concluded from my data.

Relationship between attitude items and space policy preferences

The analysis of the relationship between attitude towards space exploration and space policy preferences (government spending and means of exploration) confirms consistency between the indicators of support. A more positive attitude is associated with a stronger preference towards government spending for space exploration and corresponds to preferences for more complex means of exploration. As Table 10 indicates, all relationships between the variables tested were in the expected direction and almost all were significant; however, the strength of associations varied[20].

Support for space exploration		
	Government spending [Gamma]	Means of exploration [Cramer's V]
Attitude item 'risk'	-0.26***	0.08
Attitude item 'UK positioning'	0.23***	0.11***
Attitude item 'value for money'	0.36***	0.13***
Attitude item 'priority'	-0.42***	0.14***

Significant at the level ∗∗∗*0.001*

Table 10 – Effect sizes of the relationships between attitude items and space policy preferences (government spending and means of exploration)

A comparison of the strength of relationships for the four attitude items showed that perceived priority of space exploration had the strongest influence on space policy preferences (both government spending and means of exploration), followed by perceived value for money. People who agreed that space exploration is much less important than solving problems on Earth were also more likely to think that too much money is being spend on space activities and that less complex means of exploration should be used to explore space (Figure 4 and Figure 5).

[20] The interpretation of the effects sizes given by *Cramer's V* and *Gamma* values is as follows: *Gamma* ranges from -1, meaning a perfect negative association (the two variables move in different directions) to +1, which means a perfect positive association between the two variables (the two variables move in the same direction). A value of zero means no association between the variables measured. The sign of Gamma tells the direction of the relationship, but in experimental research the sign of gamma only reflects the way in which the variables were coded, including this study. As for *Cramer's V*, values range from 1 meaning a perfect association to 0 meaning no association between the variables. Cohen (1998) has made some widely accepted suggestions about what constitutes a large or a small effect: 0.10 means a small effect; 0.30 a medium effect; and 0.5 a large effect.

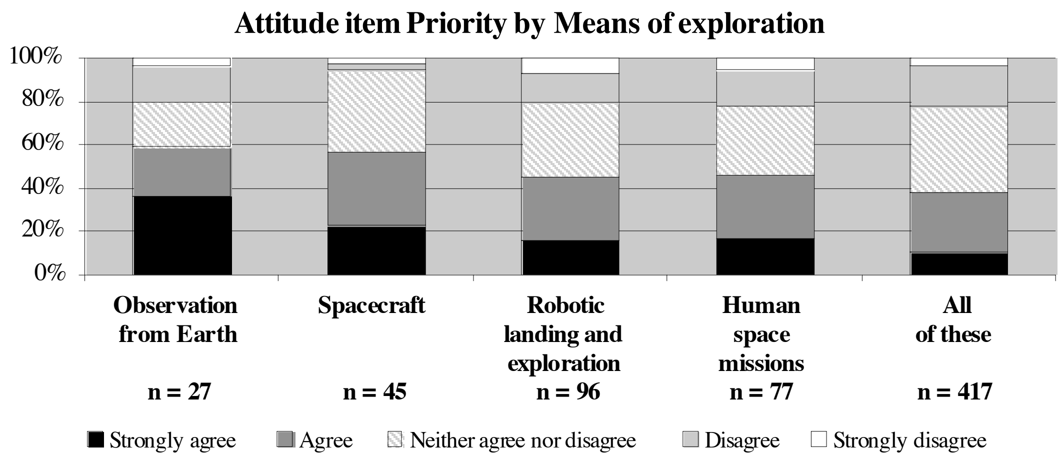

Figure 4 - Relationship between attitude item 'priority' and preferred means of exploration.

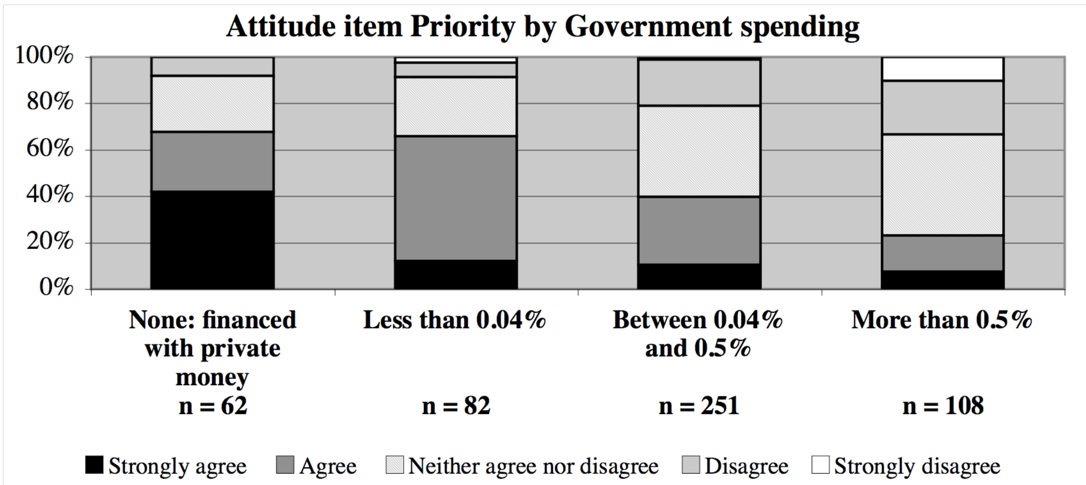

Figure 5 - Relationship between attitude item 'priority' and support for government spending.

Similarly, people who agreed that space exploration is good value for money were more likely to agree that more money should be spent on space exploration and to agree with more complex means of exploration such as robotic and human space missions (Figure 6 and Figure 7). By contrast, people who agreed that the current budget should be decreased (<0.04) were more likely to disagree that space exploration is good value for money.

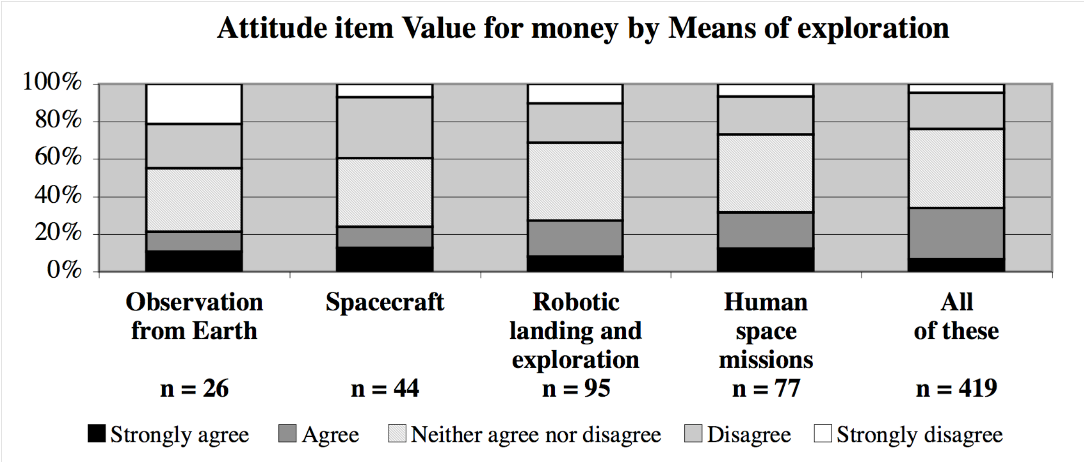

Figure 6 - Relationship between attitude item 'value for money' and preferred means of exploration.

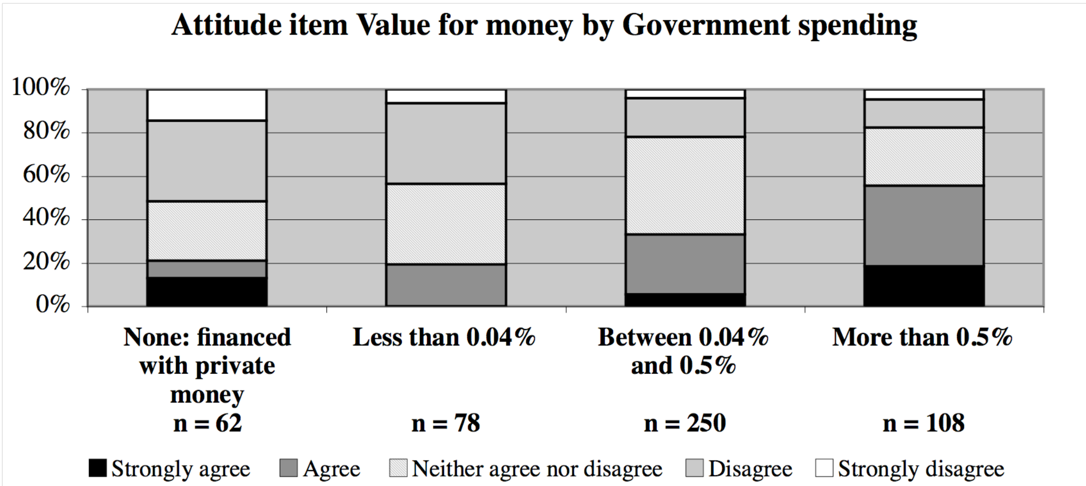

Figure 7 - Relationship between attitude item 'value for money' and support for government spending.

Attitude item 'UK positioning' showed a significant relationship, although weaker, with government spending and means of exploration. People who agreed that it is important for the UK to be at the forefront of space exploration were more likely to agree that higher amounts of money should be allocated to space research and to support more complex means for exploration.

Attitude item 'risk' showed a significant effect on government spending -- people who agreed that space exploration is risky were also more likely to disagree with higher government spending for space exploration -- and did not appear to have a significant effect on the means of exploration people supported. This finding is somewhat surprising, as I would rather have expected a clear relationship of perception of risk with a preference for less adventurous means of exploration rather than for human space missions. Nevertheless, it is important to note that, although statistical associations for the relationships between attitude item 'risk' and means of exploration did not show up in this analysis, perceived risk may still be influential: risk perceptions may have both a positive effect on support in some ways and a negative effect in others. Because of the danger involved, space exploration, particularly human space flights, involves adventure and heroism that may capture the public's attention. Even though it is considered risky, people can feel attracted to it. So risk does not necessarily have a negative connotation in that context. Indeed, during the 'space race' in the 60's when astronauts landed on the moon, the novelty, adventure and unknown consequences achieved a high public interest and awareness of space programs not only in the US, but around the world. Also, the attitude item 'risk' was phrased very generally. So it is unclear what kind of risk the question referred to or what kind of risk the respondents had in mind when answering the question (e.g. economic risk, safety risk for population, safety for astronauts).

To summarize, the findings listed in Table 10 indicate that the level of support for a space policy requiring a high level of public funding and using complex means of exploration is most strongly influenced by agreement/rejection to the item that "space exploration is much less important than solving problems on Earth" (priority). Twice as many respondents agreed to that item than disagreed with it (as Figure 2 shows). The belief that there are more pressing problems to address than exploring space thus seems to be the main factor limiting public support for a costly space program in the UK (in the sample analyzed). The second factor strongly influencing the level of support for a costly space program was the perceived benefit ("good value for money"). But here the levels of agreement and disagreement were almost equally high (as Figure 2 shows). This shows that the respondents' different views on the benefit of space exploration influence their personal level of support for a costly space policy. Perceived risk of space exploration and securing the UK position in that activity - an item with a connotation to national prestige – were less strongly but still mostly significantly associated with space policy preferences. See Table 13 for a summary of the relationships described in *step 1* (relationships between attitude towards space exploration and space policy preferences).

Table 11 – Summary of the relationships between dependent variable attitude towards space exploration (attitude items 'risk', 'UK positioning', 'value for money', and 'priority') and space policy preferences (government spending and means of exploration).

		Government spending	Means of exploration
Attitude items	***Statements:***		
Attitude item 'risk'	Space exploration is very risky.	The most concerned about risk agreed that space should be funded with private money. The least concerned agreed that higher amounts of government money (>0.5%) should be spent on space exploration [Gamma= -0.26∗∗∗].	Perceptions of risk appeared to have no impact on the means by which people think space should be explored [Cramer's V= 0.08].
Attitude item 'UK positioning'	It is important for the UK to be at the forefront of space exploration	People who agreed the most that the UK should be at the forefront of space activities were the most likely to agree with amounts >0.5%. People with no apparent interest in the UK positioning tended to agree with less than 0.04% [Gamma= 0.23∗∗∗].	People who agreed that the UK should be at the forefront of space activity supported more complex means of exploration such human space flights [Cramer's v= 0.01∗∗∗].
Attitude item 'value for money'	Space exploration is good value for money	The recognition that space exploration is good value for money drove support for higher levels of government spending on space activities [Gamma= 0.36∗∗∗].	The recognition that space exploration is good value for the money strongly related to support for more complex means of exploration such as robotic and human space missions [Cramer's V= 0.13∗∗∗].
Attitude item 'priority'	Space exploration is much less important than solving problems on Earth	The belief that there are more pressing problems to address on Earth than exploring space related to lower support for costly space programmes in the UK [Gamma= -0.42∗∗∗]	The lower the importance that people attributed to space exploration relative to solving problems on Earth, the more likely they were to support simpler means of exploration such as observation from Earth or observation from spacecrafts [Cramer's V= 0.14∗∗∗].

Note: Scale used: 1= strongly disagree; 2= disagree; 3= neither agree nor disagree; 4= agree; 5= strongly agree. Significance levels: ∗∗∗0.001

4.5.2 Step 2: Relationships of rationales for exploration, belief in extraterrestrial life, age and age with support for space exploration

Rationale for space exploration

The analysis of the statistical relationship between the reason for exploration of the solar system that the respondents considered “most important” and the *dependent variables* attitude towards space exploration and space policy preferences, showed that rationale for space exploration was statistically related to the attitude items ‘risk’ and ‘value for money’, as well as to government spending and means of exploration ($p<0.001$). However, it was unrelated to attitude items ‘UK positioning’ and ‘priority’ (Table 12).

	Attitude towards space exploration				Space policy preferences	
	Attitude item ‘risk’	**Attitude item ‘UK positioning’**	**Attitude item ‘value for money’**	**Attitude item ‘priority’**	**Government spending**	**Means of exploration**
Rationales for exploration	0.12**	0.08	0.11**	0.09	0.16***	0.12**
Belief in extraterrestrial life	0.07	0.18***	0.11	0.14**	0.16**	0.09
Age	-0.12**	0.10**	0.04	0.08	-0.00	0.13***
Gender	0.12	0.20***	0.18***	0.12*	0.21***	0.20***

*Significant at the level *0.05; **0.01; ***0.001*

Table 12 – Effect sizes of the relationships between independent variables belief in extraterrestrial life, rationale for exploration, age, and gender, and dependent variables attitude towards space exploration and space policy preferences.

Note: Effect sizes of the relationships between age and attitude towards space exploration and age and government spending are given by Gamma, all the other values on the table correspond to Cramer’s V.

In order to look closer at the relationships between rationale for exploration and attitude towards space exploration I treated the Linkert-type scales used to measure agreement/disagreement with the attitude items as metric. A comparison of the mean (dis)agreement to the attitude items showed that perception of economic benefit is associated with higher support for space exploration. For instance, finding the goal of “return value to the UK economy” as most important led to lower risk perception and to higher benefit perception (value for money): respondents for whom reason that space exploration “returns value to the UK economy” was most important were less likely to believe that space exploration is very risky and more likely to attribute economic value to it (mean ‘risk’ =3.90 and mean ‘value for money’=3.32) (see Table 13).

What do you think is the MOST important reason to explore the Solar System?		**Risk-Rec**	**UKPosit_Rec**	**Value_money Rec**	**Priority_Rec**
To generate new scientific knowledge and advance human culture	Mean	4.19	3.45	3.11	3.35
	N	469	466	468	471
	Std. Deviation	.731	.974	.945	.991
To return value to the UK economy through technological development	Mean	3.90	3.80	3.32	3.24
	N	41	41	41	41
	Std. Deviation	.917	1.005	1.234	1.241
To create international cooperation	Mean	3.95	3.55	3.09	3.36
	N	22	22	22	22
	Std. Deviation	1.046	.912	.868	1.217
To inspire new generations of scientists and engineers	Mean	4.11	3.42	2.87	3.15
	N	103	101	104	105
	Std. Deviation	.885	.930	1.089	1.045
To engage the British society in the full excitement of space exploration	Mean	4.02	3.55	2.81	3.22
	N	42	42	42	40
	Std. Deviation	.680	.968	.969	1.097
Total	Mean	4.14	3.47	3.06	3.31
	N	677	672	677	679
	Std. Deviation	.779	.969	.991	1.029

Table 13 – Comparison of the mean (dis)agreement to the attitude items.

As for the relationships between rationale for exploration and means of exploration, the majority of the respondents agreed that space exploration was important for generating new scientific knowledge, regardless the preferred means of exploration. However, those who saw space exploration as important to “inspire new generations of scientists and engineers” were also more likely to agree with more ‘complex’ means of exploration, which may suggests that people see humans in space as attracting new students to pursue scientific careers (Figure 8). This is in accordance with the Mori poll (2004) already mentioned in this chapter, which showed that fully 70% of respondents agreed with the statement “space encourages young people to become scientists and engineers”.

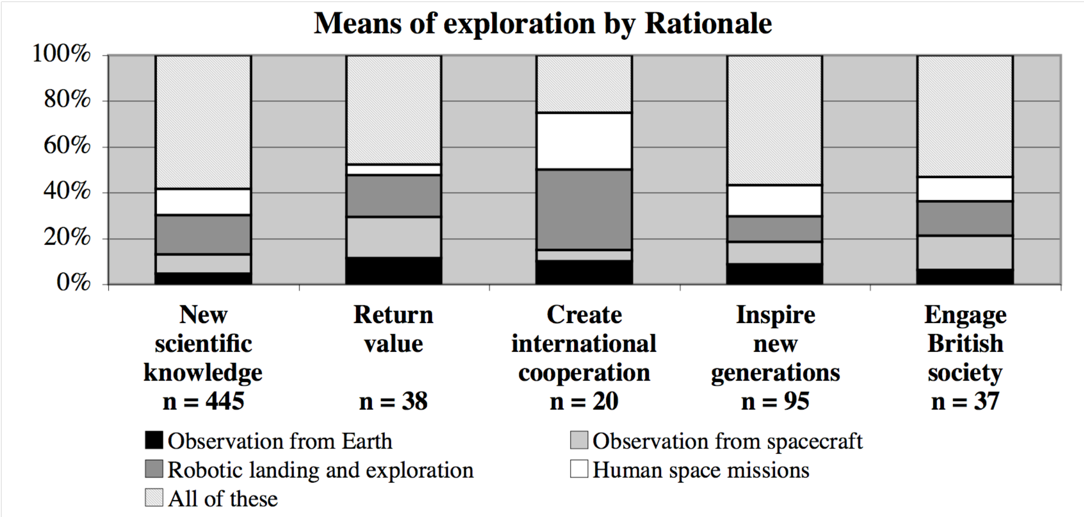

Figure 8 - Preferred means of exploration by rationale for exploration.

There is a significant relationship between rationale for space exploration and support of government spending (see Table 12). The details of that relationship are hard to interpret, however, since by far most respondents see the generation of new scientific knowledge as the main rationale for space exploration. Tentatively, because of the small group of respondents falling into those groups, the data suggest that respondents seeing “return value” as the major rationale for science exploration (n=28) and “engage the British society in the full excitement of space exploration” (n=34) are more inclined to opt against government funding and in favour of private funding of space exploration (see Figure 9). These groups probably see space exploration as a commercial enterprise and not as a scientific endeavour the support of which is a genuine task of public policy. Also, people who see space exploration as important to “inspire new generations” are more likely to think that higher amounts of government spending should be spent on space activities, which is in conformity with the previous relationship between rationales and means of exploration. This seems to suggest that the belief that space encourages young people to take scientific careers drives strong support for space exploration.

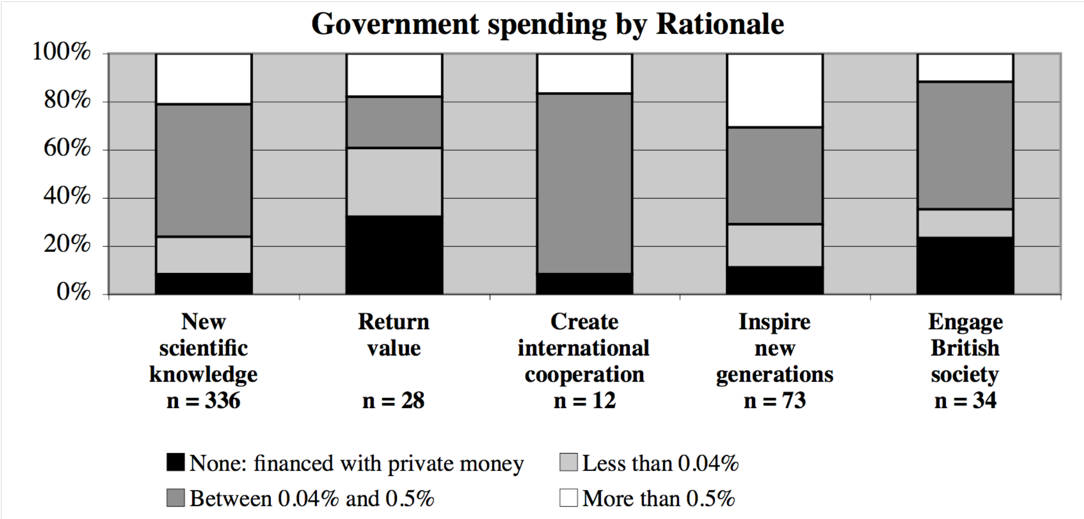

Figure 9 - Government spending by rationale for exploration.

Belief in extraterrestrial life

The belief in life on other planets was significantly related with the attitude items UK positioning and priority as well as with government spending. However, it was not significantly related to the attitude items 'risk' and 'value for money', or preferred means of exploration (see Table 12). People who believed that higher life forms might have exist in other planets were more likely to think that it is important for the UK to be at the forefront of space exploration than believers in primitive forms of extraterrestrial life or non-believers who, in contrast, were more likely to agree that solving problems on Earth is priority (see Figure 10 and Figure 11). This suggests that discovery of life outside the Earth is seen in the context of national prestige and drives support for government spending.

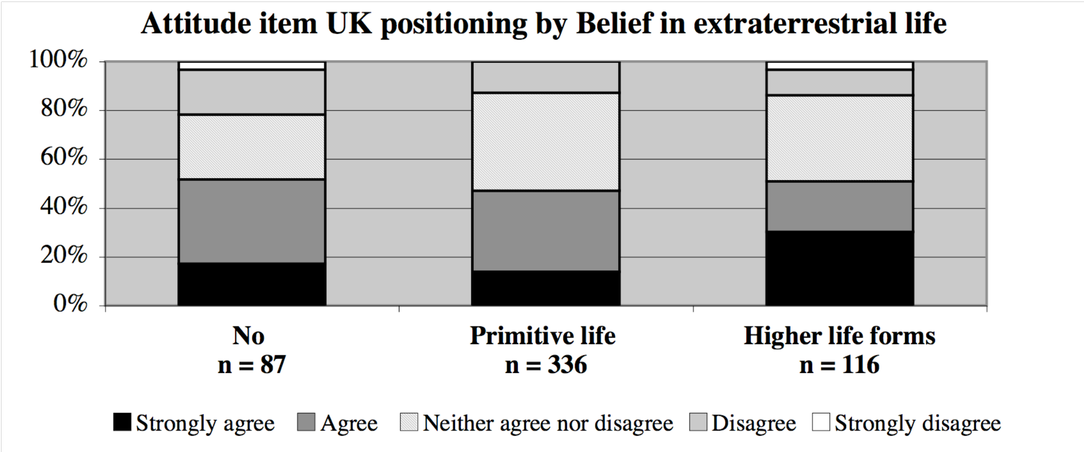

Figure 10 - Attitude item 'UK positioning' by belief in extraterrestrial life.

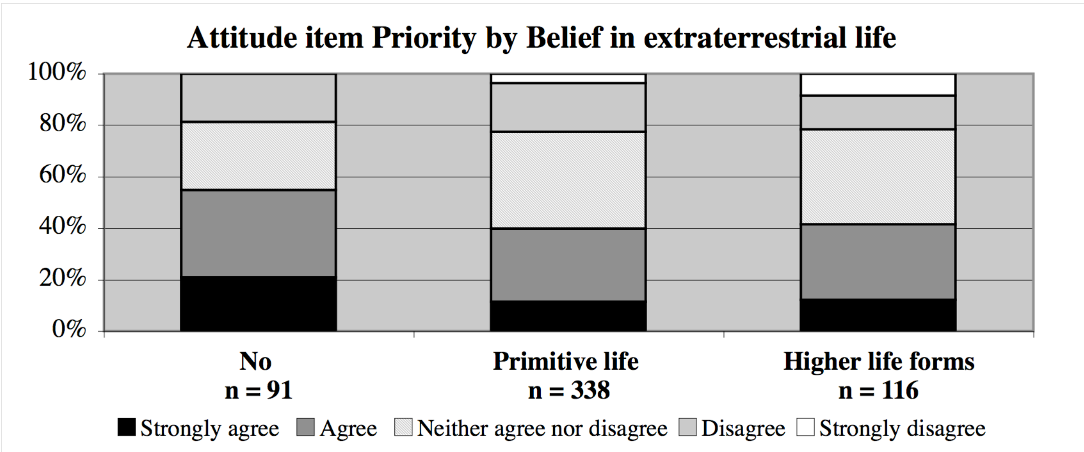

Figure 11 - Attitude item 'priority' by belief in extraterrestrial life.

Although weak, the relationship between belief in extraterrestrial life and government spending appeared to be significant (Cramer's V=0.16**): non-believers in life on other planets were more likely to agree that the current government budget for space activities should be decreased or space activities should be funded by private money. In contrast, believers in higher forms of life on other planets were more likely to think that higher amounts of money should be spent on exploring space (Figure 12).

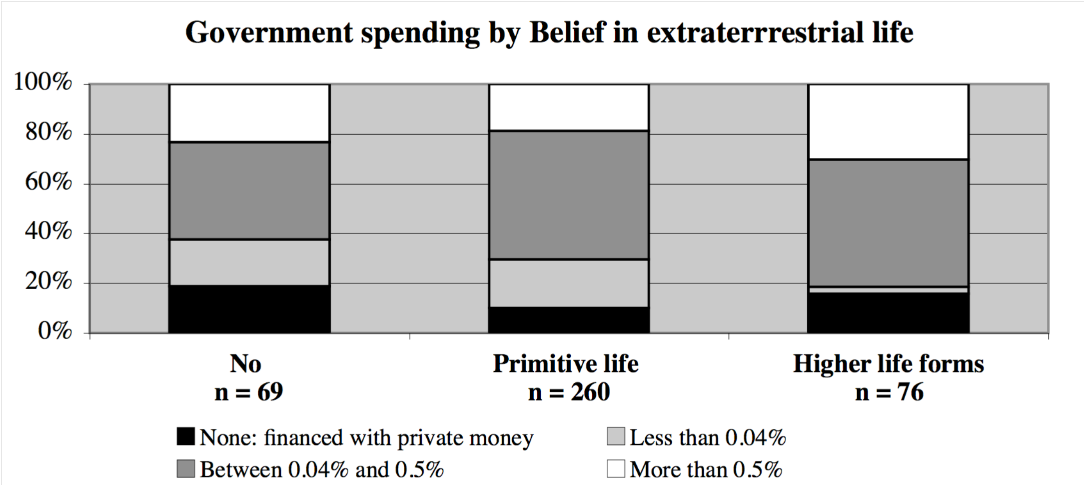

Figure 12 - Government spending by belief in extraterrestrial life.

Age

Overall, variations of support of space exploration by age were quite small and unexpectedly complex: some of the relationships turned out to be non-monotonous and inconsistent over the different indicators of support. For example, while the perception of risk (attitude item 'risk') was negatively associated with age (Gamma=-0.12), a closer look revealed a non-monotonic pattern: Respondents 15 years old and under showed the greatest concern about space exploration (90% of this age group agreed with the risk statement), followed by the middle age groups (25-39 and 40-45), while young adults (16-24) and adults 55 years old and over showed the least concern about the risk that space exploration might involve (83% and 82% respectively) (see Figure 13).

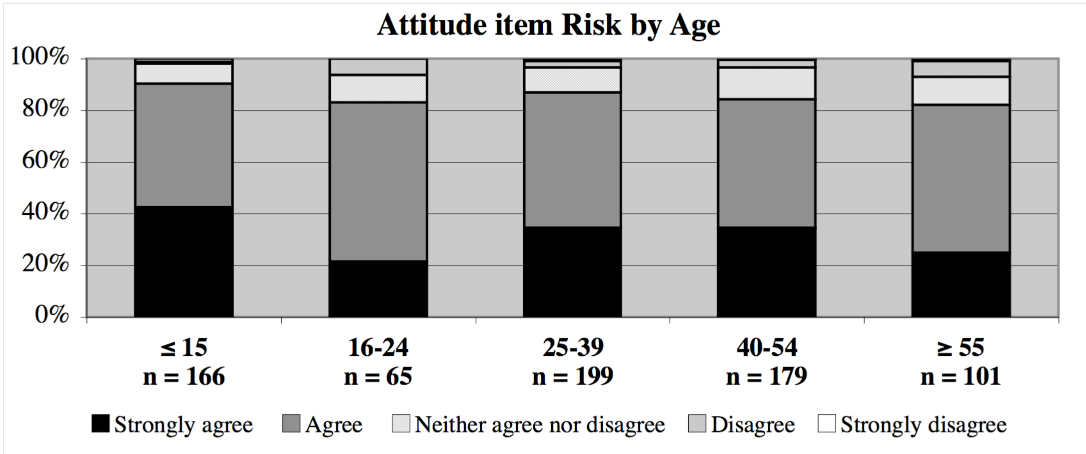

Figure 13- Attitude item 'risk' by age.

For the attitude item 'UK positioning', there was a weak positive association with age (Gamma= 0.10)[21]. Older age groups were more likely to agree that it is important for the UK to be at the forefront of space activities. I cannot fully explain the pattern of this distribution, but I found it plausible that generations older than 55 years old may have retained some enthusiasm from the Apollo missions in the late 60's early 70's when they were children or young adults, which might had led to lower perceptions of risk and stronger views on national prestige. However, this interpretation is challenged by the finding that the older generation tends to support less complex means of exploration than the younger. Respondents 55 years old and over appeared to be the strongest supporters of observation from Earth and the least of human space missions, while those aged 16-24 were the most enthusiastic about space exploration, supporting particularly robotic and human space missions (strongest agreement with "all means", "human space missions" and "robotic landing and exploration") (see Figure 14).

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[21] Although gamma showed different signals for the relationships age/attitude item 'risk' and age/attitude item 'UK positioning', the relationships were the same. This only happened because the attitude items were phrased differently (risk was phrased negatively, while UK positioning was phrased positively).

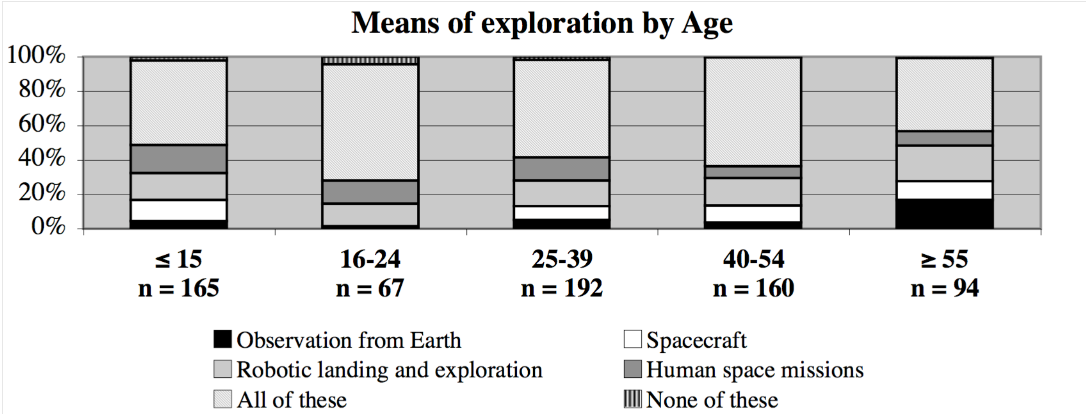

Figure 14 - Preferred means of exploration by age.

Gender effects

The analysis showed that support for space exploration – attitude toward space exploration as well as space policy preferences – varied with gender: Men had a more positive attitude than women, wanted more government spending on space exploration and preferred more complex exploration methods such as manned space flight (see Table 12). The attitude items 'UK positioning' and 'value for money' showed the largest gender difference (Cramer's V=0.20 and 0.18, respectively), while the attitude items 'risk' and 'priority' did not significantly differed with gender. Male respondents thus were more likely than female respondents to consider it important for the UK to be at the forefront of space activities and that space exploration is good value for money. Consistently, women were more likely than men to agree that solving problems on Earth was more important than exploring space. These findings suggest that male respondents had a more positive attitude towards space exploration than female respondents (Figure 15), as I hypothesized.

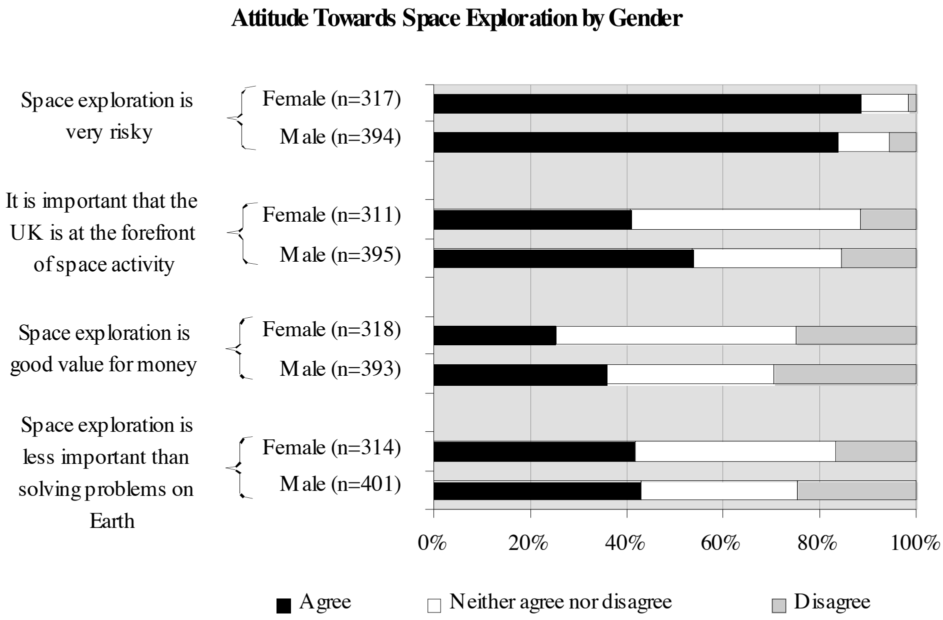

Figure 15 - Gender differences in attitude items towards space exploration.

As for support for government spending, women were more likely to think that too much money was being spent on space exploration than men (14% women vs 10% men respondents agreed with a budget <0.04%), while men were more likely to agree than women that higher amounts should be allocated to space exploration (21% male respondents vs 7% female respondents agreed with >0.5) (Figure 16). As for the relationship with means of exploration, both exploration by spacecraft and human space missions were more favoured by male respondents while female respondents were more likely to favour observation from Earth than males (Figure 17). See Table 12 for a summary of the relationships described in *step 2* (relationships between *independent* and *dependent variables*).

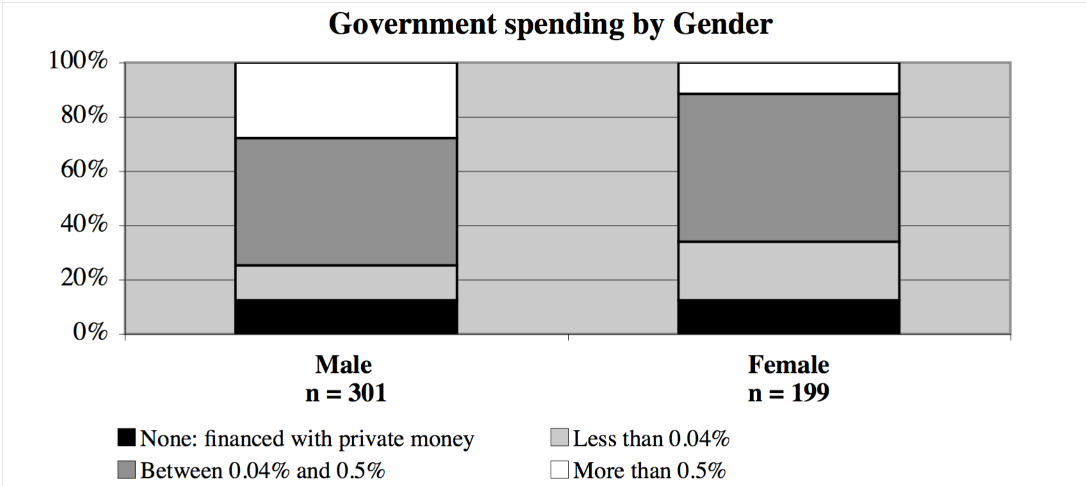

Figure 16 - Government spending by gender.

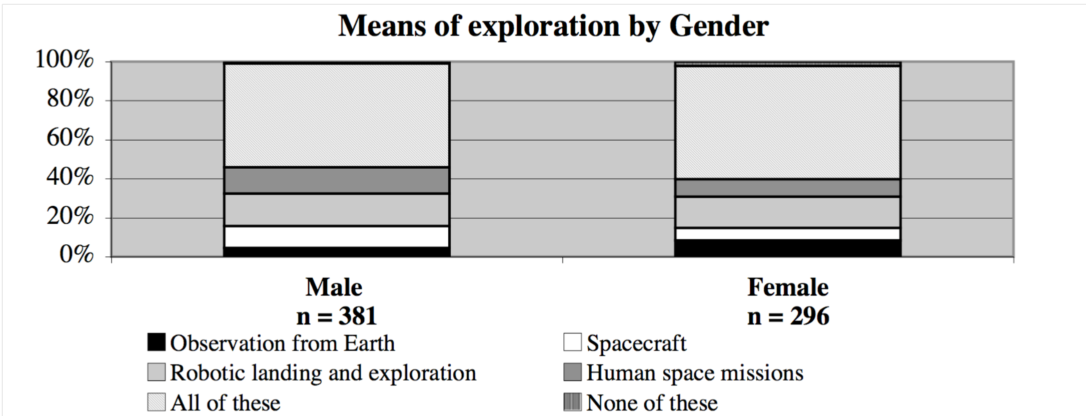

Figure 17 - Means of exploration by gender.

Table 14 – Summary of the relationships between independent variables belief in extraterrestrial life, rationale for exploration, age and gender, and dependent variables attitude towards space exploration and space policy preferences (means of exploration and government spending).

	Attitude towards space exploration			
	Attitude item 'Risk'	**Attitude item 'UK Positioning'**	**Attitude item 'value for money'**	**Attitude item 'priority'**
Rationale for exploration	The belief that space exploration can 'return value' and 'create international cooperation' associated with lower perceptions of risk [Cramer's V= 0.12**].	There was no significant relationship between attitude item 'UK positioning' and rationales for exploration [Cramer's V= 0.08].	The perception of economic benefit (agreement with the rationale 'return value to the UK economy') associated with higher benefit perception [Cramer's V= 0.11**].	There was no significant relationship between attitude item 'priority' and rationales for exploration [Cramer's V= 0.09].
Belief in extraterrestrial life	The belief in live in other planets did not significantly relate to risk perceptions [Cramer's V= 0.07].	Believers in the existence of higher forms of live outside the Earth were more likely to think that it is important for the UK to be at the forefront of space activities [Cramer's V= 0.18***].	The belief in extraterrestrial life did not significantly relate to the attitude 'value for money' [Cramer's V= 0.11].	Non-believers in extraterrestrial life were more likely to agree that solving problems on Earth is priority. Believers were more likely to disagree with the statement [Cramer's V= 0.14**].
Age	Children 15 years old and under showed the greatest concern about the risk of space activities. Age groups 16-24 and ≥ 55 years old showed the least concern about risk [Gamma= -0.12**].	Older groups, particularly those aged ≥ 55 years old, were more likely to agree that it is important for the UK to be at the forefront of space activity than younger. [Gamma= 0.10**].	There was no significant relationship between the perceptions of the value of space exploration and respondents' age [Gamma = 0.04].	There was no significant relationship between respondents' age and the perception of importance of space when compared with solving problems on Earth [Gamma= 0.08].
Gender	There is no significant relationship between gender and perceptions of risk (Cramer's V= 0.12].	Males were more likely than females to agree that it is important for the UK to be at the forefront of space exploration [Cramer's V= 0.20***].	Males perceived more benefits of space exploration than females [Cramer's V= 0.18***].	Females were more likely than males to agree that solving problems on Earth was more important than exploring space. Males were more likely to disagree with the statement [Cramer's V= 0.12*].

*Note: Scale used to measure attitudinal items: 1= strongly disagree; 2= disagree; 3= neither agree nor disagree; 4= agree; 5= strongly agree. Significance levels: *0.05; **0.01; ***0.001*

Table 14 - Summary of the relationships between independent variables belief in extraterrestrial life, rationale for exploration, age and gender, and dependent variables attitude towards space exploration and space policy preferences (means of exploration and government spending) (continued).

	Space policy preferences	
	Government Spending	**Means of Exploration**
Rationale for exploration	The belief that space exploration can inspire new generations of scientists and engineers generates support for higher government spending [Cramer's V= 0.16***].	The rationale 'Inspiring new generations' drives support for more complex means of exploration [Cramer's V= 0.1**].
Belief in extraterrestrial life	Non-believers in extraterrestrial life were more likely to agree that the current budget should be decreased or space activities should be funded by private money, in particular, believers in 'higher life forms' were more likely to agree with budget higher than 0.5% than non-believers or believers in 'primitive life' [Cramer's V= 0.16**].	There was no significant relationship between the belief in extraterrestrial life and the means of exploration people preferred [Cramer's V= 0.09].
Age	There was no significant relationship between age and government spending [Gamma= -0.00].	Older generations were more likely to support less complex means of exploration such as observation from Earth than younger; age group 16-24 were the most excited about space exploration (strongest agreement with 'all of these'; 'robotic' and 'human space missions' [Gamma=0.13***].
Gender	Males were more likely to support higher government spending than females [Cramer's V = 0.21***].	Males were more likely to support more complex means of exploration than females [Cramer's V= 0.20***].

*Note: Significance levels:. *0.05; **0.01; ***0.001*

4.6 Summary Of Findings and Discussion

The purpose of this analysis was i) to characterize the British audience attending space science outreach events in terms of their socio-demographic factors, rationales for exploration, beliefs, attitudes and preferences towards space exploration, and ii) to examine the impact of their beliefs in extraterrestrial life, rationale for exploration, age and gender on attitudes and space policy preferences as measures of support for space exploration.

The rationale for exploration, belief in extraterrestrial life, attitude towards space exploration and space policy preferences as well as socio-demographic factors such as age and gender were measured by means of self-administered questionnaires distributed in two space exploration outreach events in the UK, the Royal Society Exhibition in London and the National Space Centre in Leicester. Although limited by time and the numbers of visitors surveyed, this study offers several conclusions about "the public for space exploration". These may help science communicators and key players in engagement better understand their actual, rather than their supposed, audiences, as well as to address new audiences, as I shall discuss in deeper detail in Chapter 6.

In terms of characteristics of the certainly mostly "attentive/interested" public for space exploration, it is mainly composed of adults between 25-54 years old, and men are slightly over-represented compared with women. These findings suggest a lack of interest by a young adult female audience (16-24) and people 55 years old and older, which seem to not have been reached by science communication practitioners' efforts. Particularly, the poor attendance of young groups at informal science activities, combined with the lack awareness in astronomy and space related issues (Ottavianelli and Good, 2002; Safwat, et al., 2006, Dittmar, 2006; Jones, 2007), have showed a younger stratum of people that seems critical to engage. This cohort might be of particular interest to engage since the next 30 years long-term space programms of both ESA (Aurora Programme) and NASA

(VSE programme) call for humans exploring the Solar System, and therefore support from these individuals that will be carried from the present till retirement.

The study shows that "the public for space exploration" is very positive about space exploration (98% of respondents agreeing with space exploration), including about more 'complex' means of exploration such as robotic landing and exploration (71%) and human space missions (67%). They are supportive of government funding for space activities: 61% agreed that space exploration should be funded by the government, and only a small percentage (9%) agreed that space activities should be funded by private money. A majority of the respondents believes that life may exist, or may have existed, outside Earth (63%) particularly beyond the Solar System (56%) and on Mars (52%), and the Moon is almost disregarded as a possible host to life (33%). The belief that life may exist in other planets seems to be connected to supporting space exploration as a matter of national prestige, which drives strong support for government funding. Given that the search for signs of extant or fossil life on Mars is one of the key drivers for the ESA's Aurora programme, this indicates that the additional support given by the UK government to this enterprise resonates with people who are more likely to be attentive to this aspect of their policy, in terms of their beliefs and their feelings of national pride.

As for the individual attitude items towards space exploration, a considerable proportion of respondents shows some reservations about space exploration with respect to the importance of solving problems on Earth (42%), scepticism about value for money for the UK economy (28% disagreed with the notion that it is good value for money and 41% were ambivalent), and perceptions of risk (86% agreed that space exploration is very risky). For instance, the belief that there are more pressing problems to address on Earth than exploring space appeared to be the main factor limiting public support for a costly space program in the UK (in the sample analyzed). The second factor that influenced public support for government funding was the perceived value for money of space exploration, followed by perceived 'risk' and 'UK positioning'.

The analysis show a strong association between the two space policy preferences measured: more complex means of exploration were associated with higher amounts of government spending for space exploration – people who supported more complex means of exploration such as robotic and human space flights were also more likely to agree that higher amounts of government money should be allocated to space activities. Also, more positive attitudes towards space exploration related to stronger political support. For instance, individuals who showed a more positive attitude towards UK positioning or value for money were also more supportive of more complex mean of exploration and higher amounts of money to be spent on 'space'. And, although the great majority agreed that space exploration is very risky, this view did not influence their preferences for means of space exploration: they still supported more 'complex' means such as human space missions. This seems to suggest that the adventure and heroism involved in space exploration attracts public attention and therefore support.

Another important finding is that the more the public valued space exploration the more they tended to support higher levels of government spending on space activities. However, only 31% agreed that space exploration is good value for money, far fewer than those that supported space exploration overall. So while this survey cannot be conclusive about the kind of arguments that would increase public support for space exploration, it seems that discussing and communicating about the benefits of space exploration to the overall quality of life, and to society at large, rather than concentrating on immediate economic returns, may increase support for space exploration as well as attract other publics. I will come back to this point in my general discussion in Chapter 6.

In addition, support for space exploration in the UK is stronger among males than females, which confirms my hypothesis. Males showed a more positive attitude toward space exploration, and agreement with higher amounts of government funding as well as a preference for more complex means of exploration. This finding is in line with the situation elsewhere in Europe and in the US. Surveys showed that males (30%) reported to be more interested in "Astronomy and space" than females (16%) (Eurobarometer, 2005) and also that the "attentive/interested" public to space exploration was mainly composed of male individuals (36% of "attentive/interested" males vs. 26% females) (NSB, 2002).

Given the gender differences showed in my survey and others, and the fact that when people visit science-related informal learning institutions they are quite likely to be in groups or accompanied by family members or friends (NSB, 2008, p.14), I would argue that my sample may well be composed of mixed groups such as couples or families where —- males would be more likely to be part of the "attentive" and "interested" publics, while accompanying females would be more likely to be part of the less "attentive/interested" publics. Similar arguments may be true for other kinds of groups as school classes. Therefore, I would argue that the "attentive/interested public" -- "the converted", which would be mainly composed of males, bring with them a number of less interested in the subject – the "less converted", and these may just excellent opportunities for science communicators to target groups that otherwise would not be available for 'space' science. Thus, outreach events rather than other means of communication have the 'right' social setting to reach "more difficult audiences".

4.7 CONCLUSION

In this chapter I offered a description of the findings of the surveys conducted at two 'space' outreach events in the UK in order to characterize "the public for space exploration" and support for space exploration. The analysis was presented in two main steps. Firstly, I characterised the sample in terms of their socio-demographic factors such as age, gender and professional activity, rationales for exploration, beliefs in extraterrestrial life, attitude towards space exploration and space policy preferences. The analysis showed that the "public for space exploration" was mainly composed of adults between 25-54 years old, with men slightly over-represented compared with women. In addition, findings revealed that males appeared to be stronger supporters for space exploration than females –

had a more positive attitude towards space exploration and stronger space policy preferences.

This finding on gender differences is consistent with the literature in women and science, which have been much discussed over the last few decades (e.g. Schiebinger, 1999). I agued that male respondents in my sample would be more likely to be part of the “attentive” and “interested” public who come to outreach activities and brings a less interested public with them. Therefore, outreach activities might be seen as ideal places to reach a female audience who come with the attentive/interested male audience, and therefore could be seen as a way to address a significant policy issue about recruiting women in science.

Secondly, I analysed the interrelationship between rationales for exploration, beliefs in extraterrestrial life, gender and age, space policy preferences to determine which factors would be better predictors of public support for space exploration. The analysis showed that the main factor influencing public support for space exploration is the perceived priority of space activities when compared with solving problems on Earth, followed by perceived value for money.

This survey provides an in-depth understanding of this public that takes the time to visit and participate in ‘space’ outreach activities, which is actually the target audience for practitioners’ efforts. In Chapter 6 I will bring together the main findings of this survey and the main findings from the interviews conducted with practitioners of science communication in the area of ‘space’ to discuss how surveys like the one included here can help science communicators and other key players in public engagement such as policy-makers, framing the science communication and outreach strategy.

CHAPTER 5

VIEWS OF PRACTITIONERS OF SCIENCE COMMUNICATION ON "THEIR PUBLICS" AND PUBLIC COMMUNICATION

"For constantly I felt I was moving among two groups –
comparable in intelligence, identical in race,
not grossly different in social origin,
earning about the same incomes,
who had almost ceased to communicate at all,
who in intellectual, moral and psychological climate had so little in common that
instead of going from Burlington House or South Kensington to Chelsea,
one might have crossed an ocean".

C.P. Snow, The Two-Cultures, 1959

5.1 INTRODUCTION

This chapter moves from the characteristics of the audience for space research to the characteristics of those doing the science communication to look at the way in which science communication is performed by practitioners of science communication (hereafter practitioners) in the area of 'space'. It seeks to examine practitioners' views on "the public" and public communication in order to reflect on what science communication currently means and what the roles of practitioners and the public are.

As discussed in Chapter 2, the *Literature Review*, over the last decade public communication has been built around a changing preference for a "new mood for dialogue" (House of Lords, 2000) versus a "deficit model" (Irwin, 1991). This involves a more interactive model of communication with audiences and a public that is more participative rather than "ignorant" (Gregory and Miller, 1998). My approach in this chapter will be to confront the theory of policy discourse towards public engagement with science and communication, with the practice of those who deal directly with the public in order to critically analyze what the policy discourse has produced.

What follows therefore is an analysis of practitioners' discourse about the ways they conceptualise "the public" and public communication in various contexts, including policy-making. In particular, I will discuss the value of "dialogue" in the contemporary practice of public communication. As I showed in the literature review, recent work that has looked at the value of dialogue has argued that it has a role to play outside the context of policy-making (e.g. Lerh et al., 2007; Davies et al., 2008; Van der Sande and Meijman, 2008). In addition, I will examine how practitioners anticipate their audiences by showing them key findings of my surveys on the "public for space exploration", and how they react to surveys about this public that they are meant to be addressing. Finally, I discuss the way in which the practice of science communication and the roles of science communicators and the public can be understood in relation to science policy. When appropriate, an account of how institutional roles relate to practices and how institutional arrangements may impact the relationship between publics and science is made.

Before presenting the analysis of the data, I offer a brief description of previous studies on assumptions about the public and public communication to position the research presented here within the study of "scientific understanding of publics". I also summarize the key claims for which I will present evidence in the analysis. It should be borne in mind that the use of the term "the public" throughout the analysis of the data refers to the public that practitioners are meant to be addressing, i.e. "the public for space exploration".

5.2 Previous Research on Ideas and Assumptions about the Public and Public Communication

5.2.1 Views on "the public" and public communication

While the public understanding of science has received much attention by scholars researching science communication and relationships between science and society, it was not until very recently that studies on the "scientific understanding of the publics" (Levy-Leblond, 1992; Miller, 1992) have begun to generate academic interest. This is somewhat surprising due to the many calls for a more democratic approach to decision-making on issues involving science and technology, and to the many studies that have demonstrated that the public often have sophisticated knowledge of the local, environmental and social-cultural contexts (e.g. Irwin and Wynne, 1996).

Research on perceptions of "the public" and public communication has focused mainly on the views of scientists, where "deficit models" have frequently been found (e.g., Cook et al., 2004; Royal Society, 2006; Burchell, 2007; Young and Matthews, 2007; Davies, 2008). For instance, work by Cook et al. (2004) has examined the discourse of experts working in the controversy around GM foods in Britian to investigate experts' perceptions on non-expert knowledge and the way they communicated their research with those audiences. The study concluded that "the public" was typically categorised as "emotional rather than rational, vulnerable to manipulation and ignorant of GM science", and had a "passive role" in the controversy rather than an active one. The study also showed that GM scientists generally subscribed to a "deficit model" of the public, and communication was essentially seen as one-way where transfer of knowledge would educate the public about the scientific issues around GM foods.

Similarly, Davies (2008) has looked at the ways in which scientists and engineers in the UK talked about the purposes and content of science communication to the public. She showed that a one-way communication model was consistently used, however, there was also a minority of the scientific community whose discourse showed more complex models of communication, which is, as she argued "encouraging".

5.2.2 Views on public participation

Another important focus of research concerning assumptions of "the public", albeit still neglected in the literature, has been experts' perception of public participation in policy-making (e.g. Kerr et al., 2007; Young and Matthews, 2007). This is despite the significant attention given to the study of the intersection between lay knowledge and expert knowledge (e.g. Wynne and 1996; Collins and Evans, 2002) and the evidence of the value of lay experts' knowledge in the resolution of scientific problems (Irwin and Wynne, 1996). In fact, one of the most recent significant discussions in the sociology of knowledge has been on the potential for public participation in the shaping and implementation of scientific decisions, as I presented in the literature review chapter (see for example Collins and Evans, 2002; Wynne, 1996, for contradictory views).

Recent empirical research by Young and Matthews (2007) has investigated experts' understanding of public participation using the case of aquaculture in Canada. This case has been one of the most prominent environmental and industrial controversies in Canada in recent years. The short and long-term effects of human intervention in natural system have been the focus of fierce debate between experts and the public. For supporters, commercial aquaculture is a logical extension of food production capable of feeding a 'protein-hungry' world.

For opponents, commercial aquaculture is an invasion of marine ecosystems which may destroy species and the existing habitats. By examining how experts on aquaculture viewed lay knowledge and their participation in the debate, the authors concluded that experts were open to incorporating local knowledge into scientific practices, but were critical of the "general public opinion" due to the "cognitive processes and value choices that are thought to lead the public to erroneous or simplistic opinions about aquaculture".

Although public opinion of science and technology is seen as an important component of the process of science, studies like the ones refereed above advocate a rethinking of the role of experts and the role of the public (e.g. Levy-Leblond, 1992; Collins and Evans, 2002). Other studies on public opinion, particularly on scientific areas involving risk issues, have suggested that public opinion can "harm" scientific and technological developments if not handled carefully (e.g. Slovic, 1986). Slovic (1986) argues that there are four main limitations to public understanding of risk assessment:

> "people's perceptions of risk are often inaccurate; risk information may frighten and frustrate the public; strong beliefs are hard to modify; and naïve views are easily manipulated by presentation format".

This brings important, but also controversial arguments to what Collins and Evans (2002) called the "problem of extension", which discusses the problem of the limits of participation. According to these authors, public participation should exist, but how far it should extend needs special consideration. This suggests a conflict between public opinion and expert knowledge in which public opinion is seen as being capable of preventing science from advancing. Questions such as who should take part in policy-making and under what circumstances, and to what extent is it appropriate to "extend" public participation, are on the core of this discussion. This affects the process of science communication. The way in which the public is conceptualised by experts and other key players in science communication and public engagement such as policy-makers motivates the way in which communication is addressed. As Davies (2008) notes:

> "In practice, it is individuals or small groups of technical experts who come into contact with publics, not science as an institution or an establishment. And it is therefore the practices of individuals which will frame and shape the communication process" (Davies, 2008, p. 414).

As such, scientists and other practitioners' views on "the public" and public communication are an important component of the 'scientific understanding of publics' as an area of research. Although some studies have been conducted to examine "experts" views on "the public", there are other groups directly involved in the practice of science communication such as professional science communicators and policy makers, whose views have not been investigated. The analysis that I present here aims to contribute to filling this gap in the literature by examining the views of practitioners of science communication in the area of 'space' concerning these issues. I turn now to present the key claims that I will be arguing in this analysis.

5.3 KEY ARGUMENTS

Within the interview data, although there is a diverse range of ideas expressed by the interviewees about science communication and "publics", I have been able to identify a number of key concepts that practitioners hold with respect to the practice of science communication and conceptualisation of the public. Based on those, I will argue that:

- In contrast to previous studies such as the ones outlined above on experts' understanding of public communication, science communication is constructed by practitioners of science communication as an "interactive process" based on "dialogue" between science communicators and their audiences.

- There is a "mood of interaction" described by practitioners that does not mirror but rather *adapts* the terminology from the "mood for dialogue" in science policy to its own context and needs, and applies the terms to very particular situations. Talking about science communication as an "interactive process" allows practitioners to frame a variety of activities in terms of the now dominant rhetoric of "dialogue".

- Despite the dominant discourse on "dialogue/interactivity", both one-way and two-way models of science communication are informally in use by this community, and seem to be chosen according to the aims of communication practitioners want to achieve and the audiences they want to address.

- "Dialogue" in the rhetoric of practitioners is clearly different from the dialogue of the policy rhetoric, and can take different formats and aims: an *interactional dialogue* which is aimed at public understanding of science and public awareness of science; and a *participatory dialogue*, which aims at public engagement with science and public participation in scientific discussions that do not intend to influence policy-making.

- Science communicators can be seen as *gatekeepers* in the sense that they try to control public communication rather than simply pass on information. They implicitly draw on a set of *assumptions* about "the public" to decide on the models of science communication, the content of communication, and the type of audiences they choose to communicate with.

- Conceptualisations of the public vary according to situations: the public is sophisticated and "knowledgeable" to participate in science communication activities and "dialogue" that do not seek to influence policy. However, for matters of science policy, conceptualisations of the public are rather complex: for some, the public is sophisticated and knowledgeable to participate in science policy issues; for others, the public is a "misinformed actor" that cannot take informed decisions.

In the analysis that follows, I will present evidence that supports the above key arguments relating these to the policy discourse and academic debate on these issues. The analysis is organised in three main parts. Firstly, I will look at the concepts of discourse that characterise practitioners' views regarding "the public" and public communication, where specifically I will examine the models of science communication used by practitioners, the type of activities performed, and the aims of their communication. Secondly, I will investigate practitioners' views on public participation in 'space' science policy. This is important to provide as complete a picture as possible of how "the public" is constructed among practitioners. Lastly, I will discuss how practitioners understand their audiences: how they perceive their audiences' characteristics and how they respond to my survey findings of their audiences. I turn now to examine these, first by describing practitioners' discourse on "the public" and public communication. In the material that follows, one or two excerpts illustrate each idea discussed. Such excerpts should be considered as examples of similar comments by a number of other interviewees.

5.4 Practitioners' Views on "the Public" and Public Communication

In this section, I provide a detailed analysis of the discourse of the interviewees regarding practitioners' understanding of "the public" and public communication. In order to allow a clear exposition of the content of the discussions, I examine the views of practitioners concerning these issues before providing some examples of contradictory discourse.

5.4.1 Practitioners' discourse on public communication

"It's got to be a two-way thing"

At the beginning of the interviews practitioners were asked what outreach activities to the general public they had been involved in recently. As they described mainly activities that they had coordinated or organized themselves the discussions tended to flow easily, which helped the conversation. Despite the diverse range of activities described, ranging from traditional lectures to interactive simulators or focus groups, many points in the conversations made it clear that a two-way communication with the public must exist. In the extract below, one female professional science communicator explains her view on the importance of a two-way communication:

> "it's got to be a two-way thing because people are just not satisfied with just being consumers anymore. They don't want to just sit back and watch TV or sit back and read. They want to ask their own questions, they want to promote their own batty theories as well". (Anna, professional science communicator and blogger)

As she describes, two-way communication is essential because the public "are just not satisfied with just being consumers anymore". The public is understood, as the extract above implies, to be interested in participating in science and discussions, asking their questions and suggesting their theories rather than being consumers of information. This already suggests an image of an "active" public rather than a passive one, as I will discuss in further detail later in this section.

Similarly, two other professional science communicators express their views about the importance of having two-way communication arguing that the public "has the right to ask questions" and "do not enjoy sitting and listening to someone talk":

> "they've [the audience] got not just a right to hear it but a right to ask you about it as well. Right to shape it, to think about it, to ask questions about why we do it and ask questions about what we find out". (Peter, professional science communicator)

> "From my background in science communication I don't really enjoy, and I don't think audiences enjoy so much, sitting listening to someone talk, I always try and include some discussion, dialogue, at least questions and answers and I try and steer it towards a dialogue". (Stewart, professional science communicator)

Again, the two quotes above emphasise the idea that not only does the public not enjoy having a passive role in science communication activities but they also have the "right" to perform an active role.

Furthermore, a two-way communication is normally expressed as a "dialogue" or a "discussion" between the science communicator and the public, which very often is linked to the idea of it being good practice and capable of better "engaging" audiences in scientific topics. Practitioners argue that, in a "dialogue" or a “discussion”, the “level of engagement” of the audiences is more “intense” and “fruitful”. Moreover, such activities are also seen as opportunities for “everyone” to learn:

> “It is important to establish a dialogue. (…) if you can have a dialogue when you have a question and then you have the answer, and that answer triggers a deeper question or a question that is related to that but is sidetracked into something else, then it becomes a dialogue that is extremely engaging”. (Luke, professional science communicator)

> (…) “The debate is another format that we will want to try when we have a lecture on your contentious issue which may be life in the universe in the context of religious beliefs for example, or the discovery of the effects of the universe in our lives in the context of astrology, start playing with these ideas in a debate. (…) That will be a way of linking with young audiences, but also adult audiences, and a level of engagement that may be more intense and more fruitful and more of a learning experience for everybody, for the general public and for the people organizing and chairing and dealing with the questions in the panel. It’s very much a learning experience for everybody”. (Fred, scientist)

For both practitioners, Luke and Fred, “dialogue” and “debate” are engaging forms of communication where both parts, the communicator and the audience, can learn. As Fred puts it, it can be a “learning experience for everybody”. These extracts show an open attitude to listen to the public and to establish a “dialogue”, particularly to discuss contentious or ethical issues.

Two-way is important to give the public the sense of being part of science

When discussing the reasons why practitioners of science communication think a two-way communication with the public is needed, three important points come from the interview data: it is important to give the public the sense of "self confidence that they are contributing to science" so they feel more involved as active participants; to develop the public's "trust" in science; and to make the institution of science "transparent". According to interviewees, trust and confidence in science can only be reached if a two-way discussion exists where the public can be heard and their views and concerns taken into consideration. The three extracts below illustrate these points:

> "(…) Giving people the sense of self confidence that they can really contribute to science, I think that's terribly important. It's empowering, they're more equipped to understand new stories about the environment and nuclear power and their health and whether homeopathy works, so on and so forth" (…)". (Anna, professional science communicator and blogger)

> "It's about giving the public a sense of some kind of input into the process and also giving them a sense of trust that sensible decisions are being made. And maybe if we succeed in making them feel more involved in science, actually it could almost, in a way, not backfire but have the consequence of the public wanting to have more say in what goes on, which scientists will have to, and politicians will have to try and accommodate and balance. So that's actually a long term issue". (Matthew, professional science communicator)

> (…) To be an open and transparent organisation so the public know what we're doing, and to listen to the public and hear any

> views and concerns they have and take those into account". (William, policy maker)

Thus, a two-way communication is described as an important feature of public communication in almost all practitioners' discussions, regardless of their specific roles at institutions. Moreover, the discourse on a two-way communication as presented in previous extracts suggests that practitioners of science communication see a two-way approach as a "fruitful" experience essentially because there is an exchange of information between participants, which is described as being beneficial for everyone involved.

Another point that comes out from the quotes above, is that concepts such as "dialogue", "discussions", "debate", "engagement" (and so on) have been adopted by this community despite seeming to be used in many different ways, in different contexts, and perhaps, with different meanings. This point is better illustrated with few more quotes:

> "it's not public understanding of. It is engagement as in just generally being interested, thinking it's important, thinking it matters to them" (…) "it's more not just passively absorbing facts, or not passively just looking at something. It's really that taking an interest in the longer term". (Britney, professional science communicator)

> (…) "what we're all about is, in a sense, engagement, we don't do very much in the way of traditional outreach in terms of actually going out from the museum into the wider world (…) I think, what I would mean by engagement, traditionally people talk of science communication or science outreach, and I think that's, kind of that model is about the science people telling other people about science, whereas I think engagement is the

> more modern idea which is where there's a two-way process". (Matthew, professional science communicator)

> Interviewer: "But, what do you mean by engagement?"
>
> "Well, I mean, the people taking part in the activity. Encouraging people to ask questions". (Robbie, policy-maker and scientist)

Summary

The first and foremost point that came out of the data is that a variety of concepts that refer to a two-way communication are used by practitioners. And, although it is not clear what those concepts mean, they generally reflect an idea of interaction between the science communicator and the public. This supports my claim that practitioners of science communication have *adapted* the rhetoric of policy and by academics but are using it according to their own needs and contexts. However, despite the fact that practitioners are constantly talking about concepts such as "dialogue" and "engagement", it would be naive to think that a "genuine" dialogue is practiced in most situations.

In fact, the quotes presented here already suggest a type of "dialogue" which seems to be different from the dialogue that is described by academics and in policy contexts. However, I will come back to this idea later in this analysis when discussing practitioners' views on public participation. Furthermore, the "dialogue" described here, as expressed by Luke and Fred, can assume different formats: it can simply be a question-answer "conversation" between the science communicator and the audience; or a discussion about contentious issues. I will discuss the meaning of "dialogue" as talked by practitioners in greater detail later in this analysis.

Finally, the extracts presented above suggest that practitioners see the public as active members who not only want to participate in science but also have the right to do so. A few more quotes illustrating practitioners discourse about their audiences are presented below to provide a richer picture of their conceptualisation of "the public".

5.4.2 Practitioners conceptualization of "the public"

"The public" want to contribute to science

Conceptions of the public such as "interested", "engaged", "curious", "fascinated" and "passionate" about science, particularly astronomy and space issues, appear very frequently in practitioners' discourse about "the public". Moreover, many points in the interview data show that the public has a "deep respect" for science and is "motivated" to contribute to it. As Anna explains, more than just looking at beautiful images, which are seen by practitioners as one of the most important components of communication, the public "wants to contribute to science":

> "I thought initially that their [the public] motivation was seeing the beautiful galaxies, and also the satisfaction of being the first to look upon some of them, because the telescope is, of course, robotic. And actually it was a surprise to me to discover that Jordan Raddick and a few more people did a survey to find out what was interesting, and the overwhelming response was: I want to contribute to science. I think deep down most people - even if they didn't like science at school, even if they only read really rubbish things about science in the papers - they still have a deep respect for it". (Anna, professional science communicator and blogger)

The public is not ignorant

Similarly, Britney explains that the public is not "ignorant" and are open to "taking complex ideas on board":

> “So even if they didn’t manage to get through the whole way, they’re definitely open to… I think they’re open to taking on board more information than we might have thought. I mean, I think sometimes we’ve erred too much on the side of caution and gone, keep it really simple, and actually visitors are open to taking complex ideas on board, so…”. (Britney, professional science communicator)

The public is knowledgeable

And, Emily describes the public as very knowledgeable about recent discoveries:

> (…) they do know a lot about it [astronomy] and they have endless questions and it’s sometimes a bit of a challenge to keep up with the news (…) people will look at the news and NASA’s animations and visualisations, and then they want to know more about it”. (Emily, scientist)

To sum up, a positive perception of the public is another almost universal point in the data. This does not mean, however, there were no situations in which a deficit image of the public was presented. In fact, despite practitioners’ dominant talk reflecting an effort to move practice from “getting the message across” to “listening to the public”, on some occasions, their discourse about science communication and the public was nothing more than a sophisticated way of presenting a deficit model. I turn now to present some examples of contradictory discourse to the dominant pattern of “dialogue/engagement”.

5.4.3 Contradictory discourse on "the public" and public communication

A "deficit public"

Although the dominant discourse among practitioners on the public and public communication follow a pattern of a two-way communication and a knowledgeable and active public, during the conversations some interviewees made comments, not surprisingly perhaps, that could be interpreted as contradictory to the discursive pattern of "dialogue/public participation" and in favour of a "deficit model" pattern. However, such contradictory discourse is a minor aspect of the data. The quote below from Emily is an example of a contradictory discourse:

> "when you say the Mariner Valley is as big as America people can understand that; people know what you're saying. When you say, well, this is smaller than a human hair, again that's probably as much as they want to know". (Emily, scientist)

When she says "that's probably as much as the public want to know" referring to basic concepts, it suggests an assumption that the public does not want to know much detailed information about science. Moreover, when she says "people can understand that; people know what you're saying", it seems to suggest an assumption of a deficit public who cannot take onboard complex information, and that simple facts are as much as people can understand.

This discourse contradicts her previous statements where she describes the public as "so knowledgeable", "trustful" and "so interested". Supporting her assumption of a deficit public is also her conviction that the general public should not participate in decision-making processes because they might not be capable of taking informed decisions. Emily's quote below exemplifies this point:

> (…) Oh, let's go for the patronising; I'm not sure you can actually educate them enough [the public] to make an informed decision. Also, my colleagues, I don't think can make informed decisions, and we have peer review panels so that we gather the evidence and somebody who knows how to access the evidence makes the choice" (…) and I'm a little bit wary about letting the public to decide about big issues such as for instance about sending people to Mars". (Emily, scientist)

A "deficit model" of science communication

There is information in the interview data that show that a one-way communication is still in vogue, and that it might be very useful in certain contexts of communication such as to reach wider audiences. In the extract below, Stewart explains how the exhibition "From Earth to the Universe" (collection of astronomical images of our Universe, organised in the context of the IYA) took place in nine different venues in the UK. As he explains, the astronomical images would be left on the street, parks, or in shopping malls to surprise people who "did not expect to see astronomy". In most cases as Stewart notes "there was no-one there to explain the panels":

> "(…) we just put them [panels] in the middle of the city and left them. People were walking to work or shopping and they would walk past and see these exhibitions". (Stewart, professional science communicator)

These examples of contradictory discourse may be considered a pattern of the "deficit model" created by an image of a "deficit public" and "deficit communication". Despite the "mood for interaction" and "dialogue" with the public being dominant in practitioners' discourse, there have been situations where practitioners' description of their science communication practice clearly represented a deficit model of communication. The idea of a "deficit public" is particularly present when the topic is public participation in policy issues. Here, the public is seen by some of the interviewees as "irrational" and "ignorant" to make accurate decisions. This is an assertion that seems to contradict practitioners' discourse about a "sophisticated" public. A more detailed review of this argument will be discussed further in this chapter in the section "practitioners' views on public participation".

There are a couple other examples in the data that, at a first sight, could be considered to follow a one-way communication model, however practitioners have described them as examples of "interaction" and two-way communication with the public as I will show further in this chapter in the section "type of science communication activities".

Given this, it seems evident that the way in which practitioners understand two-way communication is clearly different from the way it is described by academics. To get a clearer picture of what a two-way communication means for this community, it seems important to analyse practitioners' practice of science communication. Firstly, what types of science communication activities are delivered to the public? And secondly, what are the aims that practitioners want to achieve when framing science communication activities, particularly "dialogue" events", as they understand them? Examining the type of communication activities performed, the aims of communication, and how both relate, seems likely to offer a fair account of the way in which practitioners understand models of science communication. I turn now to give an account of the types of activities which practitioners described during the interviews.

5.4.4 Types of activities performed by practitioners of science communication

"Interaction" is the principle

The types of science communication activities performed in the area of 'space', as described by interviewees, ranged from very 'simple' and traditional events such as conventional lectures to more 'complex' activities such as focus groups. Although activities such as discussion groups or dialogue events were less frequently mentioned than exhibitions or lecturing, a view of communication being an "interactive" process is a primary point in practitioners discourse. What is more, this "interaction" assumes many forms according to the type of science communication activity conducted: it may be human or virtual depending on whether a physical interaction between the communicator and the public exists. Human interaction occurs in activities such as lecturing, exhibitions or discussion groups, and virtual interaction in situations that involve "web interaction", "interactive panels" or "simulators".

Human interaction

Interactive Lectures

As for human interaction an example is the quote below, where Emily explains how she gives her lectures. Emily talks about the way she interacts with her audience and gives an example of a particular situation where as a result of that "interaction", she learned from the public:

> (…) and they [the public] tell me what they know about it. And it's quite fascinating because they are so knowledgeable; they are all up to date. I know one time somebody actually asked me about – when I talked about Mars, about the Phoenix mission, I said, well, actually, I'm sorry, I don't know about the Phoenix mission, you tell me. And of course, I looked on the NASA

> website and sure enough, there was a Phoenix mission going to Mars and I didn't know it but they did". (Emily, scientist)

Despite the fact that in lectures communication is mainly a process of transmission of knowledge where the public has a passive role, the way she describes lecturing shows that it may also be an interactive process where the public is invited to participate. Furthermore, the way the interviewee talks about her audience and strategy of lecturing shows an open attitude not only to listen to the pubic but also to learn from the public.

Interactive Science Exhibitions

Another example where physical interaction occurs in public engagement in practitioners' discourse is at science exhibitions. As a male scientist states while describing an exhibition he organized under the IYA: the use of "explainers" to help visitors is key to engagement:

> "(…) especially the interaction with the public and the little dialogues that take place during the exhibitions (…) the 12 helpers that we had, interpreters, did a superb job as public outreach communicators. They could explain and guide the tours along the research areas in our department and explain to them (public) what you see with the telescope (…) they were all helping to make sure that people were engaged and their questions were answered". (Fred, scientist)

Fred states that having staff mingling with the visitors to "make sure that people are engaged" is extremely important to "explain and guide" the visitors. Although some scholars question the usefulness of "explainers" (e.g. Wymer, 1991) their value is recognised by many (e.g. Arcand and Watzke, 2010). A recent study has shown the importance of human interaction in astronomy outreach activities, particularly exhibitions on the street, that otherwise would be simply a one-way communication activity with the public: “utilizing simple educational activities along with providing human interaction appears to have the potential to increase the amount and effectiveness from these types of static displays” (Arcand and Watzke, 2010).

Virtual interaction

Interactive images and simulators as means of “dialogue”

As for virtual interaction identified in the data, it was mainly mentioned by interviewees who work as science museum and science centre curators and by practitioners who use the Internet as the main means of communication. Interviewees described virtual interaction as a means of “dialogue” with the public and as a good tool that can help people understand scientific concepts and learn by experiencing science. Interactive panels and simulators seem to be now quite common in science centres and museums, and science communication professionals working in such places describe them as an important way of learning “how objects work” through experiencing science. This issue seems fairly common in the data:

> “(…) we’ve used touch screens, so we can put a bit more explanation in, animations of how the objects work, or a little animation of what the scientific concept they’re looking at is, just to try and help people to understand them a bit more”. (Britney, professional science communicator)

> “We spend time going around other exhibitions and looking at various things and what we found was that what engaged people a lot was when you got to sort of relive something or experience something rather than just reading about it or looking at pictures. So for example, when we deal with the Apollo landings, we actually give people the opportunity of a

> simulator to stand there and try and land the lunar modules (…)". (Ken, professional science communicator)

> "(…) giving people a lot more to experience, rather than just reading that actually - things they can do. We find that people are spending probably 15, 20 minutes there now, rather than two minutes, so it's been a huge change in the appreciation from the public (…)". (Ken, professional science communicator)

Furthermore, having fun while learning science is another concept that seems fairly common among science communication professionals at science centres and museums. As Ken states in the extract below, when asked what he thinks interests the public the most, he describes the simulator and the dome theatre referring to their power to "engage" people because they are "fun things that people enjoy to do":

> "I think if I'm honest, it's the fun things to do. So they [the public] enjoy the simulator (…) the simulator is one where you actually sit on and you've got 3D glasses and it's like you're flying through space. So it's fun. That's one of the big experiences; and then the dome theatre is always a big hit. It's a full dome, so it's animation all around and it's very massive. It's one of the largest, if not the largest in the UK. That's one of the main things that they [visitors] go away with". (Ken, professional science communicator)

The potential of interactive science exhibits in aiding public learning and improving the public understanding of science has been recognized by many (e.g. Perry, 1993; Wilson, 1987), but there is also criticism that education and entertainment do not go together and that interactive science centres are mainly places for fun (e.g. Shortland, 1987, Wymer, 1991). Nonetheless, this relationship appears to be complex and the outcomes of the interaction have much to do with the characteristics of the visitors such as gender, age, personal characteristics and preferences (background knowledge understanding of science, interests, etc) (e.g. Semper, 1990; Falk and Dierking, 1992).

Interactive web

A form of "dialogue" where the public participates in the development of scientific knowledge

In addition, "interactive web" is also mentioned as a form of a "dialogue" between its users. With much internet and web development taking place within astronomy and physics, this form of communication is being extensively used to communicate with the wider public (Chalmers, 2009). For instance, *GalaxyZoo*[22], a database where the general public is invited to classify galaxies in the Universe, is mentioned as a successful example of the potential of the web in science communication, where the public contributes to the development of scientific knowledge. During its first year (2007) *GalaxyZoo* received more than 50 million classifications of galaxies from almost 150,000 people all over the world. As Anna explains it, *GalaxyZoo* rather than being a factual web page, is a web forum where "everyone's in dialogue":

> "I didn't know that an online community [*GalaxyZoo*] could work so well (…) It's a web forum, then everyone's in dialogue. It's no good just having factual web pages up where

[22] *GalaxyZoo* is a database of volunteer-generated classifications of galaxies, where the general public is invited to classify galaxies. It was launched in 2007 with a data set made up of a million galaxies imaged with the robotic telescope of the Sloan Digital Sky Survey. During the first year, more than 50 million classifications were received by the project from almost 150,000 people. Because of its huge success, the developers created *GalaxyZoo 2* (http://zoo2.galaxyzoo.org/) that, in the 14 months the site was up, users helped scientists to make over 60,000,000 classifications.

> you can't write in with a question. It's very satisfying if your question comes up at once and two minutes later somebody answers it". (Anna, practitioner responsible for an online forum)

This suggests that the web is beginning to have a different and more important role in science communication. More than just a one-way 'click and download' tool, it provides new opportunities for two-way communication where the public can voice its opinion and contribute with content that helps scientists to build new knowledge. Interviewees describe this apparent new use of the web for science communication as a form of "dialogue" where the public can participate by giving their "input" to science.

Public participation in designing science communication activities

Beside the potential of web interaction to get the public participating in the development of new scientific knowledge as described by practitioners, the interview data also reveal that there are other ways of getting "public input" or "participation" in science communication activities. These can range from questionnaires/forms/focus groups where the aim might simply be to get the public's feedback on outreach activities in which they participated, or may participate in the future, levels of knowledge or levels of enjoyment, to discussions about a topic of public concern usually aimed at understanding people's views on the issue. While the former, by far the most mentioned by practitioners in the interviews, is normally discussed in the context of evaluation of outreach activities – practitioners have sometimes referred to "visitor evaluation" or "activity evaluation", "public's feedback" – the latter is generally mentioned while discussing the importance of public debates about science.

Again, similar to the use of other terms already discussed, "public participation" also seems to have been adapted by practitioners to their own realms. Furthermore, similar to what happens currently in policy contexts, proponents and opponents of public participation are also found in this context. For instance, the sequence of extracts below shows the contexts in which the public is invited to participate in the design of science communication activities, and practitioners' views on agreement/disagreement with public contribution to those activities:

> (…) "we analysed all that data [from the focus groups]. We had a specialist evaluation company who did that work for us". (…) "They actually wanted more bright colours. They wanted astronomy pictures. They wanted some very strong visual signals, so we are going to go back and actually change some of that". (Britney, professional science communicator)

> (…) "it's something that has been done, but not very often. We have out times where we've asked people their opinion on certain things. For example, before Tranquillity Base was built; that exhibition we did and we asked; what is it? If you were having an exhibition here at the [name of the centre], what would you like to see? (Ken, professional science communicator)

> (…) I think also there are times when I'm a little bit sceptical about what the public tell you and what they really want (…) I think MacDonald's is a great example. MacDonald's asked people what they wanted and they said they wanted healthy foods and so MacDonald's started doing all that and no one bought it. The director of MacDonald's said: we asked people what they wanted and they lied. And I think you have to be cautious… but at the same time I think you should at least listen and then judge. But it is ultimately judgement, it's not precise. It's a judgment that people have to make, and like I say, that's what they get paid to". (Ken, professional science communicator)

These statements show that the public is invited to participate in science communication activities, but not very often. Reasons provided by practitioners are mainly “lack of resources” and “lack of time”.

Practitioners as gatekeepers in deciding type of activities

Interviewees also point out that public decisions have to be judged by practitioners before being taken into consideration. This reflects views in existing literature advocating a rethinking of experts and lay people as distinct groups (e.g. Levy-Leblond, 1992; Collins and Evans, 2002) and brings back the “problem of extension” of public participation. Ken’s statement above, seems to give the impression of the public being given a “fake” opportunity to participate in decisions about science communication activities, as in the end, it is the science communicator who decides what should and should not be implemented. This seems to suggest that practitioners have the power to control public communication and decide what ‘part’ of public opinion is appropriate to take into consideration and what ‘part’ is not. Therefore, I would claim that communicators have a “gatekeeper” role in the science communication process, when deciding about type of activities to develop. They implicitly infer from public opinion what may or may not work, and accordingly to their judgment, take what they think are the ‘right’ decisions/activities to develop.

Upstream engagement in designing activities

Additionally, there is also information in the interview data that suggests that the public should be involved in early stages of designing of science communication activities. As I explained in the literature review chapter, the language of “upstream engagement” has been adopted in numerous science policy documents after a series of experiments in dialogue on contentious issues involving science, politics and the public. In the extract below a professional science communicator explains how she intends to involve the public in future design of outreach activities and use public opinion in the decision-making process:

> "I can see the next raft of big galleries we do, we've said that we will consult people quite early on in how we… rather than just asking them what they think about what we did, we'll have people involved as advocates to be part of that decision-making process. And that might mean we get people in to just make the curator case with us, or they might say, well, these are the kinds of things I want to see in the gallery. I think for that, what we want from people there is to give us some thoughtful input" (…) to get "them to be interested enough to feel like they are part of it (…)". (Britney, professional science communicator)

The idea of 'upstream engagement' is obvious in Britney's discourse about involving visitors from an early stage in exhibition planning. This is another example that supports my claim that the terminology from the policy discourse has been *adapted* by practitioners of science communication to their own realms.

Public dialogue aimed at discussing controversies

Dialogue about controversies should exist but it should not seek to influence policy

As for dialogue events aimed at discussing issues in astronomy and space exploration that might generate some public controversy, although not very frequently employed, interviewees recognise their value in getting public "input". Discussions of issues that might be contentious in the field normally relate to the potential risk involved in human space exploration or ethical questions about planetary protection. As William, a policy-maker, states:

> "We have either sponsored or funded or run some public discussions and dialogues, mainly at science festivals and events, and examples of the topics include space exploration and robotic… that's the most common one… I'm trying to think of other examples. Not many other examples of

> discussions (…) oh, yes, we have sponsored a discussion with the public on that (talking about planetary protection), so that's quite important about designing any space mission that returns something to Earth". (William, policy-maker)

> "if the UK was participating in a manned space flight programme, which it's probably about to do with the UK astronaut Major Tim Peake might fly on ESA missions, then it would probably be a good idea to have conversations with the public about the risk… (…). (William, science policy-maker)

William also explains how public concerns should be taken into account in future discussions. In the quote below, he explains how public "input" resulting from such discussions can make a difference when framing scientific space missions, for instance:

> "(…) [A]*nd to listen to the public and hear any views and concerns they have and take those into account.* For example, if the public are really worried about… of our not wanting to contaminate Mars with our bacteria and not wanting to contaminate the Earth with Martian bacteria, the level of public concern will probably inform the degree of security and protection and sterilisation and the arrangements for handling these samples as we go to Mars and as we bring things back. The more… *I would think that the more the public are concerned, probably the more investment in these protections and sterilisations and so on there should be.* So we should listen to the public when we think there's an issue of public concern there" (William, policy-maker).

Public dialogue is not needed because space is not "really controversial"

There were also interviewees who argued that space exploration is not really controversial to justify policy dialogue with the public:

> "Not specifically space [involvement in dialogue], I used to do dialogue a bit about vaccinations, genetic modification, ethical questions about that with school kids". (Stewart, professional science communicator)

> "I think the reason is [the UK] has not been involved in dialogue about space] that it's not really controversial. My experience of those things is that the more controversial a subject, the easier it is to do dialogue on it because, for example, one of the dialogues that we did that wasn't particularly successful was vaccinations. All these dialogues were aimed at 16 to 18 years old school audiences and almost all of those thought vaccinations were a good thing and didn't see any problem with vaccinations, so there was no debate. (Stewart, professional science communicator)

Summary

To sum up, the extracts presented throughout this section have illustrated that public communication according to practitioners' discourse represents an "interactive" process between science and the public in which the public has an active role rather than being passive consumers of information. Many points in the interview data show that the "mood for interaction" is well crystallised among practitioners' discourse about what the practice of science communication should be. This idea of interactivity is justified as an effective way of getting the public involved, trusting and participating in science. Nonetheless, despite their talk reflecting an effort to move practice from "getting the message across" to "listening to the public", on some occasions their activities and perceptions of the public are nothing more than a sophisticated way of presenting a deficit-model. Although the general approach to science communication now is a "dialogical" one, both a one-way and a two-way communication are informally in use. While a one-way communication model seems to be an efficient way of reaching wider audiences, interviewees describe a two-way model as a better tool to create public trust and show transparency in science.

Given this, I would argue that the "mood for interaction" has led to an interactive approach to the traditional one-way communication model. This new approach is based on "interaction" or "dialogue' with the public in activities such as exhibitions, hands-on-science, web-interaction, or small discussions about science. This form of "dialogue" represents a deviation from the traditional deficit model: it is neither simply a process of transmission of information to a passive public, nor a "genuine" dialogue where a mutual understanding between all parties (scientists, policy makers and the public) is priority.

There is also information in the data that identifies another type of "dialogue", an open dialogue that is intended to discuss scientific issues that usually involve some controversy. This suggests the existence of two types of dialogue that are in use by this community: *an interactional dialogue,* where there is a basic level of public involvement and involves only exchange of information between both parties, and a *participatory dialogue*, which involves higher levels of public involvement in which public input is enabled. These forms of dialogue clearly assume different formats from those described in policy documents. The same is true for other terms such as "engagement", "participation" "upstream engagement" (and so on) as seen throughout this section. This indicates that the terminology from policy is in use by this community, but it has been *adapted* to their own contexts.

In order to provide a deeper understanding of the different types of dialogue described above, I turn now to examine the aims that science communicators want to achieve when planning science communication events, in particular what are the aims of "dialogue".

5.4.5 Practitioners' views on aims of science communication

Below, data on aims of communication are presented alongside practitioners' motivations for doing science communication as most times one leads to the other. Motivations, if not personal, are in fact what practitioners believe to be the aims of science communication.

Benefits to the public and society as main goals of communication

The interview data show an entire spectrum of different ideas about the goals of science communication: most practitioners tend to refer to more than one motivation, normally a personal benefit (personal satisfaction) and a benefit to the individual and to society (the public needs to know what is being done). Thus, and despite the diverse language used, motivations and aims can be grouped under two main themes that are consistently raised by practitioners: science communicator-related benefits and public/society-related benefits. The first, practitioners' personal-related benefits, include ideas such as "enjoyment", "personal satisfaction", "pleasure", "gratification", "sharing enthusiasm", and "fun". Sometimes practitioners tend to be motivated by a mixture of personal satisfaction and a sense of duty or responsibility with society. The extract below illustrates this point:

> "(…) So, there are those three elements, I suppose; the personal satisfaction, the sense of duty towards the people who are paying for the research, and also a very strong sense that a

> better understanding of science would be good for the world".
> (Matthew, professional science communicator)

Matthew is talking about what his motivations are for engaging in public communication. These are several: personal satisfaction, duty, and the strong belief that if the public understands science better it "would be good for the world".

A more scientifically literate public and society

The second, individual/society-related benefits, is the most frequent theme within the interview data. Here many interrelated ideas are expressed about the goals of communication that might lead to a more scientifically literate public and society. Again, the exact language used varies among practitioners' discourse; however, two topics are especially predominant within the data. The first topic includes ideas such as "educate", "inform people", "people to have an understanding of science", and "awareness" as main goals of communication:

> "I think we're in the lower segment, which is more awareness-building, so we want to have awareness of the fact that there is something called astronomy and science; awareness also of the European astronomy, awareness that Europe has the world-leading observatory". (Luke, professional science communicator)

Luke points to the fact that "we're in the lower segment", and consequently, to him the most "basic" aim of science communication is "awareness-building". This idea that "we're in the lower segment" seems to suggest that science communication still has a long way to go in terms of educating the public because the public has low levels of knowledge about scientific facts. This quote could also be interpreted as an example of contradictory discourse mentioned before which shows a public ignorant about astronomy and European astronomy programmes.

In addition, there is also information in the interview data that shows higher levels of public understanding of science might lead to a more “appreciative” and “supportive” attitude to science. These claims that assert that “to know science is to love it” (Turney, 1998) are brought up by some of the interviewees when describing individual/society-related benefits. The following quotes illustrate this point:

> “(…) if we can get them interested in it and get their understanding of how science works and their knowledge of these things starting to develop an appreciation for it, realising that the UK is a big player in space and astronomy and, again, feeling like it’s something that matters to them, I think that’s a good thing”. (Britney, professional science communicator)

> “I think... I think if we can get people interested enough and inspired enough that they will go away and probably start searching on the internet to find out a little bit more, go and buy a book and start reading about it, I think that’s when we’ve probably done our job”. (Ken, professional science communicator)

> “I do think that one of my prime goals or responsibilities is to try and increase public support for funding of science and obviously for astronomy, this includes space exploration and things like that. So again, it’s about trying to highlight how it is actually relevant and how it does have economic benefits”. (Matthew, professional science communicator)

Also, the belief that people who experience astronomy events may in the future look for more meaningful experiences appears to be quite common in practitioners talk and for many it is actually one of the main practitioners' motivations to do science communication. As Stewart puts it:

> "We wanted to inspire people, we wanted to use the awesome nature of seeing the moon through a telescope to have a massive impact on them and then the hope would be that in the future they would go and have a deeper more meaningful experience". (Stewart, professional science communicator)

A public that participates in scientific discussions

The second topic of individual/society related benefits includes ideas such as "engage people in science", "provide people with the capacity to solve problems and take informed decisions", "make science part of everyday culture", and "help to bridge the gap between scientists and journalists". Although less frequent, there is information in the data that shows how practitioners see science communication as a means that might lead to a society that thinks about problems and that is able to "consider all the evidence in a balanced way":

> "(…) And then I also do think it's extremely important in modern society that the people who vote have an understanding of science and why it's important, and also are able to think in a scientific way about all sorts of problems that they face. Because the last thing we need, at this stage in our history, is to be irrational about big problems and not to consider all the evidence in a balanced way. And of course, that's something that science is very good at doing" (Matthew, professional science communicator)

Matthew is talking about the importance of empowering people to form opinions about science, opinions that do not necessarily have to be in favour of science, but should instead be strong opinions that may allow discussion in different contexts. He goes further:

> "But I do think if you've got 50 middle-aged women in a room who all said, oh, I don't know anything about science when they started but at the end of it think, actually, I understood that and I can now have an opinion about it, that when the next time there's a science story on the news, instead of just tuning out, they might listen to it and think, well, I agree with that or I disagree with that. I would like to think that they have, they feel empowered to have an opinion about science, and talk to friends about, and that it's part of their culture and something that belongs to them (…)". (Matthew, professional science communicator)

In his conversation, Matthew acknowledges the importance of having a public that feels that science "belongs to them" and to their "culture" so that, when they are in contexts in which they might have the opportunity to talk about or to discuss science, they have considered opinions which they can raise.

Summary

All in all, while the first theme of individual/society-related benefits discussed here seems to aim at educating the public, increasing public understanding and awareness of science through knowledge transfer, the second theme, although less frequent, seems to aim at empowering individuals to be active members in society by involving them in discussions and dialogues about science. These observations bring some points to the discussion, which I consider important to address here.

Two arguments could be put forward as to the importance given by practitioners to knowledge transfer and public education, and to the belief that more knowledge about ‘space’ issues will generate more public interest and support for science. On the one hand, it may be that practitioners see knowledge transfer as something necessary to explain to the public facts about astronomy and space issues, how science works, new discoveries, and what the benefits of astronomy and space sciences are for society. However, whether an increase in the level of understanding and awareness of astronomy and space sciences will generate increased public support for space activities will need further investigation. The idea that more scientific knowledge will lead to a more positive attitude towards science – what Nelkin (1995) calls “selling science” is at best questionable (see for e.g. Durant, 1999). In fact, as I showed in the literature review chapter, relationships between knowledge and public support for science have appeared to be more complex than expected. Studies have shown that, even if for certain sciences there is a positive correlation between levels of knowledge and attitude towards science, for others either there is no relationship, or higher levels of scientific knowledge relate to lower support for science.

On the other hand, it could be argued that the reason which drives practitioners to consider knowledge transfer as one of the main aims of science communication is simply that they see the public as a empty vessel (Gregory and Miller, 1996) defined by a knowledge “deficit” (Wynne, 1996) in astronomy and space exploration issues as seems to be implied by Luke’s quote above concerning ‘awareness-building’. Whatever the case is (perhaps it could be both) both arguments show, essentially, a clear approach to the deficit model of science communication, which goes against practitioners’ conceptualisation of a knowledgeable public. This brings questions about the ‘real’ meaning of their discourse. I will discuss this point in greater detail in Chapter 6.

By contrast, the second group of individual/society benefits discussed – public participation in scientific discussions seems to be more consistent with the “mood for dialogue” (House of Lords, 2000) and their discourse on interactivity and a rational public. Rather than making assertions such as “to know science is to love it”, interviewees were likely to think that the main aim of science communication is to empower people to participate in scientific discussions and to use scientific knowledge in a balanced way by considering arguments both in favour and against. These findings bring an important point to the discussion. Assuming that public scientific knowledge is an important factor to take into account when considering public participation in science, we can ask: what is the value of activities that are not aimed at, at least directly, involving people in scientific discussions, i.e. what is the value of one-way communication activities or *interactional dialogue*? I will come back to this point later in the discussion of this chapter when examining the question “deficit and dialogue: competing or complementing paradigms?”

I now turn to analyze how aims, types of activities and types of publics relate. It seems reasonable to expect that different aims of communication will involve different models of communication, and consequently, will be aimed at targeting different publics. Furthermore, it is reasonable to think that if the goal of science communication is to promote public awareness of science or public understanding of science, large-scale activities that can reach wide audiences may be suitable. On the other hand, if the aim is promoting public engagement with science or informing public policy, small-scale activities involving specific audiences in which a reciprocal understanding between science and the audience is the main objective may be more appropriate. Thus, one-way communication activities would be expected to relate to informing/educating the public by reaching wider audiences, while two-way communication activities would be expected to aim at public participation and small groups. And yet, as I shall seek to show, this distinction is not always an easy one to draw from the interview data.

5.4.6 How do aims, science communication activities and publics relate?

One-way communication aimed at public understanding of science and public awareness of science

An analysis of the way in which practitioners described the activities performed and aims of those activities, leads to the conclusion that models of communication seem to be chosen according to the type of audiences practitioners want to address and aims of communication they want to achieve. For instance, if the aim is to raise public scientific awareness or public understanding of astronomy and space science issues, transfer of knowledge is more likely to occur through activities like exhibitions, astronomical imageries, sky observations or public lectures, which by and large, target general audiences. One professional science communicator gives an example of the project "From Earth to the Universe" organised during the IYA, which was clearly a one-way communication activity. The activity was designed to reach as many people as possible and to give the public an opportunity to experience astronomy, something that they probably wouldn't look for on their own initiative:

> (…) "projects including 'From Earth to the Universe' was an activity designed to surprise people who did not expect to see astronomy while they were walking through a city centre or through a park (…)". (Stewart, professional science communicator)

As he describes below, the project was intended to reach a general audience rather than specific groups, and the exhibitions did not have anybody to explain the astronomical pictures to the public:

> "We didn't have a cross section of the population that we wanted to communicate to, we didn't specifically say, we want to target this at under 12's or over 60's or women or ethnic minorities at all, it was just whoever was going to be in those locations". (Stewart, professional science communicator)

> Interviewer: Was there anyone to explain the astronomical images to the public?
>
> "In most cases not, in most cases the text was written specifically in mind of the fact that there was no-one there to explain, so it had to be in enough details that people felt they were getting something but not so much detail that it was just a panel full of text, so it was written quite specifically for that" (…) they were just left to themselves". (Stewart, professional science communicator)

Although nobody was in the exhibit locations to explain the panels, "lots of people stopped" and many times, when in groups, they would begin discussions:

> "It was a large cross-section, we found that if they were in a group they stopped for longer because there was discussion". (Stewart, professional science communicator)

Stewart's language gives a sense of the importance of such activities in raising not only public awareness of the IYA, which was taking place that year, but also of recent discoveries in astronomy shown in the astronomical images:

> "It certainly raised the awareness of IYA and of recent discoveries in the people that saw it".

Furthermore, in his discourse, there is also a sense that activities such as exhibits might have the power to initiate discussions between the people who stop to look. This suggests that a one-way communication model, as shown in this example, might be an effective way of reaching less attentive/interested audiences to space issues and initiating very free-format, undirected dialogue between observers. These groups that usually would not look for science communication activities might, after experiencing it, "go on to have more meaningful experiences" (Stewart, professional science communicator). I will argue that events such as this play an important role in recruiting new audiences for science (Entradas, Miller and Peters, 2011).

Two-way communication aimed at public participation in science

On the other hand, if communication is likely to be aimed at public participation in science, activities are more likely to be two-way and planned to target specific audiences, so smaller group discussions are likely to occur. Public "input" as seen by practitioners, and as already explained in this chapter, can range from contribution to organising science communication activities to participation in scientific discussions about contentious issues. Below, a professional science communicator, a curator at a science museum, explains how focus groups were conducted in the museum with the aim of getting people involved in activities and making them feel that they can contribute to it:

> "They also did some focus groups, which will have been people that they invited who, again, were from that target audience. (…) So, again, starting quite openly, just going, so what were your impressions, what did you feel?" (Britney, professional science communicator)

And, although she acknowledges the difficulty of getting people to participate in decisions, she supports the idea that involving people in this process is crucial to making them understand science as part of their culture:

> "It's not always easy because, to be honest, if you ask most people what they want to see in an exhibition they don't know. Why would they? So, again, we're not expecting them to tell us what to do, but I think we would like them to be interested enough to feel like they are part of it and to really… in the end, it's the national collection. They're the taxpayers. They're the people who actually… it's their stuff. I think just to get them to really feel like that matters to them and to buy into it…". (Britney, professional science communicator)

Two-way communication aimed at public understanding of science and public awareness of science

Despite the fact that a clear relationship seems to exist between a one-way model aimed at public education and a two-way model aimed at public engagement, there is information within the data that suggests that two-way communication can also be aimed at increasing public awareness and public understanding of science. This is in accordance with previous studies that maintain that dialogue can be used for the public understanding of science (Van der Sande and Meijman, 2003). The extract below shows how dialogue appears to be an obvious tool in web interaction aimed at public understanding and awareness of science:

> "Things like Twitter especially, where people just start following random people and also passing on very good things people say or good websites. I think it's raised awareness a lot. For instance, the Newbury Astronomical Society set up meteor watch on Twitter and it actually became one of the trending topics. They inspired a lot of people on Twitter to go out and look for meteors. They've got thousands of followers now" (Anna, professional science communicator, blogger).

Another example is provided by Fred's statement describing the "little dialogues" that occurred between the science communicators and the public during the exhibition where "we exchange scientific information":

> "(…) especially the interaction with the public and the little dialogues that take place during the exhibitions (…)". (Fred, scientist and science communicator)

Summary

In short, while one-way communication activities, as described by practitioners, are aimed at public understanding and public awareness of science, two-way communication activities are normally associated with "engagement" and "dialogue" with the public in science. Nevertheless, two-way communication, as the data show, can also be aimed at public awareness and understanding of science. These findings add some input to the discussion started before about the meaning of "dialogue" in science communication. Based on this data, it seems reasonable to argue that the two types of dialogue identified here have different aims in communication: an *interactional dialogue* is aimed at public understanding of science and public awareness of science, while a *participatory dialogue* is aimed at public engagement with science and public participation in scientific discussions. Furthermore, many points in this analysis seem to suggest that the belief that empowering people with knowledge and capacity to discuss scientific topics may lead to more active public participation in scientific debates or "just" to a public able to make more assertive decisions about scientific issues in their lives. I turn now to examine the discourse on public participation in policy making decisions about 'space' issues.

5.5 Practitioners' Views on Public Involvement in Policy-Making

As explained at the beginning of this chapter, this section presents findings that deal with practitioners' understanding of public involvement in policy discussions about space issues ("public participation" hereafter).

My approach in the interviews attempted to understand practitioners' opinions on whether public concerns about space exploration (assuming that they exist) should be reflected in space policy decisions. For instance, space exploration involving humans is somewhat controversial. There are sensitive ethical questions around risk such as physiological effects on humans resulting from long journeys involving exposure to radiation and prolonged microgravity, and around microbial contamination of planets, which may need public discussion. Discussing these issues might be particularly valuable at a time when the UK has started to be involved in human space flights. However, no effort has been made to understand how those who deal with the public see public participation in policy-making about space exploration. Do they think that the public should have a say? How enthusiastic are they about the inclusion of public opinion in policy decisions? Who do they think would be the "right" public (if any) to contribute to space programmes policies? In the following pages I present an analysis of practitioners' discourse which tries to answer to these questions. This analysis also provides some insight into the discussion about the meaning that dialogue events take in the context of science communication.

5.5.1 Practitioners' discourse on public participation

Dialogue in science communication is different from the dialogue in policy-making

The first and most general idea on which a point should be made here regards the meaning of public dialogue, which is the means that permits public participation.

As seen in previous sections of this chapter the "dialogue" described by practitioners does not correspond to the dialogue of policy documents. The interview data on practitioners' views on public participation in policy-making strengthen this point. Interviewees' discourse on public participation clearly shows a distinction between public dialogue that might be used for science communication purposes, and public dialogue intended to influence policy discussions. Therefore, my data provides empirical evidence to the theoretical approaches in previous studies (e.g. Davies et al., 2008), which distinguish dialogue events that do not inform policy from those that do. I turn now to examine discourse which gives insight into how interviewees understand public participation in space policy issues.

Opinions vary among practitioners

In interviewees' discourse about public participation in policy making, although talk predominantly supports public participation in science policy, a more thorough review shows that the question is rather complex. Some interviewees agreed that public opinion should be considered in policy-making decisions, while others' attitudes clearly did not support public participation in policy-making decisions. However, most cases were certainly more complex, and rather contradictory: despite at first agreeing that the public should be a part of the decision-making process, when I narrowed the conversation to understand their reasoning, interviewees became confused and contradictory in their answers showing somewhat of a disagreement with public input into policy-making.

Thus, it can be said that the discourse on public participation had two main strands. One was driven by democratic concerns: in democratic societies, where civic participation is valued, and where public taxpayers are funding science, participation is the right of every citizen. This line of thought has been corroborated by studies that have argued that the public has a say in the organisation and application of science and technology (e.g. Wynne, 1996). The other discourse focused on the potential of the public to participate in science policy. These views are in accordance with the concerns expressed by and Collins and Evans (2002) around the notion of "lay expertise" and of potential public participation in policy making. As they argued "the public can be wrong". According to these authors, the role of expertise should be separate from the role of democratic rights.

5.5.2 Public participation is a right of every citizen

An example of the democratic rationale is given by a male professional science communicator who emphasises that the public which "funds science" must be given a more important role in decision making:

> "we need to pay more attention to this public who is funding science, so I think we need to discuss more (…) it is an important question and we are now planning a new phase for the strategy of the European Astronomy, so we have to think about that". (Peters, professional science communicator)

Similarly, a policy-maker who expresses a favourable opinion concerning the involvement of the public in policy-making says that listening to public's concerns and taking them into account is key to show an "open and transparent" organisation:

> "To be an open and transparent organisation so the public know what we're doing, and to listen to the public and hear any views and concerns they have and take those into account". (William, policy-maker)

These statements represent the supportive attitude of some of the interviewees towards involving the public in science policy issues. The main reasons emphasised by interviewees relate to the recognition of a need for a more democratic approach to decision-making on scientific issues, and the need to build public confidence.

5.5.3 Limitations of public participation --- the public as a 'misinformed actor'

The public is not sufficiently knowledgeable to make informed decisions

The second strand of discourse about public input into policy-making relates to the cognitive limitations and value choices of the general public and the consequences arising from them. Three main concerns are raised by interviewees when reflecting on why public opinion might be inappropriate to take onboard in policy decisions about science and technology. The first encompasses knowledge, understanding, skills and public informed attitudes. Interviewees argued that only if the public has the competencies necessary to discuss the issues at stake can it make informed decisions. Here preoccupations about whether the public is sufficiently "informed" or "educated" to be part of decisions (Emily, scientist) are the primary concern. Arguments were mostly that:

> (…) There are a whole pile of issues and to be fully informed one would need to spend a significant amount of time before he/she would say all right I'm now in a position where I can make a decision …" (Rob, scientist and policy-maker).

Rob's and Emily's statements show a clear criticism of the general public's lack of scientific knowledge and of the difficulty for them of remaining sufficiently updated about scientific facts in order to take appropriate participatory positions. The statements below stress this idea:

> “I'm not sure you can actually educate them enough [the public] to make an informed decision. Also my colleagues, I don’t think can make informed decisions (…) I look at thing like seat belt laws and wearing helmets for riding motorbikes – what we’re doing is not the same at all but if you ask most people, should you wear a seat belt? They would have said no, it’s interfering with my freedom; should you ban smoking? No, it’s not fair; it’s infringement of the liberty of the individual. Well, it makes good sense and people who know better have reached the decision that this has to be done and it’s a good thing”. (Emily, scientist)

> “I think public opinion is interesting but it’s not something to be followed. Because quite often the public is not fully informed. I’m not fully informed about a whole pile of issues and to be fully informed I would need to spend a significant amount of time before I would say all right. I’m not in a position where I can make a decision about… And it could be genetic crops for example, which is an interesting topic but currently I don’t feel well enough informed about that to say what I believe in it”. (Rob, scientist and policy-maker)

The quotes above relate to the relationship between scientific knowledge and public opinion. This difficulty in remaining sufficiently updated about scientific facts to be able to make informed decisions is not exclusively a characteristic of the general public, but rather is a general problem in society due, in part, to the quick advancement of science and technology. This goes in line with Levy-Leblond’s idea of a “culture of ignorance” (Levy-Leblond, 1992). The author argued that scientists and non-scientists alike are extensively ignorant about subjects outside their immediate sphere of personal or professional responsibility.

Furthermore, these quotes seem to suggest that the public is not considered guilty for being uninformed, but rather it is a product of the specialisation of science in modern societies where the amount of scientific information available is overwhelming and individuals cannot become knowledgeable about more than a relatively small set of issues.

The public can be manipulated

The second concern which is mentioned by interviewees when discussing why taking public opinion into account might be inappropriate in policy decisions is that the public can be easily "manipulated" and, as a result, this can lead to incorrect decisions. These ideas are illustrated in the extracts below:

> "There is a gut reaction where people can be eased and manipulated by, shall we call, the general media or whatever who have their own vested interests". (Rob, policy-maker)

> (…) so I am a little bit wary about letting the public decide because one of the big issues I think we have is the discussion about do we send people to Mars or not? No one country can afford to send people to Mars and the UK has always been resistant to manned space flight. Well, I think if you ask most people they'd be quite excited by it and the RAS commission, the experts were not great fans of human space flight decided that there is actually cultural value, but it's not scientific value". (Emily, scientist)

Anecdotally, the statements above in a manner conform with Slovic's argument on the "limitations of public understanding" discussed earlier in this chapter. Slovik (1986) argues that "when people lack strong prior opinions, they are at the mercy of the way the information is presented", which suggests that those presenting the information have control over the public. This idea is visible in

Rob's statement, when he says that interested parties, particularly the media, can manipulate the public, which is seen as a *misinformed actor*.

In addition, again, it could also be argued that the public is not seen as guilty of misinterpreting science. As Rob's statement suggests, the media and others "who have their own vested interests" impose their own values, an attitude which seems to be strongly criticized by scientists. The public is seen as being controlled by those interested institutions that take advantage of a public that is not sufficiently informed. These findings are in line with work by Young and Matthews (2007) on experts' views on the public which showed that experts criticize the "misguided" public as "incapable of grasping the language of science" and not "basing their opinion in good scientific information".

Public values and beliefs may misguide public opinion

The third rationale mentioned by practitioners that may limit the potential for the public to participate in policy decisions, relates to public values and beliefs that might influence their decisions. The quotes below illustrate this point:

> "It's not clear to me that actually one can apart from a long term effort. If people have deep-seated beliefs because of either religion, fear, uncertainty or anything else it's very, very hard to change that over any significant short period of time. So at the end of the day the government has to make a decision knowing it's going against popular opinion and say all right, we're going to do this because we believe it's right. So we're going to go to war because we believe it's right even though half of you think we're wrong". (Matthew, professional science communicator)

> (…) We have for example in the United States more than half of the population I understand believe in the biblical account of the creation of the universe. If you have a democracy and you say well, what shall we teach in the schools, what we find in

> science or what we find in the Bible, they win, therefore the majority say the bible is true, and are we going to come into that? I'm exaggerating a little bit. It may happen [the public participation in decision-making]. I would say not yet [is not the right time yet]". (Fred, scientist and professional science communicator)

The statements above reflect interviewees' preoccupation with the relationship between public opinion and individual factors such as religious beliefs which, again, may misguide the public. These ideas conform with Slovic's (1986) argument that "strong beliefs are hard to modify" and "change slowly and are extraordinarily persistent in the face of contrary evidence".

Decisions should be left to experts

As a result of distrust of the public taking part in policy making decisions in science and technology, interviewees stress the point that such decisions should be left in the hands of experts such as relevant scientists and policy-makers. According to this view, the legitimacy of political decisions depends only on the representatives who speak in the name of the public.

> "(…) and we have peer review panels so that we gather the evidence and somebody who knows how to assess the evidence makes the choice (…) "I elect politicians to go and do the politicking; I don't expect them to come back to me and ask me my opinion of it; get on with it". (Emily, scientist)

> "There are always going to be some issues, not just in science but in all the politics where you really do need a small number of experts to assess the evidence very, very carefully and come up with what they think is the best decision. And part of science

communication, I suppose, is trying to engender the trust in experts". (Matthew, professional science communicator)

This idea that decisions should be left in the hands of the "experts" is in line with what Collins and Evans (2002) described to be the mood in the "First Wave of Science Studies" (during the 50's and 60's) -- decision-making in science and technology could only conceivably be taken by the top leaders, i.e. the scientific community and policy-makers. Here, the wider scientific community played a special part in the decision-making. This was opposed by the "Second Wave of Science Studies" which introduced the idea of increased participation by the public to solve the problem of legitimacy (e.g. Wynne, 1996).

Practitioners as gatekeepers in deciding on types of audiences

Given this, I would argue that the conception of a deficit public as presented by some interviews can been interpreted as another example of the *gatekeeper role* of practitioners in science communication. They implicitly draw on a set of assumptions about a "misinformed public" that is not capable of taking part in policy-making decisions, and consequently decide that it is better to leave decisions to competent stakeholders such as relevant scientists and policy-makers.

Summary

To summarise, there is clearly a distinction between two types of public participation: participation that is intended to influence policy-making and participation that is not. While public participation in science communication activities is acknowledged to be of value and appropriate in the current "mood for interactivity" in science communication, public participation in policy-making is a sensitive topic. On the one hand, practitioners recognise that in democratic societies public opinion should be valued, but on the other, questions about whether the public possesses sufficient knowledge to make informed decisions seem to underlie the belief that public participation in science and technology issues should be carefully considered and that trusting experts to make decisions is probably the best option. Interviewees criticize the cognitive processes and value choices that are thought to lead the public to incorrect or oversimplified opinions about space exploration. Furthermore, public misinterpretation of science is not attributed to the public, but rather to interested institutions that take advantage of an uninformed public. The public is seen by interviewees as having limited knowledge and, consequently, as being a *misinformed actor* which is easily influenced by interested parties (particularly the media). As a result, it is better to leave policy decisions in the hand of the experts whose job it is to advise on the best solutions in science. Here, a deficit model conception of "the public" is likely to be seen, which contradicts the sophisticated image of the public presented by practitioners when talking about public participation in science communication activities.

5.6 Practitioners' Understanding of Their Audiences

This section analyses practitioners' discourse on how they understand their audiences. The section is organised in two main parts: the first looks at how practitioners plan activities to reach their audiences; and the second, analyses how well they anticipate audiences and make use of survey data about their audiences.

While discussing how practitioners plan to reach audiences, three main themes were brought up in the discussion as important features to take into account when planning activities. These were: type of audiences to address, strategies used to reach those audiences, and content of communication. Discussions about the content of communication appear to be of particular importance in the context of this thesis because my analysis on public support for space exploration shows that one of the factors that strongly influences public support for space exploration is the recognition of the value of space exploration to the UK economy. Therefore, during the interviews, I was particularly interested in understanding practitioners' ideas about communicating the benefits of space research to the public and society. I turn now to describe these themes.

5.6.1 Type of audiences to address

Understanding audiences is crucial

One of the most predominant ideas in interviewees' discourse is that understanding audiences is crucial in the process of science communication. In the statement below, Matthew explains how "understanding where your audience is coming from" is key to reach audiences:

> "I think it's one of the big problems in science communication because we've all seen instances of somebody who maybe knows loads of really cool things about their subject but pitches it at the wrong level for the audience and it's a waste of time. (…) if you want people to understand this, you have to know what point they're starting at and then to take them from where they're starting from to where they want to be, where you want them to be in terms of understanding. And if you miss one bit of the chain, you lose your audience". (Matthew, professional science communicator)

Two main reasons are given for the need to understand audiences: first, from a "very practical point of view" it is important to know your audience in order to promote and advertise the event accordingly; second and most important, it is key to presenting material "appropriately" in order to reach them – only if you understand the audience you are planning the activity for will you have the chance to design activities that are targeted at those specific audiences. Both of these ideas come across in Matthew's comments below:

> "From a very practical point of view, we need to understand what audience we're targeting so that we can market and promote the event appropriately (…) But also, we want to think about how we present the material appropriately to a particular audience. So on that level, also, it's something that we spend an awful lot of time doing. And when we plan our events, we sit down and, with a very hard head, if you like, we sit down and we say, okay, if we're running this event, who is it for? How does that affect the way we try to do it? How does that affect the way we present it?". (Matthew, professional science communicator)

As Matthew describes, knowing the audience is extremely relevant when planning an activity: for him it is the starting point in the whole process of running an event. As he states, knowing "who is it for" is key to planning an event that is intended to reach a "particular audience". These comments suggest that different audiences may involve different planning efforts. In fact, the acknowledgement that different audiences require different activity planning and efforts is a prevalent point in the data (Peters' statement below illustrates this point).

Targeting all audiences or ignoring audiences?

An important question worth addressing here which came up in some of the interviews and on which interviewees reflected during the conversations, is whether reaching 'new' audiences is the "right thing to do" or whether practitioners' efforts should be concentrated on audiences already interested in scientific issues. Despite different points of view being present, my data show that the dominant view is that, although most of the time practitioners plan to target specific groups, their efforts are intended to reach as many groups as possible. The statement below illustrates this point. Peters gives an example of how during the IYA different activities were planned to reach different groups and how projects were conceived in terms of their target audiences. It is clear from his statement that the main reason for the variety of activities developed is the existence of "different publics" and, consequently, the need for different activities to reach each:

> "We have different publics! For instance, we were trying to engage the amateur astronomers, for that we were doing projects dedicated to the Star Parties, Night Observations (…) another one was really to engage the public with astronomical images, so we set up a project called "From Earth to the Universe" that is an exhibition project that can be set up anywhere, from a small venue to a big venue, like a cultural centre; we have another one to engage the teachers and all the educators, through Teachers Training Programme - it's a global project trying to train the teachers around the globe to bring astronomy into the classroom. So we had different publics and for the different publics we had different goals, and for those goals we set a different global project". (Peters, professional science communicator)

Focus on the already engaged audience

Despite this view, a few practitioners considered the question of whether it would be better to focus on the "easy audience" rather than "having a battle on your hands". In the statement below, Ken reflects on this issue by asking himself whether reaching what he calls the "difficult audience" is worth making the effort. He concludes by saying that focusing on the audience already coming to the science centre is probably the best solution as trying to reach all audiences implies the need for a greater amount of resources than do not seem to be available:

> "… okay so what do we do, do we accept that it's a difficult audience to reach and we accept it and we just acknowledge that we're not going to do that or do we attempt to change that? And if so, how? How do you know? (…)" "(…) I think the

general... there might be a general sort of apathy almost that; well it's really difficult, we don't want to go there, it's going to be really difficult to do that, we're not going to have the resource to tackle it so let's just accept it and focus on the people that do come here. So in a sense it's almost the easy audience rather than having a battle on your hands" (Ken, professional science communicator).

Focus on the less engaged

Matthew argues for a contrary viewpoint, that it is important to reach those audiences less engaged as well:

> "We're aware of in general maybe less engagement by women, and also, depending on the context exactly, there can be less engagement by some social groups, so we're aware it would be good to involve them…" (Matthew, professional science communicator).

He goes further explaining that, for instance, gender balance "is something that they think about". Because "they get overwhelmingly more males" they run activities that are intended to target women: "we run an observing night with telescopes which is for mothers and daughters and it's staffed, as far as possible, by female staff and volunteers". Notwithstanding his focus on reaching new audiences, like Ken in his last extract, he is sensitive to the issue of how "viable" is it to reach new audiences in terms of money and efforts:

> "So I don't know; ... what I've found is you have to make a business case for it all. You have to sort of say; commercially how is that viable (…) So we can't afford to invest money in reaching a new audience if it's not actually going to at least cover itself and probably actually improve our situation. Those

are realities we face" (Matthew, professional science communicator).

In short, despite the difficulties that reaching new audiences bring, the most common idea appears to be that engaging as many audiences as possible and not neglecting specific groups is the right thing to do according to science communicators. This point is better illustrated by some examples of strategies reported by practitioners for reaching different types of audiences. The data that follow allow a more explicit investigation into strategies and content of communication.

5.6.2 Strategies of public communication to reach audiences

Relating things to people's lives and use "themed blocks"

When discussing best strategies to reach audiences, two key ideas came out of the data: the importance of communicating things that relate to people's lives and the preference for having a mixture of activities. People are seen as being interested in things that affect them personally; therefore, relating messages to what the public knows is essential. In the extract below one practitioner explains why these two ideas are crucial to reach audiences:

> "I just think it's about relating sometimes quite esoteric topics to everyday life, that kind of analogy is useful; offering things in different ways so verbal clearly, but backed up with imagery in astronomy, that's essential, but also backed up with practical models and experiments is the kind of thing you can do" (Rob, scientist and policy-maker).

As he describes, offering messages in different ways is essential: "verbal", "imagery" and "experiments" as well as relating concepts to "everyday life".

Another professional science communicator describes how during the IYA he found a “pleasant surprise” in a “package” of activities such as exhibitions, talks, family activities, which appeared to be very efficient at attracting different publics:

> “For example, what we found worked very well with our audiences, and we didn’t really know whether this would before IYA, was when we put something together as a package. So for example in June last year, we had an exhibition of images from the Cassini spacecraft at Saturn and we invited three of the Cassini scientists to come and give talks during the first week of the exhibition. (…) “There’s an exhibition, there are these three talks, there are family activities etc. And so it became a much, it acquired a much greater momentum because there were lots of things going on. So, that was a pleasant surprise for us that that model worked quite well. And that’s something that we’ve adopted this year; that we’re running things in themed blocks now because we know that that seems to be a popular way of doing things”. (Matthew, professional science communicator)

As Matthew explains, “themed blocks” have proven quite successful with the public, essentially because audiences can choose what they are most interested in. Whilst some audiences seem to enjoy certain type of activities, others may feel unsatisfied with the same activities. Thus, if people are given the choice of picking those activities they enjoy best for learning, more people can be engaged:

> “(…) it’s trying to provide something for children to do and something for adults to do (…) So we’ve tried to learn those things” (Ken professional science communicator).

According to both Matthew and Ken this is a model that works well and which they have "tried to learn". Britney expresses precisely the same idea when talking about the media resources they display in the science museum to allow people to "engage with it in different ways":

> "Again, as we found, the best way to do that is have a mix of different types of media so people can engage with it in different ways and have it well-paced so that they can stop, start, do different kinds of stuff". (Britney, professional science communicator)

In addition to "themed blocks" usually present in bigger events, practitioners also referred to the importance of presenting content in different ways in smaller events. In the excerpt below a male scientist explains his personal style to engage his audiences:

> "I try to make my style such that I have interaction with more than a few people and change the level of tone, not be monotonous throughout, introduce a little bit of humour in-between, use slides that are colourful, pictures with text and so mix things up so that it doesn't become just a boring thing. In the hope that actually, if anybody's attention is going down, then by changing the scene, but changing the atmosphere you actually bring them back…". (Daniel, scientist)

Again, demonstrations, hands-on-science activities, use of comedy, colourful slides and beautiful images are all suggested as important ways of attracting different members of the public.

5.6.3 Content of communication

Communicating big astronomy questions and "sexy topics"

One key theme which came from the interviews when discussing how best to reach audiences concerns the content of communication. According to interviewees, it is better to discuss "big astronomy questions" than detailed research. Moreover, "novelty", "uncertainty" and "mystery" are seen as relevant in the context of communicating astronomy to the public, and "great newsworthiness criteria that drive people's imagination" (Luke, professional science communicator). Discussing "sexy topics" whose answers are still unknown such as "black holes", "where do we come from", "how will our universe evolve or end", "is there life elsewhere", or "life on Mars" was an almost universal point discussed by practitioners.

Putting things into context

In addition, practitioners also referred to the importance of "putting things in context". In the quotation below, Ken shows his attentiveness to communicating what was happening in the "social cultural context" at the time of the "space race", so that people could contextualise the events instead of seeing them as isolated episodes.

> (…) "we actually literally have timeline walls running on two of the decks and we've tried to put things in context as well, so it's not... We've got the space race all along a central band on that wall, but above, we have the sort of social cultural context of the events that were happening in the world at that time". (Ken, professional science communicator)

Ken's idea, in a manner conforms with Wynne's (1996) argument on the "contextual model" discussed earlier in this chapter and in the literature review, which seems to suggest a 'contextual' approach to practitioners' attitudes towards science communication.

Communicating benefits

Surprisingly, perhaps, is the infrequent occurrence in practitioners' talk of the idea of communicating benefits/applications of space research to the public. It was not until I guided the discussion to the topic that interviewees addressed the question of whether communicating the benefits and value of astronomy and space research to society could attract audiences. While most discourses recognise the importance of communicating benefits with the public, analysis of the data allow concluding that the practice is rather different.

Two trends in thoughts appear in the interview data: on the one hand, communicating benefits is seen as positive and is key in engaging people and securing support for science; on the other hand, while communicating benefits is seen as important it is not needed in the actual context of astronomy and space exploration in the UK economy.

Communicating benefits is a crucial part of public engagement

Practitioners' awareness of the importance of discussing benefits is demonstrated by their views that the process of science engagement is incomplete without discussing benefits with the public. Moreover, the discussion of benefits is the opportunity for making a real connection to people's lives. In the citation below, Matthew states that talking about benefits is a "crucial part of science engagement" process:

> "I think this is the crucial part of science engagement (talking about benefits), that with astronomy, because we have such beautiful images and we have the night sky, which obviously is beautiful and fascinating, it's very easy to think, well, lots of people have turned up and they've all gone wow, I've done my

> job. And actually, I think that's just the first stage. When they go wow, that's when you have to actually really engage them properly (…) once you've got them interested in that sense, this is when you start to talk about the benefits of science (…)". (Matthew, professional science communicator)

As Matthew explains, it is as a two-step process in which the first step is to get people interested and the second is to "engage them properly":

> Interviewer: "So, it looks like you have a two-step plan strategy".
>
> "Yes. It is a two-step. Because to engage people and to get them to understand better how science works and how it affects them, before you can do any of that, you have to get their attention. And in the modern world, you're competing with so many other things. You're competing with soap operas, with sport, with celebrities, with climate change, with the latest political scandal, all of these things. You've got to grab their attention somehow when you've got it. And then you can do interesting things with them. But unless you get it, you're just shouting into the wind and it's not making an impact". (Matthew, professional science communicator)

Communicating benefits may increase public appreciation and support for science

Moreover, the importance of discussing benefits is associated with increasing public appreciation for science and public support for funding of space research, as the quotes below illustrate:

> (…) But as soon as you start to talk to people about some of the technology spin-offs… then filters through into everyday life.

> Then people sort of appreciate it a bit more, but it's a subtle thing to get through to people". (Ken, professional science communicator)

> "(…) So, one of the things that I'm very interested in doing is trying to make people understand why science like astronomy, so quite abstract blue sky science, if you like, is important and is worth funding". (Matthew, professional science communicator)

> (…) But also, [what we expect from the public] we are trying to show to the public that when we invest money, public money, tax payers money, in basic research, we can bring something back, in terms of technology applications, but also in terms of knowledge (…)". (Peters, professional science communicator)

Communicating benefits should not be priority in science communication – the "beauty" of space is the "benefit"

Although there is a general agreement among practitioners that communicating benefits may help secure public support, they state that the communication of astronomy and space exploration should not make the communication of benefits the priority of communication. The main reason given is that the "beauty" of such topics is powerful enough to involve people in science (Emily, scientist). As Fred states:

> "[A]nswering the "big astronomy questions" is the "benefit" of exploring the universe: "The benefit is knowledge, satisfaction of curiosity" (Fred, scientist).

Rob makes the same point:

> (…) It's tricky [discussing benefits with the public]. When I'm talking to the public ones I don't sell astronomy per se, like a packet of washing power or a brand name. It's something which is interesting and exciting and something which they can get something from". (Rob, scientist and policy-maker)

Moreover, there is also the "mystery" and "curiosity" 'factors' that inspire people and drive their curiosity, which practitioners do not want to diminish.

Who and to whom should benefits be communicated?

The interview data also suggest that communicating benefits is still a new approach for many practitioners. Either they tend to think that communicating benefits is not important, or although they recognise its importance, they have not incorporated it into their practices yet. According to those interviewees, communicating benefits of space research to the public is something which is "hard" do to and brings questions as to what audiences it should be discussed with and who should communicate it.

> "It's something I'm working on at the moment actually, because we realise we've got to argue this with the government, and so we are very keen to make that case, but it's hard, especially at the moment it's not going to get easier [Referring to the world economic crisis] and I think it's really important (…) "I don't know whether I feel I should discuss it with every audience, because you know they don't want to know it, they're here to… well, they may want to know it but they're also interested in the science in it's own sake". (Robbie, professional science communicator)

Robbie's statement above shows that communicating the benefits of exploring space has not been a priority of communication so far. However, because of encouragement from the government, he is keen to include it as part of his communication tasks. Nevertheless, he manifests his scepticism about who should be responsible for communicating benefits to the public and to whom should it be communicated.

The public is not interested in the communication of benefits

Robbie justifies the difficulty of explaining benefits by citing disinterest from the public, a view which is shared by other interviewees as well. For example Emily assumes that beautiful images and what is currently happening in astronomy and space exploration are "exciting enough" for the public:

> "for a lot of people the fact that it's happening is fine, it's exciting enough; they like the pictures and you can lure them in" (Emily, scientist)

But, in the end, practitioners recognize that communicating benefits with the public is "slowly improving":

> "I think it's slowly improving [communicating benefits]. I wouldn't say we're doing well. I think looking around the globe, that NASA always seem to do the best job of communicating the benefits of what they're doing and getting the public and tax payers excited about the missions. And they always have lots of literature and websites and things that they share with people and they just seem to be very, very good at communicating what they're doing. I think when we come... not just to the UK but to Europe in general, I think we tend to not really see the value of it so much. We invest a certain

amount of money into outreach, but I don't think it's always spent efficiently". (Ken, professional science communicator)

Practitioners as gatekeepers in deciding on the content of communication

Interviewees' assumptions that audiences may not be interested in knowing about benefits of space research is, I would argue, evidence of practitioners' *gatekeeper role.* Based on a set of assumptions about what the public wants to know, practitioners decide what should be the content of communication and what content should be communicated to each audience.

Summary

Practitioners' discourse on reaching audiences can be summarised as follows: it is important to know the characteristics of audiences in order to address them properly, and efforts should be made to target as many audiences as possible. As for startegies of communication, practitioners referred to the importance of having "themed blocks" or groups of activities so that different audiences can be reached; that it is better to discuss "big astronomy questions", and use novelty, uncertainty and mystery; and it is important to put things into context and to relate things to peoples' lives. In terms of communicating benefits with the public, most of the interviewees recognise benefits as an important component of public communication, however doubts about who and to whom they should be communicated still remain. Furthermore, communicating benefits is seen as something that is "hard" to do and that, according to practitioners assumptions, people may not be interested in knowing. For some interviewees, the "beautiful images" are strong enough to catch the public's interest and are preferred to attract people's attention. However, this is questionable. One could ask: should astronomy science communicators trust the 'beautiful images' as a 'remedy' to engage the public in science, particularly when there are so many other competing sciences and investment in space exploration is not particularly low. Or, should practitioners concentrate their efforts on communicating the benefits and value of astronomy and space to society, instead of focussing their energies communicating only the beauty of space? And also, who and to whom should benefits be communicated? These are some of the questions that science communicators, policy-makers and other communities involved in the communication of science will have to consider. I will come back to this discussion in Chapter 6. I turn now to analyse the data that deals with practitioners' perception of their audiences' characteristics.

5.6.4 Anticipating audiences – practitioners' perception of their audiences' characteristics

As previously stated in this thesis, one of the topics I covered in the interviews related to the way in which practitioners anticipate their audiences. In order to analyse this, I showed practitioners key findings of my surveys on the "public for space exploration" to investigate how they understand their audiences' characteristics and how they react to surveys about the audiences they are meant to be addressing.

Audiences' support for astronomy and space exploration is not surprising

Many points in the interviews clearly show that practitioners see their publics as positive towards astronomy and space exploration issues. Therefore, interviewees were not surprised to hear that the results of my survey showed a public positive towards space science. Conceptions of the public such as "interested", "engaged", "curious", "fascinated" and "passionate" about astronomy and 'space' appear very frequently in the interview data.

However, variations in practitioners' perception of the public's level of scientific knowledge are found in their discourse. Some argue that the public is "very knowledgeable", while others describe public knowledge as "fairly limited":

> "It definitely varies among the public, because quite a few of them watch The Sky at Night or read astronomy projects, and some of them know absolutely nothing. A lot of them don't know the composition of a star and didn't realise there were other galaxies". (Anna, professional science communicator, blogger)

> "In general most people's knowledge is fairly limited, their enthusiasm might be very high but their knowledge, if they've never taken part in an activity before is fairly limited". (Mary, professional science communicator)

Audiences' specific attitudes towards space exploration are completely surprises

When the discussion was narrowed to determine practitioners' perceptions on particular audience' characteristics that I have analysed in my surveys such as attitude towards risk or value for money, support for means of exploration or gender differences in support for space exploration, the conversations became quite difficult. Most often practitioners did not have a clear idea of what public opinions concerning such matters would be, and did not know how to respond; so their discourse can be regarded as more questioning and less certain. They paused more often and used more fillers such as "hum", "er", "well", "you know". Thus, when I confronted them with key findings of "their audiences", practitioners were frequently surprised, and confessed to having to "guess" many times when planning activities (Marcus, scientist). For instance, interviewees were often surprised to hear that a great majority of my sample thought that space exploration is very risky, that there is strong support for complex means of exploration such as robotics and human space missions, or that space exploration is not good value for money. Regarding this last point, practitioners' were also surprised to hear that the perceived value for money of space exploration is a strong factor that drives public support for space exploration.

> "It's very nice to hear and quite surprising that so many people are in favour of manned space flight, I would not have expected it to be that high". (Daniel, professional science communicator)

This already suggests that practitioners do not know many aspects of the audiences they are supposed to be communicating with, so that their ideas about these audiences might be only based on *assumptions*.

Gender differences in support for space exploration is not surprising

Practitioners were not surprised by differences in gender support, recognising that males have a more positive attitude towards space exploration than females. In the extracts below, Stewart and Anna explain their opinions about females being more likely to be concerned about solving problems on Earth, and men tending to be more adventurous. Accordingly they were not surprised by survey results on public support for means of exploration:

> (…) "many of the women did not want us to travel in manned space flight because first of all there's so much to do on Earth, so many problems to fix here environmentally". (Stewart, professional science communicator)

> "I think the men tend to feel under a licence to be more adventurous and more willing to explore, run away and look, where we women think, oh, I've got to keep my head down and concentrate on what's here". (Anna, professional science communicator and blogger)

Audience's gender is not surprising

Some socio-demographic characteristics of the audiences attending astronomy and space exploration outreach events were expected by practitioners. For instance, gender differences did not appear to be a surprise -- practitioners recognised that men are more likely to attend astronomy and space exploration events than women. As practitioners say:

> "majority are male and quite well educated" (Mary, professional science communicator).

> "I'm not surprised that there are more men than women taking part in a lot of these activities" (Daniel, professional science communicator).

The way science communication is performed influences audiences' gender attendance

Lack of female attendance at astronomy and space events is often explained by their lack of interest, which in turn is explained by the whole context of education in the UK. As Luke puts it: "females don't go into the physical science area"; "which seems to be more appealing to men". In some cases, this lack of female attendance is linked to the way science communication has been performed. Rob explains:

> "A lot of science communication is done in a way which automatically appeals more to that male way of looking at things usually (…) the more technology orientated title tends to get a more male dominated audience, but if it's super massive black holes and things like that tends not to be so gender specific" (Rob, scientist and policy-maker)

Similarly, Ken points out that the "Space and Air Gallery" attracts a more male than female audience because of the setting and way it is organised, which resembled "a very cold engineering space":

> "(…) for example, one of the things we found there was that it was primarily male dominated - that area, the whole Space and Air Gallery. And you might get father and son, but it was very rare to see a woman in there by herself or mother with a child in there. And we looked at it and it was a very cold engineering space. It was like a hard floor, there were lots of hard surfaces and it just looked very much like a workshop, an engineering workshop". (Ken, professional science communicator)

These extracts show that practitioners attribute the predominance of males in the audience in part to the way in which they pitch science communication activities.

Audiences' age group is surprising

While gender attendance at astronomy and space communication events was not a surprise to practitioners, age group attendance appeared to be:

> "(…) I think we were a little bit aware but not fully of the point you just mentioned about the 16 to 24, because they're not coming with the family groups, but they're not adults bringing family groups either". (Daniel, professional science communicator)

Although surprised, Daniel acknowledges that families are more likely to attend such events than young adults on their own initiative. Another practitioner was surprised regarding the low attendance of older audiences and referred to the importance of targeting them. This already suggests the importance of such surveys to help identify potential audiences to target. Moreover, similarly to Rob and Ken's statements quoted before, Daniel's talk implies that in order to reach such audiences, activities may have to be planned in a different way:

> "The age differences are also very interesting (…). It may well be that we will consider trying to do something that's targeted at an older audience. And that may affect how we pitch the event" (Daniel, professional science communicator).

5.6.5 Use of survey data in science communication

Limited quantitative surveys as a reason for practitioners' assumptions of the public

Practitioners' lack of understanding of audience's characteristics is very often justified by the lack of quantitative data on public opinion and attitudes towards astronomy and space issues. One example is given by Britney who, although aware of the fact that the public has the reputation of being supportive of space research, points out that there is actually very little evidence for it:

> "It's funny because it tends to be said a lot that people really like space and astronomy. Now, there's very little quantitative evidence on that and it would be really good to get more because it's something, in fairness, if we're trying to get sponsorship for a gallery we'll always say space, a brilliant subject to engage children with science, but there really isn't a lot of hard evidence on that (…) "I think a lot of the time we are flying slightly blind on what people do know and what their attitudes are likely to be because I just feel there hasn't been anything". (Britney, professional science communicator)

This lack of information about the characteristics of audiences is actually brought up by practitioners as one of the biggest problems in science communication:

> "And in fact, I would say that one of the big issues for science communication and engagement at the moment is the lack of really good hard data and what works and what doesn't, and a clear idea of what the different audiences are" (Matthew, professional science communicator).

Surveys as important to help targeting specific groups but very little is available

Practitioners recognise that surveys are extremely important tools that may help in understanding audiences to better target specific audiences. As one practitioner puts it:

> "(…) they are actually evidence, empirical evidence to us" that "affects, or should affect the way that you design activities, depending on what kind of audience you are approaching" (Robbie, professional science communicator).

Surveys of audiences including the one presented here are particularly important because, as Robbie says: "many times we have to make some assumptions" (Robbie, professional science communicator). Similarly, Matthew's statement below suggests that in order to be able to reach specific audiences, one has first to get information about who will be targeted. William, a policy-maker refers to the same point:

> [talking about the survey findings] (…) "it's particularly interesting because I think it then starts to make you think about

> targeting events at specific groups" (Matthew, professional science communicator).

> "These sorts of surveys would inform us on the views of different audiences and the engagement level of different audiences, and then we could take steps to try to see if we can engage them better" (William, policy-maker).

Summary

In essence, the data on practitioners' perception of their audiences' suggest that practitioners' understanding of their audiences is limited. Socio-demographic characteristics such as gender were not a complete surprise because those are actually the characteristics they observe while contacting with their audiences. However, conversations on public attitudes and support for space research proved slightly more difficult as many times practitioners did not seem to know specific characteristics of their audiences. Many findings from the surveys were complete surprises to them. Reasons provided relate mainly to the lack of resources to conduct their own evaluation and surveys, as well as the lack of academic studies of publics and public attitudes towards astronomy and space exploration. As a result of the lack of information, practitioners make *assumptions* on their audiences and, consequently, the process of engagement is not as efficient as it could be as practitioners plan activities based on "fictitious" audiences rather than the 'real' audiences. Interviewees' comments regarding the importance of using survey results to understand what audiences are not being reached by their efforts, suggest that surveys of publics including the one presented here may be a valuable contribution to help practitioners address new audiences, if they want to.

5.7 Summary and Discussion

In this section I will bring together the main findings on practitioners' understanding of "the public" and public communication described in this chapter to critically discuss what the policy discourse has produced in the practice of communication of 'space' to the public. In particular, I will refer to the meaning that "dialogue" has assumed in science communication as a field of practice in the space arena.

5.7.1 Science communication practice -- the "mood for interaction"

Although traditional science communication activities like lecturing, organising exhibitions and organising museums appear to be more frequent than public discussions or focus groups, science communication seems to be understood by practitioners as a two-way process which involves "dialogue" with the audience. The discourse on public communication suggests that the "mood for interaction" has crystallized in practitioners' minds. Terms such as "dialogue", "engagement", or "participation" are consistently brought up in the conversations by interviewees. Furthermore, when looking at their discourse on practices, it is clear from the data that practitioners are applying new methods of communication with the public in which activities apply an "interactive" approach to science communication. This "interaction" is described as a form of "dialogue" which may take numerous formats such as web interaction, simulators, imagery, hands-on-science activities, or public discussions. By facilitating "dialogue" these new methods of communication reach beyond the one-way communication model to create stronger relationships between communicators and their audiences. In addition, these "dialogue" approaches do not appear to *mirror* the approaches in policy contexts. They are mainly aimed at creating situations where people can interact with science and encouraging people to participate in science. Thus, the "mood for interaction" in science communication deviates from the traditional deficit model of communication in the sense that practitioners show a positive attitude towards listening to the public and science communication activities are based on interaction with audiences. This view of *interactive practices* corroborates with a view of an interactive "public".

In addition, the data show a sophisticated view of the public in most times: practitioners perceive the public as capable of contributing to science, science communication activities, and discussions that do not seek to influence policy decisions. However, in the case of public participation in science policy, a more complex view of the public is present. While there seems to be a general agreement that "dialogue" is the right way to communicate science, when considering the issue of whether the public should participate in decisions decisions, the question is rather complicated. The data show divided opinions among practitioners: while there is a general agreement that in democratic societies the public has the right to participate, questions on the potential of the public for participating in science policy is seen as a barrier.

In fact, I want to argue that the "mood for interaction" in science communication has been *adapted* by practitioners from the "mood for dialogue" in policy context. This "mood for interaction" brings new methods of communication with the public and the use of a different language than that from the policy rhetoric. Within this "new" language of science communication, which is normally controlled by practitioners of science communication, the same terms are used flexibly to achieve different aims: Talking about science communication as an "interactive process" allows science communication practitioners to frame a variety of activities in terms of the now-dominant rhetoric of "dialogue". This is not surprising, perhaps, as no universal definitions of such terms exist despite the numerous attempts that have been made to create comprehensive definitions from the vagueness of these related terms.

5.7.2 Deficit approach to "the public" and communication still in use

Notwithstanding, not surprisingly perhaps, some discrepancies between discourse and practice occur. In some situations practitioners appeared to hold nothing more than a sophisticated view of the "deficit-model" in which assumptions about public communication such as that "to know science is to love it" were, although not very often, made by interviewees. This was particularly evident when discussing the aims of science communication -- some practitioners showed a strong belief that higher levels of public scientific knowledge would increase public support for science. Moreover, practitioners informally use a one-way and a two-way model of communication. As practitioners described, there were situations in which one-way activities proved to be very efficient at reaching large audiences and facilitating public understanding and awareness of space research developments.

Similarly, there were situations where assumptions of a "deficit public" were made by interviewees. This was more evident when discussing the potential of the public for participating in science policy issues. Most times practitioners drew on a set of assumptions of a "deficit" public to judge its capacity to participate in policy-making decisions about science and technology.

5.7.3 Dialogic approach in science communication

According to the analysis presented in this chapter, I argue that "dialogue" in the context of science communication can assume different formats and have different aims. Based on practitioners' discourse there seems to exist an *interactional dialogue* and a *participatory dialogue* where public "input" remains key to differentiating between the two types. An *interactional dialogue*, which involves a conversation between the science communicator and the public, can be performed using either direct or indirect interaction, and does not require public input. A *participatory dialogue* is open to input from the public, and involves mutual understanding between both parts, the science communicator and the audience. It can be defined accordingly to the Bohmian conceptualisation of dialogue, which has been particularly influential: "Dialogue is not an exchange and it is not a discussion. Discussion means batting it back and forth like a ping-pong game. That has some value, but in dialogue we try to go deeper…to create a situation where we suspend our opinions and judgements in order to be able to listen to each other" (Bohm, 1996).

Furthermore, these different types of dialogue involve different levels of public involvement in science activities. These can range from low involvement (as in *interactional dialogue*) to higher involvement (as in *participatory dialogue*). As the data suggest, levels of public involvement with science are closely related to aims of communication and the roles that the public plays. Lower levels of public involvement may occur in situations aimed at informing or educating the public such as in lecturing or exhibitions where the public assumes a more passive role and practitioners are in full control of the activity. As for higher levels of public involvement, these are more likely to occur in situations aimed at getting public "input" such as in discussions about contentious issues or designing of science communication activities.

5.7.4 Two-way communication aimed at public understanding of science and public awareness of science

In addition, my findings suggest that, despite the fact that a clear relationship seems to exist between a one-way model aimed at public education and understanding of science and a two-way model aimed at public debate, two-way communication can also facilitate public awareness and public understanding of science. Practitioners mentioned examples of interpersonal dialogues between communicators and the public where there was simply an exchange of ideas where both parts can learn. As discussed before in this thesis, authors such as Van der Sande and Meijman (2008) consider, for example, that dialogue can have a functional goal (dialogue about facts) and a conceptual goal (dialogue about concept and notions, fears, emotions and feelings). Although I do not entirely agree with the classification presented by these authors, my empirical research supports their argument that the "public understanding of science goals is only as open to dialogue as public awareness, public engagement, and public participation" (Van der Sanden and Meijman, 2008).

Given this, I argue that the "mood for interactivity" in science communication is tremendously important to closing the gap between science and the public. Not only does it contribute to raising public understanding and awareness of science, but it also allows public participation in general discussions about science, as well as potentially encouraging public participation in science policy issues. By providing opportunities for people to discuss science and technology issues, this approach to science communication represents a powerful tool to help develop the public's involvement in science; in particular dialogue events in science communication may contribute to improve people's argumentative skills and eventually, public participation in policy issues.

This argument is supported by a recent study (Zorn et al., 2010) that examined the effects of dialogue with scientists on laypeople's attitudes towards human biotechnology (HBT) and participants' communicative self-efficacy. The study found that laypeople reported increased positive attitudes towards HBT and HBT scientists, and that participating in dialogue increased participants' confidence and motivation to participate in public discussions regarding HBT. Thus, I argue that dialogue in the context of science communication can contribute to creating a public that is not only more knowledgeable and confident to make decisions about science but might also be more willing to discuss controversial issues and, ultimately, to participate in dialogues that intend to influence science policy decisions. However, public participation in policy decisions should not be seen as the main goal of public communication but rather an opportunity to bring science and the public closer together. Many times people have the opportunity to participate in such discussions but they chose not to (Dijkstra, et al., 2010). Furthermore, having a public that has the knowledge to participate in policy-making decisions is as important as having a public that is aware of scientific achievements and has the knowledge to argue about scientific issues, or simply is able to take science into consideration when making decisions in everyday life.

5.7.5 Practitioners as gatekeepers in science communication process

Finally, from the various examples described throughout this analysis, I would argue that science communicators seem to *play the role of gatekeepers* in controlling public communication: They choose the ways they want to communicate, the content of communication, and the audiences they want to address. Many times such decisions are based on nothing but naïve assumptions about the "public" and public communication, as the analysis on the way practitioners anticipate their audiences have showed. A good example of this is the communication of the benefits of space with the public. Practitioners appeared to assume a gatekeeper role when deciding if audiences wanted to know about benefits, and to what audiences should it be communicated. Lastly, I cannot conclude whether the concepts from science policy have been adapted by communicators due to a misleading communication between those who theorise public engagement and those who are asked to practice it, or whether the concepts of the policy rhetoric do not quite fit practitioners' needs in particular situations what makes them to assume a gatekeeper role in deciding their agenda and the message to be conveyed.

5.8 CONCLUSION

In this chapter I have provided an analysis of the discourse of practitioners of science communication in the area of astronomy and space exploration concerning “their publics” and public communication. I started with a number of key claims for which I presented evidence throughout this chapter. The analysis was presented in three main parts.

First, I looked at the concepts of discourse that characterized practitioners views about their audiences and public communication. In particular, I looked at the models of science communication they use, the type of activities they perform and the aims of communication they want to reach when planning their outreach activities. My empirical data showed that, in practice, elements of the deficit model still remain in the current practice of science communication. This is although the one-way model of science communication has been criticised strongly in the academic literature. I will discuss the use of a one-way model in relation to communication of ‘space’ issues to the public later in Chapter 6.

Moreover, the interview data suggest that practitioners have *adapted* the terminology from the “mood for dialogue” described in science policy documents and by academics to its own context and needs, which allows practitioners to frame a variety of activities in terms of the now-dominant rhetoric of “dialogue/interactivity”. This “dialogue” assumes different formats: at a lower level, there is an *interactional dialogue* which represents a deviation from the deficit model by allowing “interactivity” with the public, and it is mainly aimed at public understanding of and public awareness of science; at a higher level, there is a *participatory dialogue* which allows public participation in outreach activities and discussions about contentious issues about ‘space’. The *interactional dialogue* is the dominant practice among this community.

Secondly, I analysed practitioners’ views on public participation in the policy-making process about space issues. This approach was important to better understand how “the public” is constructed among practitioners. My data suggest that the public is perceived in a rather complex way. For some interviewees, the public is perceived as informed and capable to participate in policy decisions about space exploration. For others, the public is refereed as “misinformed” actors that should be left outside the policy strategy.

Lastly, I looked at the way in which practitioners responded to surveys of their audiences by using data collected in *Phase 1* of my empirical research. By showing practitioners’ findings of my survey about the “public for space exploration”, I investigated how well they anticipate their audiences and how they might make use in future of these type of surveys when planning outreach strategy. The data allow me concluding that practitioners of science communication base their ideas about their publics on simple assumptions. This is corroborated by other information in the data. Furthermore, practitioners play a *gatekeeper* role in the process of science communication – they decide on the types of audiences they communicate with, the contents of communication, and the type of activities of science communication.

CHAPTER 6

SUMMARY AND DISCUSSION: IMPLICATIONS FOR SCIENCE COMMUNICATION

And now look again, and see what will naturally follow
if the prisoners are released and disabused of their error.
(…) and then conceive someone saying to him, that what he saw before was an illusion,
but that now, when he is approaching nearer to being
and his eye is turned towards more real existence,
he has a clearer vision, -what will be his reply?
And you may further imagine that his instructor
is pointing to the objects as they pass and requiring him to name them,
-will he not be perplexed?
Will he not fancy that the shadows which he formerly saw
are truer than the objects which are now shown to him?

-- Plato, The Republic

6.1 INTRODUCTION

In this chapter I describe what I have accomplished in terms of my original statement of purposes not only for PUS theory but also for the practical application of the theory to the communication of "space" with the public. One of the enduring questions in social science research is why it has so little impact (Wolcott, 1929). Due to the nature of this study, its intended audiences, and the nature of the data collected, I considered it important to give sufficient attention to the impact of my research efforts in the practice of science communication, offering a personal reflection on how I think this study can benefit the groups who are in charge of communicating with the public.

In the discussion that follows, I draw on some of the main findings of my empirical data, as well as on other studies, to reflect on the issue of whether the "deficit model" and "dialogue" are competing or complementary paradigms, and how they fit in the contemporary practice of communication of astronomy and space. Furthermore, I discuss how outreach events can been seen as situations of 'preaching to the converted', and how survey data can assist science communicators in addressing their audiences.

6.2 Deficit and Dialogue -- Complementary Or Competing Paradigms?

Throughout this thesis I have referred to the current policy discourse in relation to public engagement and dialogue about science and technology. The two pieces of research that I presented here bring a number of key ideas with respect to the meaning of science communication, the role of the public and the role of a science communicator, to which I will refer in the discussion that follows.

One of the main findings of my empirical qualitative data, as discussed in Chapter 5, is that a "mood for interaction" has been strongly ingrained in practitioners' minds. Science communication is constructed by practitioners as an "interactive process" based on "dialogue" between science communicators and an "active" public. My qualitative data also show that the "mood for interaction" described by practitioners does not mirror the terminology from the "mood of dialogue" in science policy discourse but rather has *adapted* it to its own contexts and particular needs. While my research cannot be conclusive about the reason why practitioners have adapted the policy language, two explanations are possible. First, this is a result of misleading communication between those who theorized public engagement and those who are asked to practice it. Second, the concepts of the policy rhetoric do not quite fit practitioners' needs in the particular area of 'space', which leads practitioners to decide their own agenda and the message to be conveyed, assuming a gatekeeper role in the process of science communication.

Whatever the case may be, this situation has allowed practitioners to use flexibly a variety of terms in the now-dominant rhetoric of "dialogue/interactivity". The most salient example is, perhaps, the use of the term "dialogue". In the discourse of practitioners, "dialogue" can assume different formats and might play different roles in science communication. At a lower level of public involvement in science communication activities, there appears to exist an *interactional dialogue*, which seems to be a "dialogical" approach to the traditional one-way communication model: while it allows "interaction" with the public permitting a 'two-way communication', it serves the same goals of the deficit model, public understanding of science and public awareness of science. At a higher level of public involvement with science, there is a *participatory dialogue*, which is an open-ended dialogue where public input is required, and it is aimed at public engagement with science and public participation in science communication activities or discussions that may involve controversy.

However, *participatory dialogue* has not been much put into practice by this community so far. One reason for the limited use of this type of dialogue for discussing controversial issues on space exploration, as some practitioners put it, is that the actual context of space exploration in the UK is not controversial enough to justify such type of discussions with the public. Nevertheless, the majority recognised its value and showed openness to integrate such type of discussions into their activities.

In addition, notwithstanding the recognition that a two-way communication is needed to give the public the sense of being part of science, and to transmit trust and transparency, in practice both the one-way and the two-way models of communication are informally in use by this community to communicate ‘space’ issues to the public. What is more, these models seem to be chosen according to the aims of communication that practitioners want to achieve and the type of audiences they want to reach: one-way activities and *interactional dialogue* are intended at public understanding of science and public awareness of science, and are described as being effective for reaching wider audiences; while activities involving a *participatory dialogue* are mainly aimed at public participation in discussions of controversial issues that do not relate to science policy and are intended to reach smaller audiences.

Given the fact that an *interactional dialogue* is most often used, the aims that *participatory dialogue* serves will not be realised. Therefore, it seems reasonable to infer that if science communication continues serving the same aims that it has been serving in the last decade, i.e. mainly public understanding of science and public awareness of science, the expected impacts from the theory will not be reflected in “the public” and in the science communication practice. An important question seems to be: Whether there have been positive changes in the levels of public understanding of science, and whether further evolution in PUS and public participation is desirable in the area of ‘space’?

As I briefly explained in the literature review, studies that have looked at the evolution of public understanding throughout time have shown that a positive change in the levels of PUS has occurred in the last decade (e.g. Eurobarometer, 2005, Martin Bauer, 2005). As Martin Bauer argues (2005), due to the fact that many government organizations have in the last decades actively promoted many forms of public engagement with science as a result of the Bodmer Report (1985) and more recently the Science and Society Report (2000), it could be said that event making such as exhibitions, science festivals, organizing museums and science centres, citizen-juries, conferences, deliberative forums and so forth, is recommended. While these studies are not conclusive about the effectiveness of such activities, works that have looked at the importance of non-school science learning activities support the idea that informal science activities play a very important role in public's science interest and understanding of science. For instance, Falk et al. (2007) have conducted a random telephone survey of Los Angeles, California residents to look at how and why individuals learned science. The authors showed that nearly half of the surveyed respondents (43%) claimed to have learned science during their leisure time through some kind of "free-choice learning" (internet, magazines and books, museums, zoos and aquariums, and participating in special-interest clubs and groups). As the authors argued (2007) while school provides basic knowledge about science, "it is only through need, motivation, and occasionally curiosity" that adult's specific knowledge are further activated, and even more important "applied in specific everyday activities". These studies suggest that outreach activities and the aims that they serve have a role to play in the public levels of PUS. However, a question that is not possible to answer is whether a more 'dialogical' approach to science communication would have had a greater impact on PUS.

While my aim here is not to judge the superiority of which is the best communication method, although many of the academic discussion for the use of a two-way communication are linked to perceived weakness in a one-way communication, I believe that both means have a role to play in the science communication practice. Therefore, I argue that both one-way and two-way communication serve different aims which should not be underestimated, and science communication activities that allow reaching these aims should be encouraged. Therefore, rather than competing, both models of science communication, one-way and two-way communication, should be seen as complementary paradigms in the communication of science to the public. This might be especially true in communication of issues such as astronomy and 'space'. As many practitioners referred during the interviews, much of the beauty of space can only be appreciated through its beautiful images such as those taken by the Hubble telescope, in which people are always curious about.

Science communication should then be seen as a continuum process that allows not only the empowering of people with knowledge, but also provides the capacity for them to use that knowledge in a balanced way by considering arguments in decisions both in favour and against, and eventually, participate in policy decisions about science if they are allowed or want to. Sometimes people have the possibility to participate in discussions and they choose not to (Dijkstra et al., 2010). In the same way that some members of the public want to be consulted and engaged in scientific discussions about controversial issues, others simply may not want. As Einsiedel (2008) argued "the process of communication depends on the context and circumstances, and publics are both receptors and producers of communication and scientific information; they decide what they are interested in, what they want to participate in, and of what they want to know or remain unaware" (Einsiedel, 2008).

My argument is supported by recent research which has found that knowledge is an important factor in public participation. Dijkstra, et al., (2010) in a study of public participation in human genetics, showed that the most predictive factor for participation is knowledge followed by information searching behaviour and level of information. From this perspective, citizens need to have sufficient levels of scientific knowledge on which to base their decisions, but also the confidence and argumentative power to participate in those discussions. And, even if the public chose not to take part in policy decisions, they would still be empowered with the necessary "tools" to discuss science.

In addition, the study presented here provide input to the discussion over the role of dialogue in the contemporary practice of science communication, in particular to whether dialogue in science communication should serve the same goals of dialogue in public participation. As discussed in the literature review chapter, many detailed typologies have been offered to classify the science-society relationship (e.g. Bucchi and Neresini, 2008; Rowe and Frewer, 2000, 2005; Van der Sande and Meijman, 2008). While some authors who have distinguished between participation and communication based on the way information flows have argued that dialogue is only possible in public participation (Rowe and Frewer, 2005), others have maintained that dialogue has a role to play not only in public participation but also in public awareness of science and public understanding of science (Van der Sande and Meijman, 2008). My data show that: firstly, science communication involves both one-way and two-way communication, contradicting the distinction between science communication and participation presented by Rowe and Frewer (2000, 2005); secondly, there is a clear distinction in terms of formats between the "dialogue" conducted by science communication practitioners and that which seeks to influence science policy, already suggesting that aims of dialogue in science communication and aims of dialogue in participation should be different; and lastly, dialogue in science communication may serve public understanding of science, public awareness of science and public participation in scientific discussions about contentious issues that do not seek to influence science policy.

Given this, I would argue that the aims of dialogue in science communication should be different from the aims of dialogue in public participation. Furthermore, public participation in policy decisions should not be seen as the main goal of science communication, and the goals that science communication serve should rather been seen as opportunities to strengthen the relationships between science and the public, which ultimately can encourage public participation. Having a public that participates in policy-making decisions is as important as having a public that possess the knowledge and confidence to argue about scientific issues, or simply is able to make more assertive decisions about scientific issues in their everyday lives.

This is to say that the process of science communication should not be thought of using the simplistic conception of a dichotomy between one way and two way communication: a one-way communication that sees the public as an empty vessel in need to be fed with scientific knowledge provided by experts; and a two-way communication where the public is placed among the scientific community and policy-makers to take decisions about science. My empirical data allow me to argue that science communication is a more complex process than that presented by those two-models. For instance, the "mood for interactivity" is neither a ‘deficit’ model nor a genuine “dialogue”. Similarly, conceptions of the public are also complicated, but it is not my aim here to conclude about what would be the ‘right’ conceptualisations of the public in different situations, Thus, science communication should then be seen as a continuum process involving different aims that can benefit the public in different ways, whenever it is public understanding of science, public awareness of science or public participation in science. For instance, the interactional dialogue can lead to a participatory dialogue, which eventually, can facilitate public participation in policy-making.

This argument is supported by work by other scholars. Research that has looked at public participation processes have referred to the role that ‘deficit’ models might have in the communication of certain issues with the public. For instance, Massimiano Bucchi (2008) stated that public/expert interaction with regard to a certain issue such as nanotechnology might be complex and therefore move across models of science communication and their combinations: “an emerging topic as nanotechnology may lend itself to deficit-like communication in its initial stages, and later become the subject of public consultation/mobilization (Bucchi, 2008)”.

Lastly, my analysis brings some points with regard to the conceptualisation of the public which contribute to the discussion on the issue of the role of the public in science policy and non-policy contexts. An interesting and surprising finding, perhaps, is the role that practitioners attribute to the public in different situations. The public is conceptualised as sophisticated and knowledgeable enough to participate in science communication activities and in dialogue discussions non-related to science policy; however, in activities that relate to science policy, the role of the public is a more complex issue. Some practitioners portray the public as a *misinformed actor* easily influenced by interested parties and unable to make informed decisions about science policy related issues. As a result, it is better to leave decisions to competent stakeholders such as scientists and policy-makers. Nevertheless, public misinterpretation of science is not attributed to the public, but rather to interested institutions that take advantage of an uninformed public, or to the enormous spectrum of scientific information available so that people can only be knowledgeable about a certain number of scientific matters. This contrasts with the vision of other practitioners that argue that in democratic societies public opinion should be valued, and the public should participate in science policy-making. This brings fundamental questions about whether the public should be conceptualised in the same way for participating in different situations and contexts.

While my research is by no means conclusive about this issue, what the analysis of constructions of social audiences presented here allows to claim is that, for the aims of public participation in science policy to be satisfied and public participation in space policy issues to grow, practitioners might have to develop a more sophisticated conceptualisation of the public and activities that enhance a more participatory dialogue with their audiences. As I have already shown in this thesis, practitioners see the public as a misinformed actor. This shows, essentially, a clear conceptualisation of a “deficit” public. Therefore, while the aims of public understanding of science and public awareness of science seem to be well established among the practice of this community, a more *participatory dialogue* approach will be needed for communication to meet the aims of the policy rhetoric. This leads me to conclude that current public engagement activities will not challenge the aims of public participation without more reflexive problematisation of the dominant rhetoric of public engagement by practitioners of science communication.

6.3 Preaching to the Converted?

Another important aspect that I want to bring here to discussion is the potential of science outreach activities to attract audiences that would not otherwise be available to practitioners. As I showed in previous chapters, members of the “attentive” and “interested” publics are often the people with whom science communicators are, in reality, dealing, and that this public tend to be mainly composed by males rather than females. While my survey is not conclusive about what makes a male audience more attentive to space issues, my quantitative data show that, one of the reasons for gender differences relate to the way in which practitioners pitch the communication activities. As some interviewees acknowledged, many ‘space’ activities are primarily male dominated: “a lot of science communication is done in a way which automatically appeals more to that male way of looking at things” (Rob, policy-maker).

However, when visiting science informal institutions, people tend to come in groups. As such outreach activities could be thought of by science communication practitioners as excellent opportunities that are characterized by “preaching to the converted”, i.e., situations to reach a less attentive public that just happens to be in the ‘right’ social setting, but which otherwise would be very difficult to reach through other means. If what I argue in this thesis is correct, “the converted”, i.e. the male “attentive” and the “interested” publics attending outreach events bring with them a number of “less converted” female audience, and these may be just the people that constitute the most relevant target group for outreach activities and science communication. And, reaching a female audience could then be seen as a way in which to address a significant policy issue about recruiting women in science.

The social setting of museums/exhibition visits brings together mixed groups predominantly composed of individuals with more interest, but also including people with less interest than the general average, which makes them ideal places for reaching not only the interested and attentive audiences but also less interested audiences. This argument is supported by information provided by science communication practitioners during the interviews. As Stewart, a professional science communicator, put it: “if they were in groups [referring to people attending the exhibition “From Earth to the Universe”] they stopped for longer because there was discussion, if they were on their own just walking to work, you would most often not expect to see this”.

Thus, science communicators and outreach professionals whose aim is to convince citizens of the general worth of space and planetary science may be satisfied to find an audience well-prepared to attend their communication offers, as my surveys results show, or they may feel that addressing this attentive/interested public is not the best use of their efforts, as this public is already positive of space exploration. If practitioners in the interviews meant what they said -- that their efforts are directed towards reaching as many groups as possible, without ignoring audiences -- this may suggest that in order to address the less attentive/interested publics they may need to reconfigure their efforts in order to attract new audiences.

Furthermore, these opportunities to “preaching to the converted”, I argue, are facilitated by the new “mood of interaction” that practitioners seem to have incorporated in their practices. These should be seen as advantages of this ‘new mood’ in science communication, because it makes science communication more ‘dynamic’ and, most importantly, it facilitates conversations with the public, shortening the distance between science communicators and their audiences.

6.4 Use of Survey Data for Planning Science Outreach Activities

Finally, the last point that I want to discuss concerns the role that science communicators assume in the process of science communication and how the findings of surveys of public opinion including the one presented here can benefit that role. In fact, as seen in Chapter 5, the lack of surveys that characterise specific audiences was brought up by practitioners during the interviews as one of the “biggest problems” in science communication, who recognise their power to help reach their ‘real’ audiences and to attract new audiences.

Very often practitioners assumed a *gatekeeper role* by implicitly drawing on a set of assumptions about their audiences. Based on the assumptions made, practitioners decide on the content of communication, the strategies to reach their audiences, and the type of audiences they want to address. A good example of this regards the communication of benefits to the public. Practitioners assumed a *gatekeeper* role when deciding whether the public wanted to know about the benefits, who should communicate benefits and applications of space exploration with the public, and whether they should make it a priority in their communication. And despite they acknowledged the importance of communicating the benefits to the public, in practice it has not been a priority in their communication activities. As my data showed, some practitioners argued that communicating benefits is not needed in the actual context of 'space' in the UK economy, particularly because 'space' issues alone are powerful enough to attract people's interest and support.

However, my quantitative analysis of the factors that influence public support for space exploration suggests a rather different argument. The more economic value the public saw in space exploration, the more they tended to support higher levels of government spending on space activities. Nevertheless, a small percentage of respondents (31%) agreed that space exploration is good value for money, and the majority was ambivalent in their answer. Although my qualitative study cannot be conclusive about the kinds of arguments that would increase public support for astronomy and space exploration, it seems that discussing and communicating the benefits of space exploration to overall quality of life, and to society at large, may increase public support and attract new audiences that have not being reached by practitioners' efforts. Science communicators and outreach professionals could make use of this survey data to understand who are their actual rather than their supposed audiences, what are the audiences that are not being reached, and what factors could attract more support for astronomy and space exploration. Whatever their decision would be I argue that the key for the success of science communication depends upon achieving both accurate understanding of audiences, and accurate reflection on the role of science communicators.

6.5 Future Research

As I have shown throughout this thesis, past studies conclude that scientists believe the public knows little about a range of science and technology issues and that public 'deficit' in knowledge influences their perceptions and attitudes towards science. While my data about practitioners' constructions on "the public" supports these findings, it also shows that conceptualizations of "the public" vary accordingly to the role that the public is asked to play in the process of science communication. It also appears that practitioners' negative views on public participation coincide on some occasions with a difficulty in understanding their role as an enabler of policy engagement. There are a number of issues, however, that my data and past research do not address such as 'who is the public' practitioners are referring to. A lack of understanding of the types of 'public' scientists and other practitioners make reference to results in oversimplification of the 'public' as a whole. While my data contributes to this discussion by showing that practitioners recognize the public's different roles in public engagement, it does not address the opinions of practitioners about different subsets of the public. Therefore, this is an issue that should be addressed in future research.

Second, the data presented here show that the "mood for interaction" in science communication of space issues with the public most often involves an "interactional dialogue" between science communicators and the public. Whether these conclusions concerning models of science communication would have been the same if I have investigated a different specialty, I am unable to conclude. But, it is reasonable to expect that the fact that interviewees' specialties related to communicating a topic that involves the universe's beauty, which many times can only be appreciated through its beautiful images, might make the presence of this "interactional dialogue" particular to areas such as 'space' communication. Also, due to the specificity of space as an area of research and communication, the type of "engagement activities" performed, general engagement or engagement in practitioners' specific specialty may not only limit the type of science communication activities conducted, but also the importance that such activities may play in different specialties. For instance, for scientists and other practitioners involved in non-controversial scientific issues, an emphasis in school-based outreach, museums or exhibitions, and “interactional dialogue” and engagement may be effective. In contrast, for practitioners involved in controversial issues of science and technology such as genetic engineering or climate change, other forms of engagement and public participation may be more desirable. In order to answer such questions, future research could investigate the views of scientists’ from different specialties on engagement. Thus, future research could more specifically to investigate the types of engagement and science communications activities used for specific topics (Besley and Nisbet, 2011).

Another point worth mentioning here refers to the opinions and views of policy makers on public participation in space policy. Despite the numerous reports that have called for the development of programs of public engagement with space and public participation in space policy decisions, there has been a failure to ask high-level policy-makers their opinion on such issues. Thus, another interesting area for future research will be finding out whether the conclusions presented in this thesis are shared by those policy-makers, in particular what their conceptualizations are of the public and public participation in policy-making. To address these questions, a follow up with interviews with high level policy-makers would be appropriate. These could include not only ministers and MPs, including members of the House of Commons Science and Technology Select Committee, but also policy makers from DfES (Department for Education and Skills) and Department for Business, Innovation and Skills, and Research Councils such as the STFC (Science and Technology Facilities Council). This analysis could also be extended to other key players in space policy and advisory committees responsible for providing strategic advice to policy-makers on space science objectives, priorities and missions such as the BNSC Space Advisory Council, UK Space Agency Steering Board members, The Space Leadership Council and other relevant advisory committees, industry or even at a more international level, members of the ESA.

Finally, I would like to address the question of how a revised questionnaire could be used to examine not only other groups but also other factors that might influence public support for space exploration. For instance, recent studies that have focused on opinion formation about new technologies have showed that support for funding of the technology is influenced by religious beliefs (e.g. Brossard et al., 2008). Thus, future research could examine people's religious beliefs and how such beliefs shape public support for space exploration. Similarly, future work could also be extended to investigate the general population's support for space exp.loration. This would allow comparison of how the characteristics of 'the public for space exploration', their attitudes, beliefs and support differ from the population as a whole. For this purpose, methods of data collection could be handing questionnaires to people at shopping malls or on the streets, telephone interviews or an online survey. A way of informing the design of the quantitative research and refining questions would be to conduct a piloting of the questionnaire and a focus group. An interactive focus group setting where participants are free to report their feelings and emotions and to talk openly with other group members, would be particularly important to inform questions that can be have an ambiguous meaning for different people such as perceived 'benefit' (whether it relates to creating new knowledge, value for money, international cooperation, the UK playing a key role, etc); and perceived 'risk' of space exploration (whether it relates to mission failures, risk to astronauts, economic risk, political risk, etc.).

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APPENDIX I – QUESTIONNAIRE

Questionnaire cover

Questionnaire questions

1. Do you think we should explore the Solar System with:

___ Observation from Earth
___ Observation from spacecraft
___ Robotic landing and exploration
___ Human space missions
___ All of these
___ None of these: we should stop exploring the Solar System

(If your answer is "All of these" then mark with (1) the MOST important and with (0) the LEAST)

If the answer is "None of these" go to question 2A, if the answer is "yes" to space exploration go to question 2B and then on.

2A. What is the MOST important reason why we shouldn't explore the Solar System?

___ Space exploration is very risky
___ Space exploration is very costly
___ Space exploration will only be carried out by a rich or scientific elite
___ Space exploration is not good value for money
___ Space exploration is much less important than solving problems on Earth

If the answer is "Yes" to space exploration.

2B. What do you think is the MOST important reason to explore the Solar System?

___ To generate new scientific knowledge and advance human culture
___ To return value to the UK economy through technological progress
___ To create international cooperation
___ To inspire new generations of scientists and engineers
___ To engage British society in the full excitement of space exploration

3B. Do you think life has ever existed on other planets in our Solar System?

___ No
___ Probably primitive life
___ Higher life forms
___ Don't know

4B. Where do you think we should explore for any traces of life?

___ Mars
___ Moon
___ Other planets in the Solar System
___ Beyond our Solar System
___ All of these
___ None of these

(If your answer is "All of these" then mark with (1) the MOST important and with (0) the LEAST)

5B. To what extent do you agree or disagree with the following statements about space exploration?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Space exploration is very risky					
It is important that the UK is at the forefront of space activity					
Space exploration is good value for money					
Space exploration is much less important than solving problems on Earth					

6B. How much of the national budget do you think should be spent on space exploration?

___ None: It should be financed with private money
___ Less than 0.04%
___ Between 0.04% and 0.5%
___ More than 0.5%
___ Don't know

(Currently the UK spends approximately 0.04% GDP on civil space science and 9.2% GDP on the Health Service)

Re-entry for the "non-explorers" in addition to the 'explorers'

ABOUT YOURSELF:

• Are you a UK resident?
___ Yes
___ No

• Gender
___ Male
___ Female

• Age
___ ≤ 15
___ 16- 24
___ 25-39
___ 40-54
___ ≥ 55

• Are you:
___ Secondary school student
___ Undergraduate
___ Post- graduate
___ Academic research
___ Other: __________________

• Have you enjoyed the exhibition?

Not at all |-----|-----|-----|-----| *Very much*
1 2 3 4 5

(Place a cross along the scale)

APPENDIX II – STATISTICAL TESTS USED TO TEST RELATIONSHIPS BETWEEN VARIABLES

Chi-square test: Tests whether two categorical variables (nominal or ordinal) forming a contingency table are associated. The formula for Chi-square (χ^2) is calculated by:

$$\chi^2 = \frac{(o - e)^2}{e}$$

That is, chi-square is the sum of the squared difference between observed (*o*) and the expected (*e*) data (or the deviation, *d*), divided by the expected data in all possible categories.

To perform a chi-squared test, the number of observations expected in *each cell* of the contingency table is calculated as follows:

$$\frac{\text{row total x column total}}{\text{grand total}}$$

(*Note:* the chi-square needs to be calculated for each cell in the table; and the chi-square statistic is calculated to be total of these chi-square values)

Cramers's V: measures the strength of association between two nominal variables used when one of these variables has more than two categories. It is used as post-test to determine strengths of association after chi-square has determined significance. It gives a value between 0 and +1 (inclusive).

Cramer's V is computed by taking the square root of the chi-square statistic divided by the sample size and the length of the minimum dimension (*k* is the smaller of the number of rows *r* or columns *c*). The formula for the ϕ_c coefficient is

$$\phi_c = \sqrt{\frac{\varphi^2}{(k-1)}} = \sqrt{\frac{\chi^2}{N(k-1)}}$$

where:

φ^2 is the phi coefficient.

χ^2 is derived from chi-square test

N is the grand total of observations

k is the number of rows or the number of columns, whichever is less.

The p-value for the significance of ϕ_c is the same one that is calculated using the chi-squared test.

Gamma: Measures the strength of association between two ordinal variables. Values range from −1 (100% negative association) to +1 (100% positive association). A value of zero indicates the absence of association.

The value of a gamma test statistic, G, depends on two quantities:

N_s, the number of pairs of cases ranked in the same order on both variables
(number of concordant pairs)

N_d, the number of pairs of cases ranked differently on the variables
(number of discordant pairs)

where "ties" are dropped. That is cases where either of the two variables in the pair are equal. Then

$$G = \frac{N_S - N_d}{N_s + N_d}.$$

(Note: a concordant pair is a pair of a two-variable observation data-set {X1, Y1} and {X2, Y2}, where:

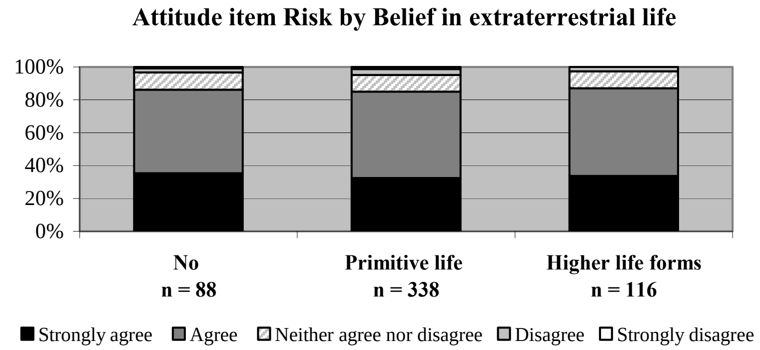
$$\operatorname{sgn}(X_2 - X_1) = \operatorname{sgn}(Y_2 - Y_1)$$

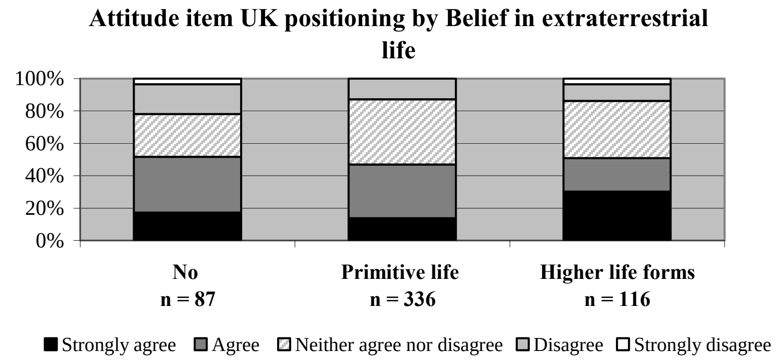
And a discordant pair:

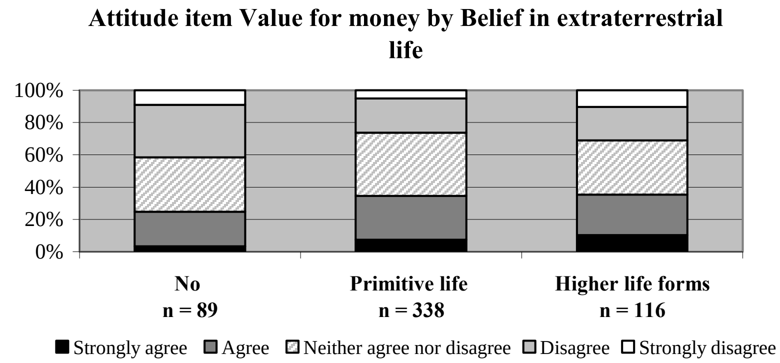
$$\operatorname{sgn}(X_2 - X_1) \ = -\operatorname{sgn}(Y_2 - Y_1)$$

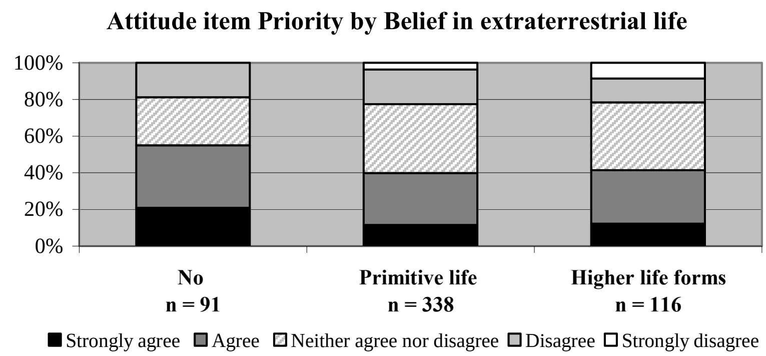
APPENDIX III – CHARTS SHOWING RELATIONSHIPS BETWEEN VARIABLES

Attitude Items



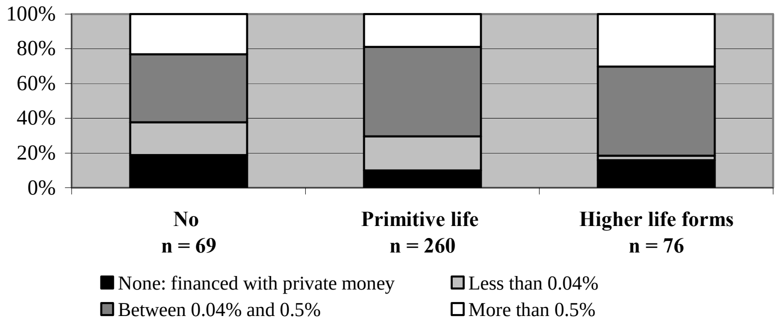




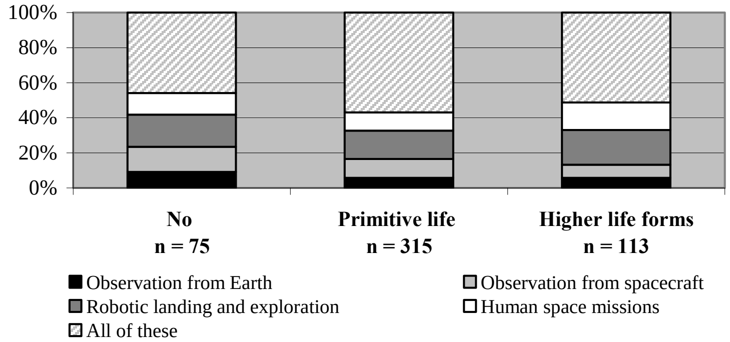


Political Preferences

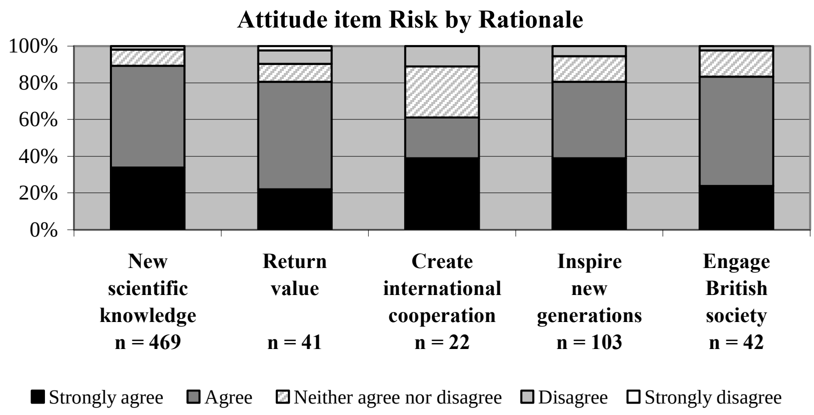
Government spending by Belief in extraterrrestrial life

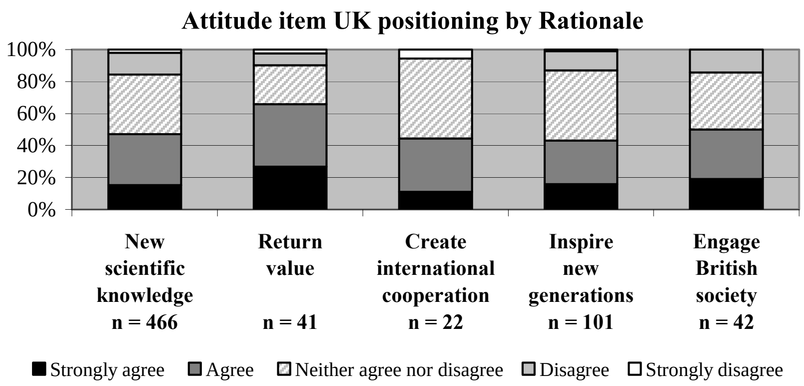


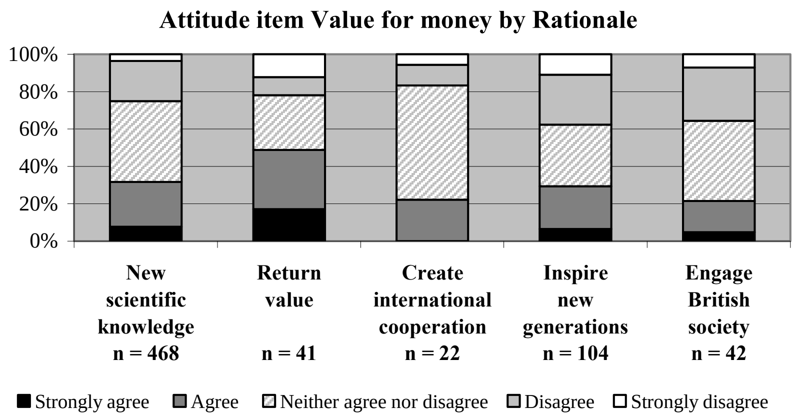
Means of exploration by Belief in extraterrestrial life

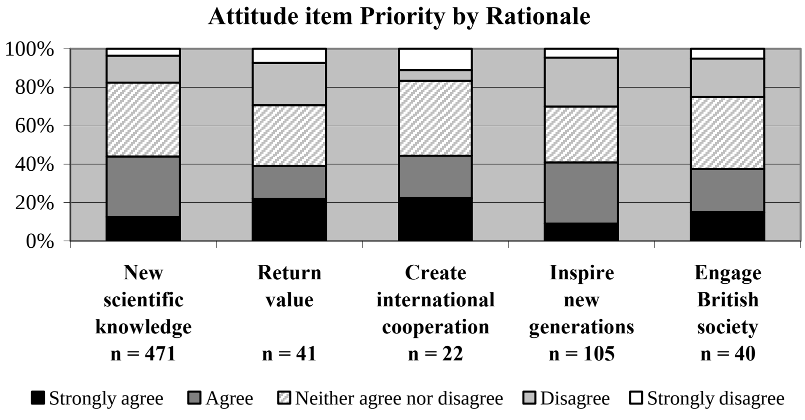


Attitude Items

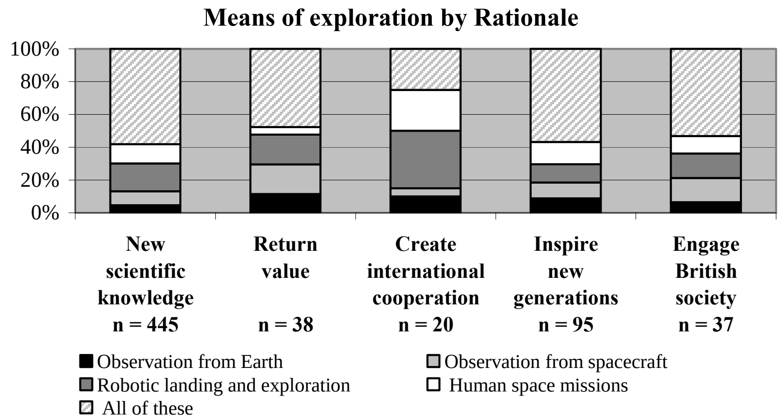


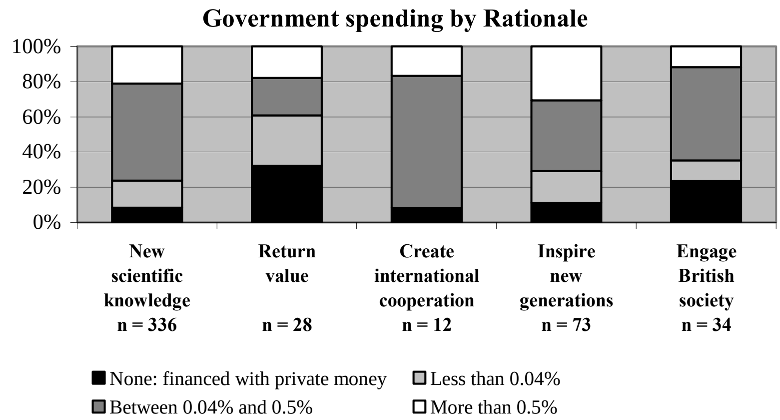






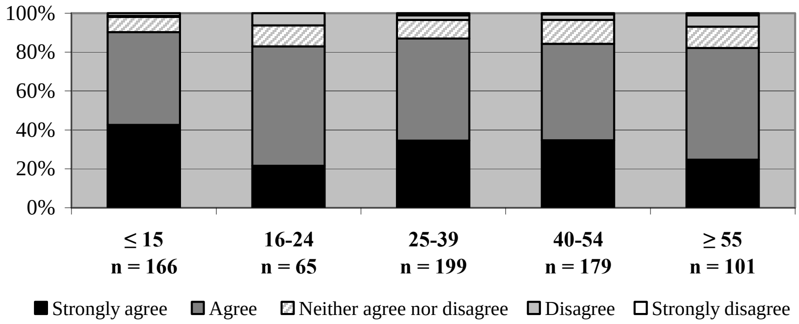
Political Preferences



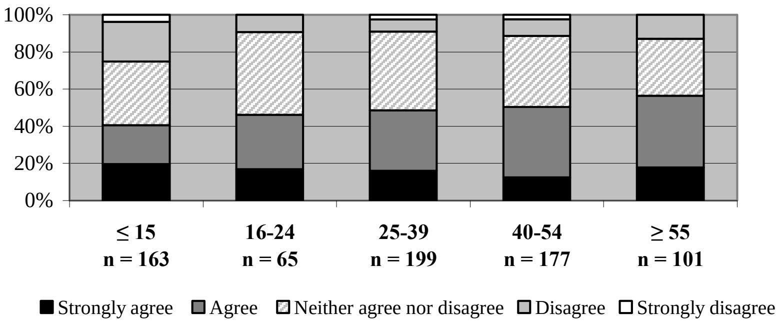


Attitude items

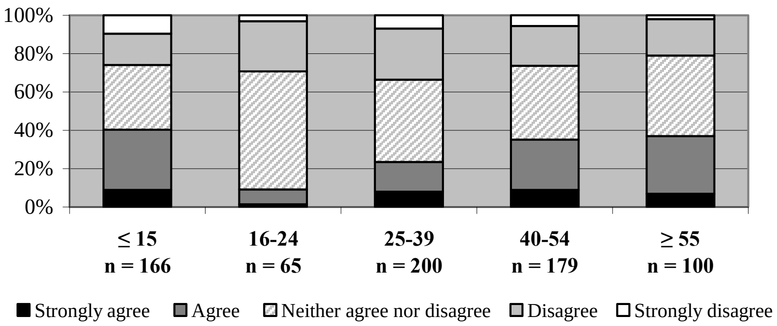
Attitude item Risk by Age



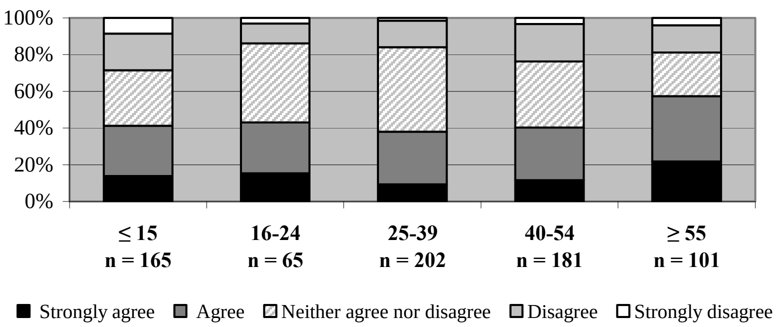
Attitude item UK positioning by Age



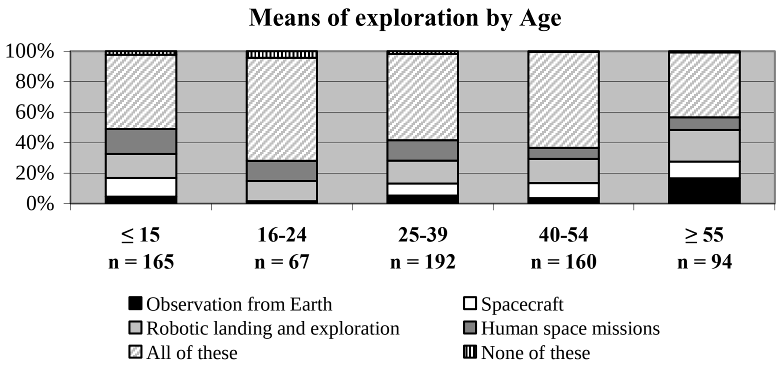
Attitude item Value for money by Age

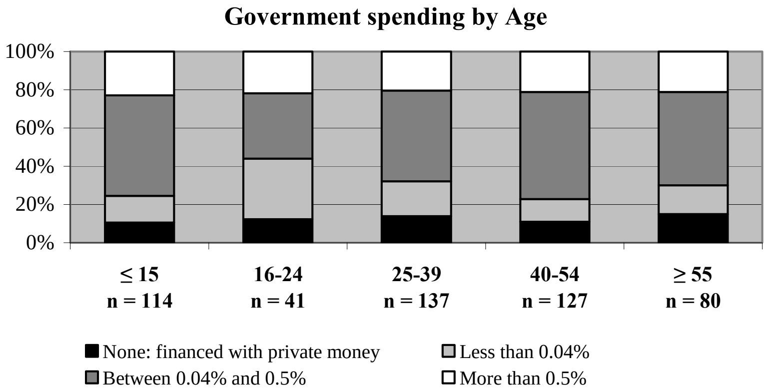


Attitude item Priority by Age

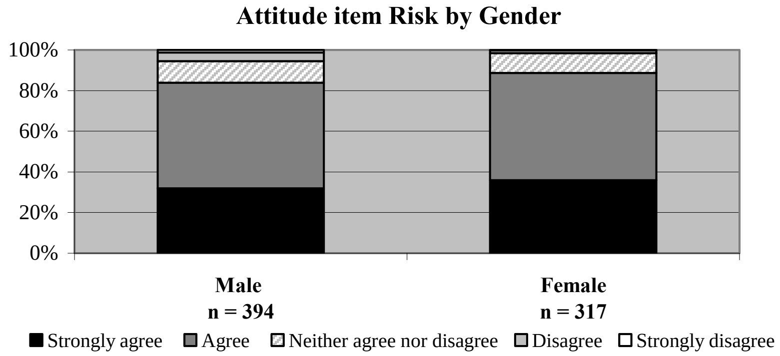


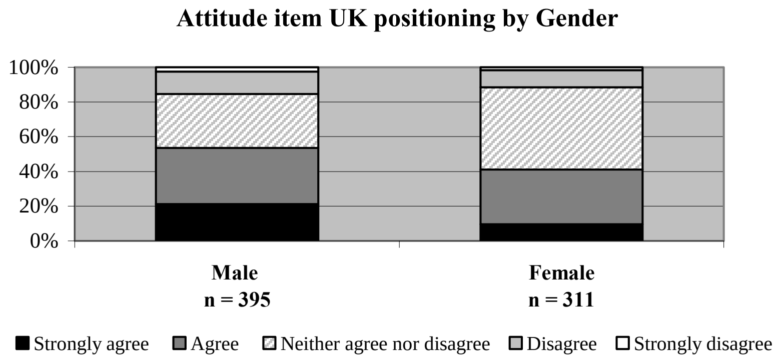
Political Preferences

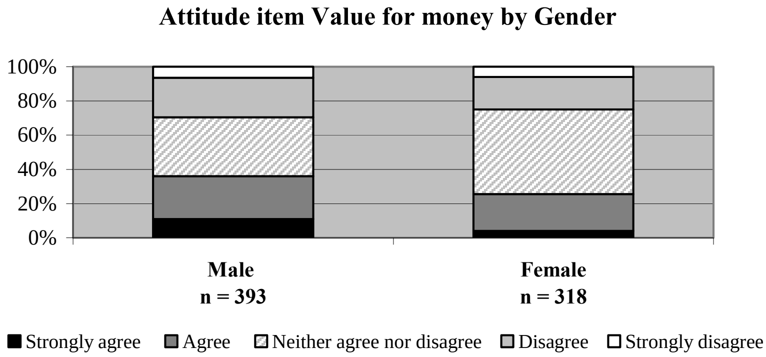


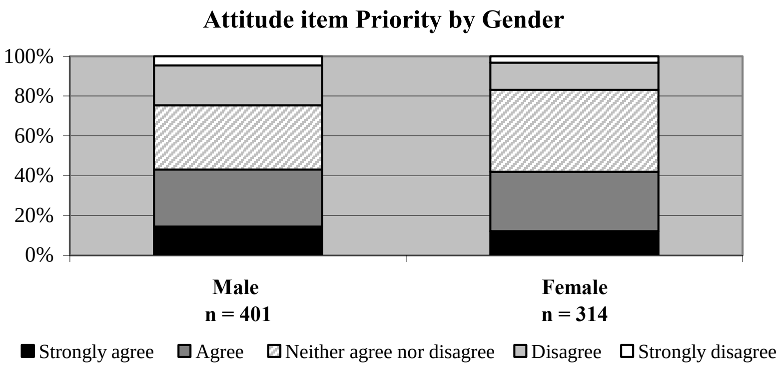


Attitude items

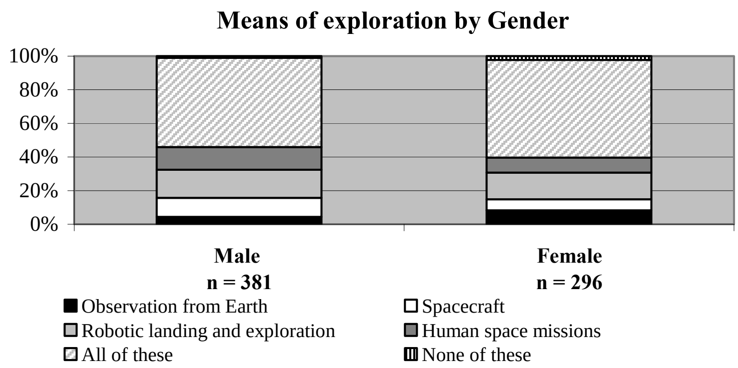


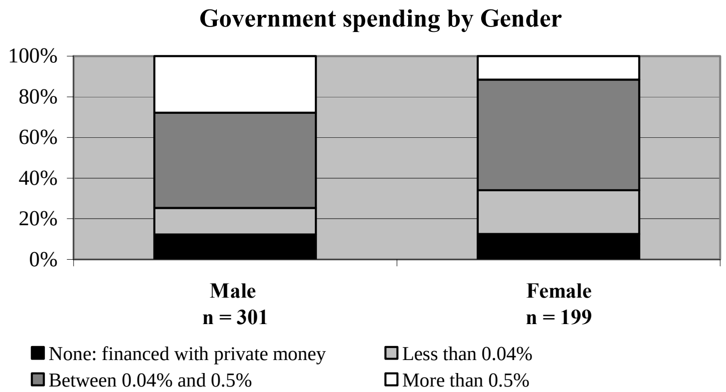




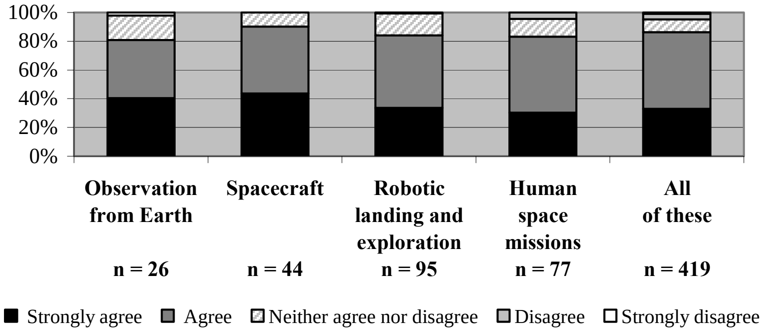


Political Preferences

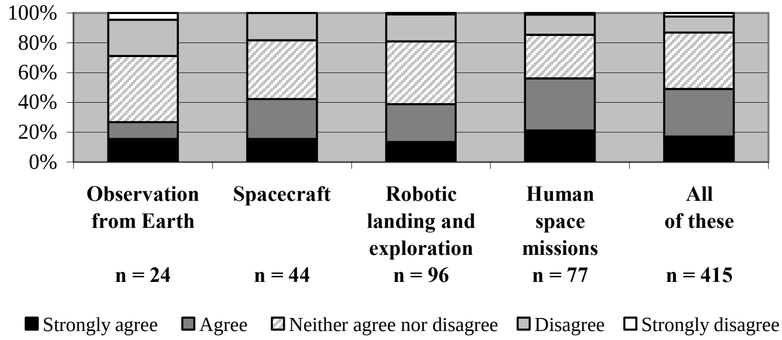




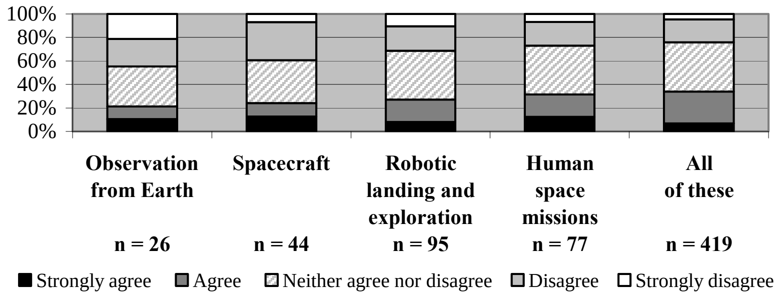
Attitude item Risk by Means of exploration



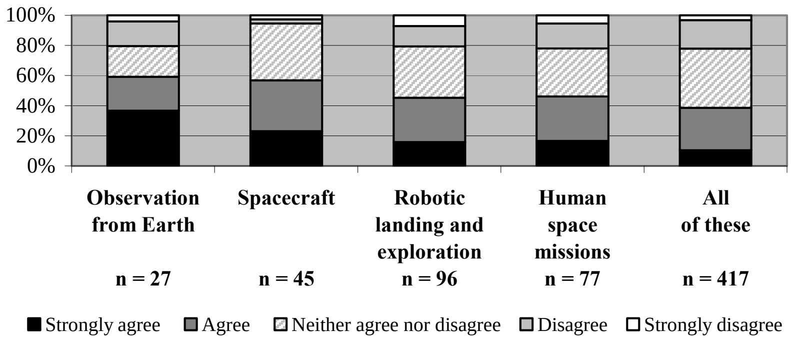
Attitude item UK positioning by Means of exploration



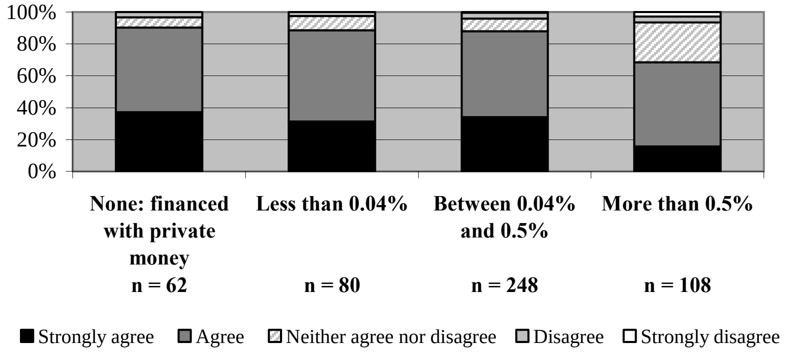
Attitude item Value for money by Means of exploration



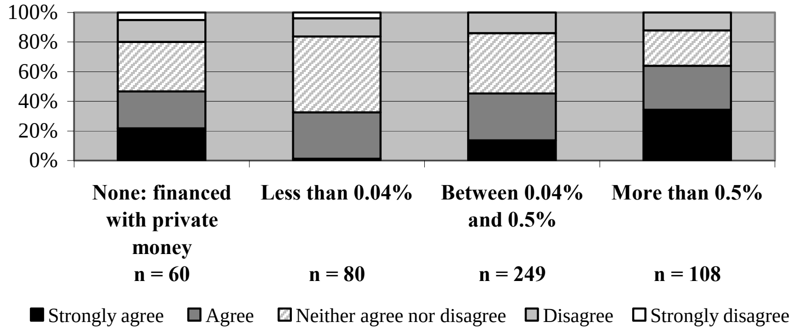
Attitude item Priority by Means of exploration



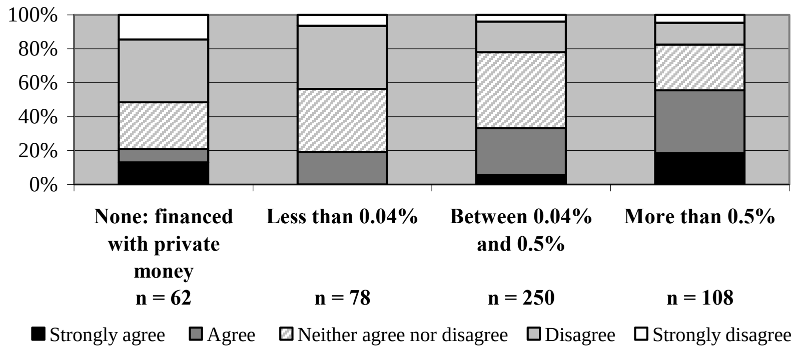
Attitude item Risk by Government spending



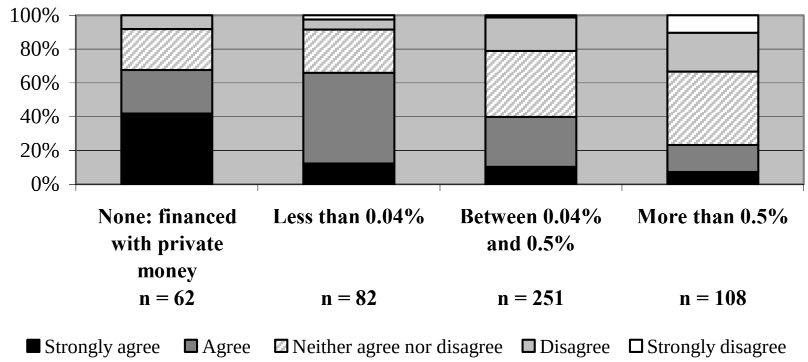
Attitude item UK positioning by Government spending



Attitude item Value for money by Government spending



Attitude item Priority by Government spending



Means of exploration cross with Government spending