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Preaching to the converted? An analysis of the UK public for space exploration

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Abstract
This article presents the results of a survey carried out at two space outreach events in the UK aimed at characterising "the public for space exploration" and measuring public support for space exploration. Attitude towards space exploration and policy preferences were used as measures of public support. The sample involved 744 respondents and was mainly composed of adults between 25 and 45 years old, with men slightly over-represented compared with women. Findings revealed that males appeared to be stronger supporters than females – men had a more positive attitude towards space exploration and stronger space policy preferences. Because mixed groups tend to come together to such events we argue that male respondents would be more likely to be part of the "attentive" and "interested" public who come to outreach activities and bring a less interested public with them.

Keywords
gender and science, political support for space exploration, public attitudes, public opinion, science communication, science outreach events, space exploration

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; National Science Foundation surveys, Eurobarometer surveys) as numerous bodies have recommended the development of sustained programmes of public engagement (e.g. Royal Society, 1985; EC, 2001, 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;

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Petersen et al., 2010). 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 to 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 study presented here empirically examines what, for want of a better term, we call "the public for space exploration" in the UK. Our purposes are i) to characterise the British audience attending space science outreach events in terms of *socio-demographic factors*, *rationales for exploration*, *belief in extraterrestrial life*, *attitude towards space exploration*, and *space policy preferences*, and ii) to examine the impact of their beliefs in extraterrestrial life, their rationale for exploration, their age and their gender on attitudes and space policy preferences, as measures of support for space exploration. Our work is based on the analysis of a sample of the British population attending two space science outreach events: the Royal Society Annual Exhibition in London and the National Space Centre in Leicester in the summer of 2008. It is not intended to be a purely academic study attempting to test a general theory of opinion formation but should be understood as an applied study with the purpose of describing some characteristics of the public for space exploration and some structures in the belief and attitudes of the people attending those events for the benefit of those doing practical science communication in the field of "space."

2. Previous studies of public attitudes to space and astronomy

In Europe, only two items related to astronomy and space have been included in surveys conducted by the European Commission (Eurobarometers 2001 and 2005) as part of questions regarding "interest in science and technology" and "image and knowledge of science and technology." For 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 more recent survey of 2005 only one in four respondents mentioned astronomy and space (23%) and this interest had grown from 17% in 2001 (Entradas and Miller, 2009).[1] For 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 to be. 70% regarded "astronomy" as being scientific, but 41% regarded "astrology" as being scientific as well. However, when "astrology" was replaced by "horoscope," that number dropped from 41% to 13%.[2]

Recent studies to investigate what people in the UK think about space exploration indicate that although there is general support (MORI, 2004; OST, 2005; Safwat et al., 2006; Research Councils UK, 2008), there is also increasing scepticism particularly amongst younger people. Surveys have shown that the younger generation has generally lost interest in space exploration and has little knowledge of space issues, especially of European space programmes and achievements (Ottavianelli and Good, 2002; MORI, 2004; Safwat et al., 2006; Jones et al., 2007). This also appears to be true in the US where the 18–25 year old generation has revealed considerable apathy towards NASA's space programme with the exception of Mars Rovers (Dittmar, 2006). A citizens' jury on space exploration was recently commissioned by the European Space Agency (ESA) in the

UK to engage the new generation of the space public born after the Apollo missions (under 35 years old) in the creation of ESA's long-term space exploration programme. This found that, although the participants generally supported the idea of exploring space, they valued space exploration in a rather complex way that reflected concerns regarding human space flight and the amount of money invested (Safwat et al., 2006).

Despite evidence that interest among younger generations has decreased in the last few years, both in the UK and the US, the longer term perspective shows that public awareness of space exploration has been increasing (Withey, 1959; Michael, 1960; Eurobarometer, 2001, 2005; NSF, 2002, 2010). Compared with the survey carried out in 1957 in the US 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. 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). Nevertheless, in the 20 years following Sputnik, public acceptance of the space programme had increased and support for government spending had improved steadily in the decade following the Apollo missions (Miller, 1984). Results of the major survey of attitudes towards the space programme and the US Challenger shuttle accident (1986) showed that the Challenger accident 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: 122). Although there have been ups and downs in the numbers of supporters over time, public support, as measured by the perception of the cost–benefit ratio, has stayed high in the US (NSF, 2002; Gallup, 2009). However, support for space exploration ranks relatively lowly compared with other areas of science, technology and medicine. The most recent *Science and Technology Indicators* data (NSF, 2010) showed that support for increased spending in space exploration is 14%, which contrasts with areas such as health care (75%) or environment protection (66%).[3]

In Europe and in the UK, particularly, there has been a notable increase in support for government spending. For instance, in 1988 43% of the British people 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 comparable data are not available, public support for government spending seems to have been rather stable in the UK: 65% of British people surveyed by MORI in 2004 disagreed that space research was a waste of money, while only 28% agreed with the statement (MORI, 2004).

Awareness and support for government funding seems to have increased in the last 30 years, but the question of to what extent space exploration, its benefits and applications are really understood by the public still remains unanswered. There are substantial differences in the level of public understanding of space exploration (e.g. Miller, 1983, 1992; Miller et al., 1997). Miller (1983) distinguishes three types of issue-specific "publics" according to their knowledge level and issue involvement: "attentive," "interested" and "residual" public.[4] 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" (NSF, 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). This cannot be simply 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 order of television 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 understand the public itself. Moreover, it is crucial to go beyond the categorisation 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. To date, however, almost no effort has been put into investigating significant variables that may influence public support of space exploration. So this study is aimed at understanding the public for space exploration and support for it.

3. Study design and research focus

This study comprised a sample size of 744 respondents; about two thirds from the National Space Centre sub-sample and one third from the Royal Society sub-sample. Given the locations at which our 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. According to the *Science and Technology Indicators (2008)* "involvement with S&T in informal, voluntary, and self-directed settings such as museums, science centers, zoos, and aquariums is an indicator of interest in S&T" (NSF, 2008: 14). This means that we start with a number of hypotheses and assumptions, which we have used this study to test.

We *assumed* that our sample would over-represent people particularly interested in space exploration, i.e. in the terminology of Miller (1983) the "interested public" and the "attentive public": at least, the sample members were sufficiently "interested" to actively attend a space outreach event or science centre, or to accompany family members, teachers or friends who are. And, despite the widespread rhetoric about reaching the "general public," members of the attentive/interested public are often the people with whom science communicators and key players in engagement are, in reality, dealing. So a careful analysis of our survey data may provide a useful framework for thinking about appropriate communication strategies to reach different audiences and therefore to inform effective public engagement in space issues.

Previous studies have shown that attitudes to science and technology very often vary with gender, and that 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, 2010). This somewhat smaller interest of women in science and technology in general was also found to be true for space exploration issues. In Europe, men reported themselves to be 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% men vs. 2% women) and a two-times-larger male "interested public" (28% men vs. 14% women) for space issues (NSF, 2002: Volume 2, Appendix, Table 7-8, "Public attentiveness to science and technology issues"). Therefore, in this study it is reasonable to expect a more positive attitude towards space exploration and stronger support for space policy among male than female respondents. For example, we 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. Therefore, we also *hypothesised* that – overall – men in our sample would be stronger supporters of space exploration than women.

4. Methods

Administering our questionnaire

The questionnaire used in this study was distributed to visitors in the form of a postcard to be self-administrated and completed in about 5 to 10 minutes. At both locations, the postcards were handed to respondents individually while they were walking around the exhibits and they were asked to return them after the visit. This was the best approximation to a random sample we could manage to implement; clearly, methodological compromises had to be made regarding the rigidity of the sampling procedure in order not to disturb the science centres' routines, but we think that these compromises are more than compensated by the advantage that we study a real-life communication event. We obtained a response rate of 62% at the Royal Society Exhibition, and 71% at the National Space Centre. All the questionnaires were anonymous, and no ethical issues were identified.

As the survey was concerned with public support for space exploration and beliefs and rationales related to it, in developing the questionnaire, a set of questions was designed as indicators of the concepts *rationale for space exploration*, *belief in extraterrestrial life*, *attitude towards space exploration*, and *space policy preferences*. In this context, the latter two concepts (a) *attitude towards space exploration* and (b) *space policy preferences* are 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 operationalised as preferred *means of exploration* and support for government spending. *Belief in extraterrestrial life* was included as a relevant belief because the possibility of extraterrestrial life, friendly or hostile, has always been a significant topic in science fiction books and movies, making it a familiar and involving topic to almost everyone. These concepts were compiled into five closed questions as shown in Table 1. For some questions we draw on ideas of Neal (1994). Country of residence was also included as a question and the answers to it were used to exclude non-UK residents, which we thought would increase the "efficiency of the sample" (Floyd, 1993).

Analysis

Although it is not possible to determine the direction of the effects between variables with a single survey, in some cases we distinguish between independent and dependent variables on the basis of our working assumptions. For example, we *assumed* that it is more likely that *attitudes* would influence *space policy preferences* rather 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. Furthermore, we also *assumed* that an individual's *rationale for exploration* and *belief in extraterrestrial life* influence both *attitudes* and *space policy preferences*. However, while an individual's preferred *means of exploration* would be expected to influence preferences for *government spending*, the reverse is also possible. To analyse these relationships we defined *rationale for space exploration*, *belief in extraterrestrial life*, *age* and *gender* as independent variables, while *attitude towards space exploration* and *space policy preferences* were defined as dependent variables.

Table 1. Operationalisation of key concepts, indicators and frequencies of survey questions.

Concepts	Indicators	Frequencies		
Belief in extraterrestrial life	Do you think life has ever existed on other planets in our Solar System?	No (12%) Primitive life (47%) Higher forms of life (16%) DK (24%)		
Attitude towards space exploration	To what extent do you agree or disagree with the following statements about space exploration:	Agree	NA/D	Disagree
	Space exploration is very risky	(86%)	(10%)	(4%)
	It is important that the UK is at the forefront of space activity	(48%)	(38%)	(14%)
	Space exploration is good value for money	(31%)	(41%)	(28%)
	Space exploration is much less important than solving problems on Earth	(42%)	(37%)	(21%)
Rationale for exploration	What do you think is the MOST important reason to explore the Solar System?	New scientific knowledge (69%) Return value to the UK economy (6%) International cooperation (3%) Inspire new generations (16%) Engage the British society (6%)		
Space policy preferences	Do you think we should explore the Solar System with* …	Observation from Earth (6%) Observation from spacecraft (9%) Robotic landing and exploration (16%) Human space missions (12%) All of these (55%) None of these (2%)		
	How much of the national budget should be spent on space exploration?	None: Private money (9%) Less than 0.04% (11%) Between 0.04 and 0.5% (35%) More than 0.5 (15%) DK (29%)		

DK, don't know; NA/D, neither agree nor disagree.
*In this question multiple answers were possible, however only 37 respondents (5%) chose more than one answer (item). Each item of this variable was coded 0-No/1-Yes, so that all the answers were counted. Therefore the frequency column of the above table for this question presents the frequencies of responses rather than the frequencies of respondents. However, for the analysis these 5% were excluded.

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 you agree with the following statements": (1) "Space exploration is very risky" (*Risk*); (2) "It is important that the UK is at the forefront of space activity" (*UK positioning*); (3) "Space exploration is good value for money" (*Value for money*); and (4) "Space exploration is much less important than solving problems on Earth" (*Priority*). Items (1) and (4) are negatively phrased (i.e. agreement with the statements implies a negative evaluation of space exploration) while items (2) and (3) are positively phrased.

A Likert scale, based on the sum of the recoded values of the four items mentioned above, was provisionally created to measure attitude towards space exploration. As this scale only showed a poor reliability (Cronbach's Alpha = 0.43), however, we did not use the aggregate scale. Rather, we decided to use the four individual (attitude) items as ordinal measures of evaluation of different aspects of space exploration. Retrospectively, we explain the low internal consistency with inter-individually very different cognitive frames in which respondents develop their evaluation of space activities, and a variation in the meaning of some of the items dependent on the frame applied. These 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." That said, as Table 2 shows further in this article, that all four attitude items are associated with support for *government spending* for science exploration and *means of exploration* with values of Gamma or Cramer's V that have the expected signs. Thus it is reasonable to use them as attitudinal items, i.e. as measures of evaluation of space exploration.

Space policy preferences. Two kinds of space policy preferences were measured: *government spending* and *means of exploration*. Space policy preferences on *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%." Because enquiring about space exploration funding without anchoring 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).

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."

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 through technological progress," "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 a potentially influential belief. 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."

Analytical procedure

All variables were either nominal or ordinal. We used contingency tables, non-parametric tests (χ^2) and Cramer's V to determine relationships among nominal or between nominal and ordinal data.[5] For ordinal variables we calculated "Gamma" to measure the strength of bivariate associations. In all cases, a significance value of $p = 0.05$ was used as the critical value to reject the null hypotheses and accept the hypotheses about relationships being tested.

After the characterisation of the sample, the analysis was conducted in two steps: in the first step the relationships among the three indicators of support for space exploration – attitude items, government funding and means of exploration – (our dependent variables) were explored. In the second step the relationships between the independent and dependent variables were analysed with special emphasis on gender-specific differences in support of space exploration.

5. Results

Characterisation of the sample: the public for space exploration

A majority of the public attending space exploration outreach events was male (55.5% males, n = 408; and 44.5% females, n = 327). 23% of the surveyed visitors were children (younger than 16 years), 9% were young adults (16–24 years), 54% were between 25 and 54 years old (25–39 years: 29%, 40–54 years: 25%), and 14% were 55 years old or above.

The frequency distribution of the socio-demographic factors in both sub-samples was largely the same, which suggests that these characteristics are 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. Therefore, we do not distinguish between the two sub-samples in the statistical analysis and present an aggregated data analysis here.

Beyond demographic differences, the public for space exploration in the sample analysed also held different beliefs in the existence of extraterrestrial life, rationales for exploration, attitudes and space policy preferences (Entradas and Miller, 2010). For instance, a majority believed that life has existed or exists outside of Earth (63%), either primitive (47%) or higher forms (16%), and showed particularly strong expectations of the existence of life "beyond the Solar System" (25%) and on "Mars" (21%), while the Moon was almost disregarded as a possible host to life (2%).

Analysis of the public's attitude towards space exploration showed that nearly 9 out of 10 respondents (86%) saw space activities as "very risky." Four out of 10 (42%) agreed that space exploration is "much less important than solving problems on Earth," and nearly half of the respondents (48%) agreed that "it is important for the UK to be at the forefront of space exploration." As for value for money, nearly a third agreed that space is good value for money (31%), while almost half (41%) said "don't know."

The public for space exploration also held substantial expectations of the means of exploration: over 70% of respondents agreed that space should be explored using robots, 67% were in favour of human space missions, 64% of observation from spacecraft, and 61% of observation from Earth. As for government spending, there was a general feeling that government should finance space activities: about a half of respondents (50%) agreed that the current budget should be maintained or increased, while 11% agreed that the UK was spending too much in space activities and 9% that it should be funded by private bodies[6] (see Table 1 for frequencies of responses to survey questions).

Step 1: Relationships between indicators of support

Relationship between preferred means of exploration and government funding (space policy preferences). First, we analysed 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. 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 believe that space exploration should be funded by private companies. In fact, the frequencies showed that the majority advocating private money (56% of a total 55 respondents) were strong supporters of human space missions. However, whether respondents had in mind space research or space tourism, cannot be concluded from our 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 2 indicates, all relationships between the variables tested were in the expected direction and almost all were significant; however, the strength of associations varied.

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*. Attitude items *UK positioning* and *risk* showed significant relationships, although weaker, with government spending. Attitude item *risk* did not appear to have a significant effect on the *means of exploration* people supported. This finding is somewhat surprising, as we might have expected a clear relationship of perception of *risk* with a preference for less adventurous means of

Table 2. Effect sizes of the relationships between attitude items and space policy preferences (*government spending* and *means of 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.

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 1960s when astronauts landed on the Moon, the novelty, adventure and unknown consequences achieved a high public interest and awareness of space programmes 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).

The findings summarised in Table 2 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 with/rejection of 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 (see Table 1). 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 programme in the UK (in the sample analysed). The second factor strongly influencing the level of support for a costly space programme was the perceived benefit ("good value for money"). But here the levels of agreement and disagreement were almost equally high (see Table 1). 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.

Step 2: Relationship of rationales for exploration, belief in extraterrestrial life, age and gender with support

Rationale for 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* and *space policy preferences* showed that the 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 3).

In order to look closer at the relationships between *rationale for exploration* and *attitude towards space exploration* we treated the Likert-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 the 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.

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

Table 3. 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.*

	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
Belief in extraterrestrial life	0.07	0.18***	0.11	0.14**	0.16**	0.09
Rationale for exploration	0.12**	0.08	0.11**	0.09	0.16***	0.12**
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.
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.

scientific knowledge, regardless of the preferred means of exploration. However, those who saw space exploration as important to inspire new generations were also more likely to agree with more "complex" means of exploration, which may suggest that people see humans in space as capable of attracting new students to pursue scientific careers.

There is a significant relationship between *rationale for space exploration* and support of *government spending* (see Table 3). The details of that relationship are hard to interpret, however, since by far the majority of respondents see the generation of new scientific knowledge as the main rationale. Tentatively, because of the small group of respondents falling into that group ($n = 26$), the data suggest that respondents seeing "return value" as the major rationale for science exploration are more inclined to opt against government funding and in favour of private funding of space exploration. This group probably sees space exploration as a commercial enterprise and not as a scientific endeavour the support of which is a genuine task of public policy.

Belief in extraterrestrial life. The belief in life on other planets was significantly related to the attitude items *UK positioning* and *priority* as well as to *government spending*. However, it was not significantly related to the attitude items *risk* and *value for money*, or preferred *means of exploration* (see Table 3). People who believed that higher life forms might exist on 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. This suggests that discovery of life outside the Earth is seen in the context of national prestige and drives support for government spending. 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 the existence of higher forms of life on other planets were more likely to agree that higher amounts of government money should be spent in exploring space (see Figure 1).

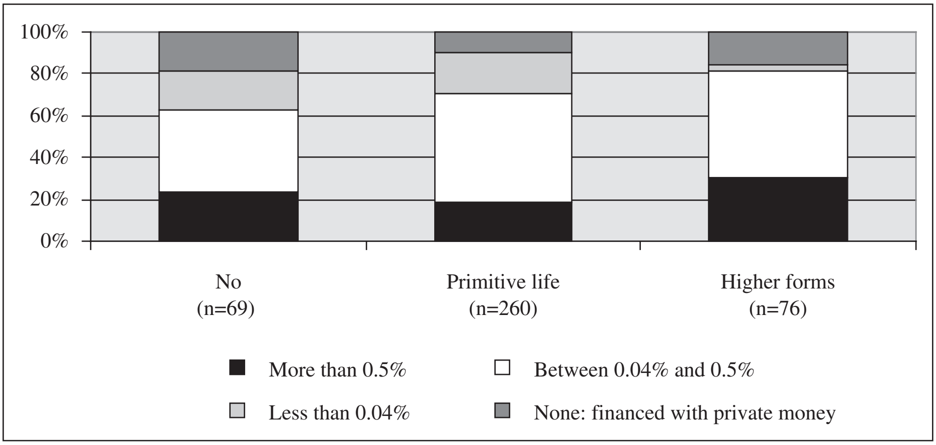

Figure 1. Government spending by belief in extraterrestrial life.

Age. Overall, variations of support for 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 was negatively associated with *age* (Gamma = −0.12**), a closer look revealed a non-monotonous pattern: respondents 15 years old and under showed the greatest concern (90% of this age group agreed with the risk statement), followed by the middle age groups (25–39 and 40–54), while young adults (16–24) and adults 55 years old and above showed the least concern (83% and 82% respectively). For the attitude item *UK positioning*, there was a weak positive association with *age* (Gamma = 0.10**).[7] Older age groups were more likely to agree that it is important for the UK to be at the forefront of space activities. We cannot fully explain the pattern of this distribution, but we found it plausible that generations ≥55 years old may have retained some enthusiasm from the Apollo missions in the late 1960s–early 1970s when they were children or young adults, which might have 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 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.

Gender effects. The analysis showed that support for space exploration – *attitude* 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 3 and Figure 2).

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 differ 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.

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% female vs. 10% male respondents agreed

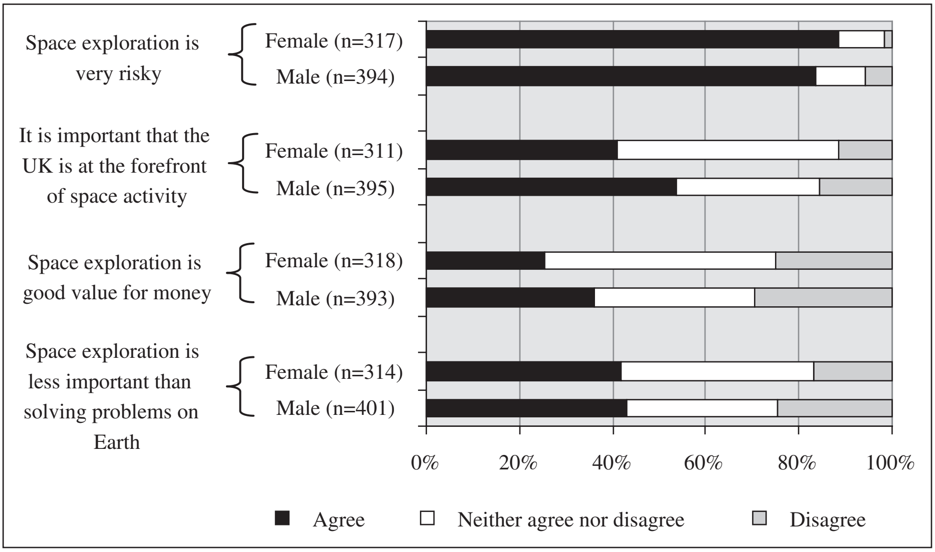

Figure 2. Gender differences in attitude items.

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%). 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.

6. Discussion

The purpose of this analysis was i) to characterise the British audience attending space science outreach events in terms of socio-demographic factors, 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*, were measured by means of self-administered questionnaires distributed at two space exploration outreach events in the UK. 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, and to address new audiences.

Our study shows that the (mostly attentive/interested) public for space exploration is already 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 activities should be funded by the government). Interestingly, a majority believes that life may exist, or may have existed, outside Earth (63%), particularly beyond the Solar System (25%) and on Mars (21%). The belief that life may exist on 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 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 showed some reservations about space exploration with respect to its relative importance compared with 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%). There was a strong association between the two *space policy preferences* measured – more complex means of exploration were associated with support for higher amounts of government spending for space exploration. Also, more positive attitudes towards space exploration related to stronger political support. 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.

The more the public valued space exploration economically, 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 our survey cannot be conclusive about the kinds of arguments that would increase public support for space exploration, it seems that discussing and communicating 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).

Support for space exploration in the UK is stronger among males than females, which confirms our hypothesis: males showed a more positive attitude toward space exploration, and more 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 European males (30%) were reported to be more interested in "Astronomy and space" than females (16%) (Eurobarometer, 2005) and also that the American "attentive/interested" public for space exploration is mainly male (36% of "attentive/interested" males vs. 26% females) (NSF, 2002).

7. Conclusions

Outreach activities could be thought of by science communication practitioners as situations that are characterised by "preaching to the converted." 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 to their communication offers, as our survey 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 supportive of space exploration. They may thus conclude that they need to reconfigure their efforts in order to address a less attentive/interested public that might be converted towards more interest in and support for space exploration.

When people visit science-related informal learning institutions they are quite likely to be in groups, however, or accompanied by family members or friends (NSF, 2008: 14). So our sample may well be composed of mixed groups such as couples or families where – given the gender differences shown up by our survey and others – males would be more likely to be part of the "attentive/interested" public while accompanying females would be more likely to be part of a less "attentive/interested" public. Similar arguments may be true for other kinds of groups such as school classes. If what we argue here is correct, "the converted" bring with them a number of "less converted," and these may be just the people that constitute the most relevant target group for outreach activities and science communication. Thus the social setting of the museums/exhibition visits brings together mixed groups usually composed of individuals with more, but also of people with less, interest in the subject than the general average. These situations appear to be excellent opportunities 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.

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Notes

1. These numbers refer to the average for the EU15 in 2001 and in 2005. There has been no recent survey including questions regarding astronomy issues.
2. 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.
3. Support for increased spending in space exploration rose from 11% in 2001 (NSF, 2002) to 14% in 2006 (NSF, 2008). This figure remained the same (14%) in 2008 (NSF, 2010), when other areas generated higher increases in public support.
4. For a general discussion of the concept of issue attentiveness, see Miller, Pardo and Niwa (1997).
5. Because small values of Cramer's V often correspond to quite large proportional differences between groups, the proximity of Cramer's V to zero can be misleading. It may happen that a Cramer's V of 0.10 provides a good minimum threshold for suggesting that there is a substantial relationship between variables. Cohen (1988) has suggested standards for interpreting Cramer's V according to the degrees of freedom. For $df = 1$, the criterion for interpretation is exactly the same as for interpreting a regular correlation; for $df = 2$, 0.07 is a small effect, 0.21 is a medium effect and 0.35 is a large effect; for $df = 3$, 0.06 is a small effect, 0.17 is a medium effect and 0.29 is a large effect. As this analysis comprises variables with a minimum of 4 columns or rows, the values for $df = 3$ will be used for interpreting the results.
6. In this question, 29% 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, or perhaps people really 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 those of 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.
7. 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).

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