

Research Article

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Attitudes towards the scientific search for extraterrestrial life among Swedish high school and university students

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Abstract

The aim of this study is to increase our understanding of the attitudes towards the scientific search for extraterrestrial life among high school and university students in Sweden. The most important results of the analysis are that: (a) the great majority of students believe that extraterrestrial life exists; (b) most students regard searching for extraterrestrial life to be quite important or very important; (c) very few students think that we should actively avoid searching for extraterrestrial life; (d) the most common motive for assigning a high priority to search for extraterrestrial life is that it is interesting, the most common motive for assigning a low priority is that such knowledge would not be practically useful, or that the money would be better spent elsewhere; (e) most students do not think they are very well informed regarding the search for extraterrestrial life. A higher percentage of the students who judge themselves to be well informed also believe that extraterrestrial life exists. We have also found some differences between subgroups (men/women, high school students/university students and different fields of study), but the differences are with few exceptions small in comparison with the overall trends, and they mostly differ in degree rather than direction.

Introduction

The *Washington charter for communicating astronomy with the public*, formulated at the *Conference on communicating astronomy with the public* in 2003 states the importance of outreach and education efforts. It also urges the scientific community to actively participate in, and universities and other research institutions to provide institutional support for such efforts (Billings 2006). In order for education and outreach to be effective, whether we talk about astronomy, or as in this case astrobiology, it is important to have an understanding, not just of the level of knowledge of a given group but also of their general attitudes towards the discipline in question, its research questions and its basic concepts. This has implications for several areas such as funding allocation, the educational and professional recruitment base and science communication.

In this study, we aim to present an indication of the attitudes among high school and university students in Sweden, towards what seems to be the most popular and inspiring part of the wider subject astrobiology, and even of modern space research in general, namely the scientific search for extraterrestrial life. To understand the attitudes towards a scientific field among students is important for several reasons. Firstly, it brings insights into how students perceive the field, its research questions, and the subject area in general. Secondly, it enables us to assess the level of interest in the discipline; and finally, it helps us understand how scientific enquiries shape public opinion and attitudes towards a given branch of knowledge. These are all aspects that affect, for example, the recruitment of future students. This, in turn, has a direct effect on university funding, either in the form of student tuitions, as is the case in many countries (including Sweden when it comes to non-EU students), or in the form of government money, which is partly based on the number of students. This type of knowledge is also important for research funding *per se*, since it indicates how researchers can justify their work to a wider audience. Finally, it can provide useful information for making decisions about how to design course components of school's science curriculum, as well as effective science communication and dissemination strategies.

The search for extraterrestrial life is a good test case since it is a field that evokes much interest among students as well as the general public, and since it is a field that encompasses many different scientific disciplines and even deals with questions that need to be considered in a wider societal context. Knowing and understanding the attitudes towards the scientific search for extraterrestrial life among students is of course also a matter of scientific curiosity for understanding the social aspects and public understanding of science in general and of astrobiology in particular.

We chose to concentrate our efforts on astrobiology for the following reasons:

1. Astrobiology education is often presented as a useful way to increase the interest and literacy in science among students (e.g. van der Meer *et al.* 2000; Staley 2003; Arino de la Rubia 2012; Fergusson *et al.* 2012; Domagal-Goldman *et al.* 2016). This means that a better understanding of student attitudes to astrobiology can have repercussions also for other science disciplines. Astrobiology is obviously wider than just the search for extraterrestrial life (Gargaud 2011), but the search for extraterrestrial life is one of the centrepieces of astrobiology and it is the part that is most well-known and that tends to attract the most attention. It was, therefore, the most obvious choice for a questionnaire that had to be rather limited in size.
2. Even though studies show that astrobiology is one of the most popular research areas among young people, there is a shortage of studies targeting student attitudes towards astrobiology in more detail (Hansson & Redfors 2013). Most studies that explore public attitudes to space research do not include astrobiology (see e.g. Launius 2003; Cook *et al.* 2011; Lee 2015). Some studies have been performed regarding students' knowledge and understanding of facts, theories and concepts in astrobiology (e.g. Offerdahl *et al.* 2003; Foster & Drew 2009; Arino de la Rubia 2012; Hansson & Redfors 2013) or how astrobiology education and outreach affect students' interest in studying or pursuing a future career in science (e.g. Brake *et al.* 2006; Foster & Drew 2009; Fergusson *et al.* 2012; Dougherty *et al.* 2014). There have also been studies focusing on other target groups than students (e.g. Dartnell & Burchnell 2009; Nadeau 2013), but essentially no work has been done regarding students' attitudes towards the search for extraterrestrial life as such.
3. Astrobiology is the scientific discipline that investigates the origins, nature, existence and the search for life beyond earth (Gargaud 2011). As such it incorporates many other disciplines and it approaches some of the oldest and most intriguing questions to the human mind. At the same time, astrobiology is a relatively young branch of science, whereas the roles of science communication, as well as themes of public understanding of, and social engagement with, astrobiology, are of high importance.

Materials and methods

The data were collected using a one page paper questionnaire distributed among high school students (grades 10–12, ages 16–19) and university students in Sweden. The questionnaire was distributed and collected by the teachers who were also instructed to inform the students that participation in the study was optional. The questionnaire contained a short note on its purpose, and also the URL to the project website. In order to incentivize the students to participate, a book price was drawn among those who answered the questionnaire and also submitted their e-mail address with the questionnaire. The paper slips with the e-mail addresses were not handled together with the questionnaires but used solely for the lottery and then destroyed.

Students from the following educational institutions participated in the study:

- Universities: Lund University, Linköping University, Malmö University and the Royal Institute of Technology (Stockholm).
- High schools: Europaskolan (Strängnäs) and Filbornaskolan (Helsingborg).

For the analysis, the students were divided into subgroups according to the education level, gender and primary field of study. The questionnaire was answered by a total of 512 students, out of which 366 were university students and 146 were high school students, 284 of the respondents were women and 222 men, 154 were science majors, 125 humanities majors, 158 social science majors, 74 medicine/health science majors and 55 engineering majors. These divisions were performed for both university and high school students. Some students indicated two majors, in which case their answers were included in both subgroups. None of the respondents indicated more than one gender, but some choose not to answer this question.

In addition to the demographic questions, students were also asked the following questions aimed at revealing their attitudes towards the scientific search for extraterrestrial life:

1. *Do you think there is life outside our own planet? (Yes/No) (Table 1, see also Table 3).*
2. *How informed would you say that you are regarding the scientific search for extraterrestrial life? (A, Very well informed; B, Relatively well informed; C, Somewhat informed; D, Not that well informed; E, Don't know anything about the subject) (Table 2, see also Table 3).*
3. *How long do you think it will take before we find life outside our own planet? (A, Maximum 10 years; B, Maximum 50 years; C, Maximum 100 years; D, More than 100 years; E, Never) (Table 4).*
4. *How important do you think it is to search for extraterrestrial life? (A, Very important; B, Quite important; C, Does not matter; D, Something we should not prioritize; E, Something we should stay away from) (Table 5).*
5. *What is the primary reason for your answer to (the previous) question? (Open-ended question) (Table 6).*

The questions and alternative answers were formulated in Swedish. We opted for students' mother tongue in order to avoid language barriers as a possible source of misconception

Table 1. Do you think there is life outside our own planet?

| | Yes (%) | No (%) |
|-------------------------|---------|--------|
| University students | 91 | 9 |
| High school students | 89 | 11 |
| Women | 90 | 10 |
| Men | 90 | 10 |
| Science majors | 93 | 7 |
| Humanities majors | 93 | 7 |
| Social science majors | 89 | 11 |
| Medicine/health majors | 87 | 13 |
| Engineering majors | 85 | 15 |
| Total (<i>n</i> = 492) | 90 | 10 |

N = 492.

Table 2. How informed would you say that you are regarding the scientific search for extraterrestrial life?

| | Very well informed (%) | Relatively well informed (%) | Somewhat informed (%) | Not that well informed (%) | Do not know anything about the subject (%) |
|------------------------|------------------------|------------------------------|-----------------------|----------------------------|--|
| University students | 3 | 4 | 22 | 46 | 26 |
| High school students | 8 | 9 | 24 | 46 | 14 |
| Women | 3 | 3 | 17 | 49 | 28 |
| Men | 6 | 7 | 29 | 41 | 16 |
| Science majors | 7 | 11 | 28 | 43 | 11 |
| Humanities majors | 5 | 5 | 25 | 47 | 18 |
| Social science majors | 4 | 3 | 14 | 50 | 30 |
| Medicine/health majors | 3 | 4 | 27 | 36 | 30 |
| Engineering majors | 0 | 0 | 22 | 49 | 29 |
| Total (=510) | 4 | 5 | 22 | 46 | 22 |

N = 510.

and to make it easier for students to answer the questionnaire, and thus achieve a higher response rate.

We did not supply any more detailed definitions of what was meant by ‘extraterrestrial life’, ‘search for extraterrestrial life’ or ‘scientific search for extraterrestrial life’. We decided not to use the word ‘astrobiology’ because we did not know whether the respondents would understand the meaning of the word. Lengthy explanations were avoided in order to keep the questionnaire short and simple, and as a result fast and easy to fill out. It is quite likely that different respondents were thinking of different life forms (e.g. microbial versus intelligent) as well as different methods for searching for extraterrestrial life (e.g. radio SETI versus Mars landers) when they answered the questions. This does not matter for our main question, since our aim was to better understand the attitude to the search for extraterrestrial life on a general level, though some probing questions regarding these issues would surely have helped interpreting some of the results of the study. This, in turn, indicates the need for further investigations regarding the type of life students imagine when thinking about extraterrestrial life.

The first question in the list above was formulated as a Yes/No-question. For the following three questions in the list, the

Table 3. Do you think there is life outside our own planet?

| | Yes (%) | No (%) |
|--|---------|--------|
| Students who consider themselves to be very well informed | 100 | 0 |
| Students who consider themselves to be relatively well informed | 96 | 4 |
| Students who consider themselves to be somewhat informed | 92 | 4 |
| Students who consider themselves to be not that well informed | 86 | 11 |
| Students who think they do not know anything about the subject (<i>n</i> = 490) | 77 | 17 |

N = 490.

respondents were given five ordered alternatives. Question 5 in the list above was designed as an open-ended explanatory, respondent focused question where the respondents were asked to formulate their own answers. One reason for using an open-ended question was to give the students the opportunity to answer in their own words and to express their own motivations. Another reason was that we expected that we would not be able to anticipate all possible motives. This was particularly useful in order to minimize the role of research biases, especially in the qualitative analysis.

The data were analysed by Excel 2016 for Windows and R 3.2.4 for Windows. The statistical significance was calculated through χ^2 tests.

No ethical review was needed for this study.

Results

Belief in life outside our planet (Table 1)

A total of 492 students (96% of the total number of respondents) answered this question – 352 of those who answered the question were university students and 140 high school students. 271 were female and 216 were male. 149 of the respondents to this question were science majors, 120 humanities majors, 150 social science majors, 71 medicine/health majors and 54 were engineering majors.

The analysis revealed that 90% of those who answered this question believed there was life outside our own planet. When dividing the respondents into different categories, we also found that in every single subgroup a vast majority (85–93%) of the respondents believed that there is extraterrestrial life outside our planet. We did not find any statistically significant differences between the subgroups (in terms of education level, field of study or gender).

Students’ self-assessment of how well informed they are regarding the scientific search for extraterrestrial life (Table 2)

This question was answered by a total of 510 students, that is, by nearly all respondents – 366 of those were university students and

Table 4. How long do you think it will take before we find life outside our own planet?

| | Maximum 10 years (%) | Maximum 50 years (%) | Maximum 100 years (%) | More than 100 years (%) | Never |
|-------------------------|----------------------|----------------------|-----------------------|-------------------------|-------|
| University students | 7 | 24 | 26 | 37 | 6 |
| High school students | 2 | 38 | 17 | 37 | 6 |
| Women | 5 | 29 | 25 | 36 | 5 |
| Men | 7 | 27 | 22 | 38 | 7 |
| Science majors | 3 | 32 | 18 | 41 | 6 |
| Humanities majors | 10 | 24 | 29 | 33 | 5 |
| Social science majors | 5 | 30 | 27 | 32 | 5 |
| Medicine/health majors | 7 | 25 | 32 | 33 | 4 |
| Engineering majors | 4 | 24 | 20 | 44 | 9 |
| Total (<i>n</i> = 506) | 6 | 28 | 23 | 37 | 6 |

N = 506.

144 were high school students. 282 were women and 222 were men. 152 were science majors, 125 humanities majors, 158 social science majors, 74 medicine/health science majors and 55 engineering majors.

Only a small fraction of the students, independently of the subgroup, described themselves as being very well informed or relatively well informed. The high school students typically assessed themselves to be better informed than what was the case with university students, and men typically judged themselves to be better informed than what was the case with women. When divided according to field of study, we found that science majors described themselves to be better informed than what was the case with the respondents from the other subject areas. Engineering majors, on the other hand, judged themselves to be less well informed compared with the judgements of other students. It can also be noted that the better informed the students judged themselves to be, the more likely they were to believe in the existence of extraterrestrial life (Table 3).

The differences in results between different subgroups were all statistically significant (education level: $P = 0.001$, gender:

$P = 5 \times 10^{-5}$, the area of study: $P = 0.0001$, the connection between how well informed the students judged themselves to be and their belief in extraterrestrial life: $P = 0.003$).

How long it will take to find life outside our planet (Table 4)

This question was answered by 506 students (99% of the total), divided by 362 university students and 144 high school students, 279 women and 221 men, 154 science majors, 122 humanities majors, 155 social science majors, 73 medicine/health majors and 55 engineering majors.

The most common assessment among all groups except for high school students was 'more than 100 years' (32–44%). For high school students, it was a close call between 'maximum 50 years' (38%) and 'more than 100 years' (37%).

Very few students chose the extremes – 'Maximum 10 years' and 'Never'. We can note, however, that a higher percentage of university students (7%) than high school students (2%) believed the search would be successful within the next 10 years. Among the different study areas, humanities students were the most

Table 5. How important do you think it is to search for extraterrestrial life?

| | Very important (%) | Quite important (%) | Does not matter (%) | Something we should not prioritize (%) | Something we should avoid (%) |
|-------------------------|--------------------|---------------------|---------------------|--|-------------------------------|
| University students | 12 | 36 | 25 | 23 | 4 |
| High school students | 24 | 40 | 19 | 15 | 1 |
| Women | 13 | 37 | 26 | 21 | 3 |
| Men | 19 | 38 | 20 | 19 | 4 |
| Science majors | 23 | 40 | 18 | 18 | 2 |
| Humanities majors | 14 | 37 | 37 | 26 | 0 |
| Social science majors | 15 | 39 | 25 | 18 | 3 |
| Medicine/health majors | 15 | 38 | 28 | 19 | 0 |
| Engineering majors | 7 | 28 | 39 | 20 | 6 |
| Total (<i>n</i> = 510) | 15 | 37 | 24 | 20 | 3 |

N = 510.

Table 6. What is the main reason for your answer to the previous question?

| | Interesting (%) | Uninteresting (%) | Useful (%) | Useless (%) | Economic reasons (%) | Other (%) |
|-------------------------|-----------------|-------------------|------------|-------------|----------------------|-----------|
| University students | 34 | 9 | 17 | 26 | 11 | 14 |
| High school students | 45 | 7 | 25 | 19 | 9 | 15 |
| Women | 40 | 10 | 16 | 29 | 10 | 11 |
| Men | 33 | 6 | 25 | 18 | 12 | 18 |
| Science majors | 45 | 3 | 21 | 23 | 10 | 15 |
| Humanities majors | 44 | 5 | 13 | 26 | 12 | 12 |
| Social science majors | 29 | 13 | 25 | 21 | 9 | 14 |
| Medicine/health majors | 36 | 7 | 18 | 31 | 9 | 13 |
| Engineering majors | 29 | 13 | 16 | 16 | 18 | 20 |
| Total (<i>n</i> = 444) | 37 | 8 | 20 | 24 | 3 | 14 |

N = 444.

optimistic in this respect. Ten per cent thought the search would be successful within 10 years. Most pessimistic regarding success within 10 years were science majors (3%). Less than 10% of any group thought that the search would never be successful. The most pessimistic were engineering majors where 9% thought we would never find extraterrestrial life, while medicine/health majors were least pessimistic in this respect (4%).

The difference between university students and high school students, and among different study areas was statistically significant ($P = 0.004$ and 1×10^{-26} , respectively). There was no statistically significant difference between men and women.

The importance of searching for extraterrestrial life (Table 5)

This question was answered by close to all respondents, namely 510 students, divided between 365 university students and 144 high school students, 281 women and 222 men, 151 science majors, 125 humanities majors, 158 social science majors, 74 medicine/health majors and 54 engineering majors.

The most common answer among all groups except for engineering and humanities majors was that it is quite important. For the humanities majors, it was a tie between 'quite important' and 'does not matter' (37% for each answer). For the engineering majors, the most common answer was 'does not matter' (39%) with 'quite important' in second place (28%).

The percentage of respondents who thought it was very important to search for extraterrestrial life differed considerably between high school students and university students. Almost one in four high school students (24%) but only about one in eight (12%) of the university students thought it was very important. There was also a large difference between science majors who were the most (23%) and engineering majors who were the least (7%) prone to think that it was very important to search for extraterrestrial life. All the other study areas were fairly well collected in the middle range (14–15%).

Very few respondents in all subgroups (0–6%) thought that search for extraterrestrial life was something we should actively avoid. Not a single humanities or medicine/health major and very few of the others gave that response. Most hesitant were the engineering majors but even in this group the percentage of students who thought we should avoid searching for extraterrestrial life was very low (6%).

Only the differences between university students and high school students were statistically significant ($P = 0.001$) for this question. Even though the differences between study areas were sometimes relatively large, the differences were not statistically significant.

Motives (Table 6)

The respondents presented a variety of motives for their answers to how important they thought it was to search for extraterrestrial life. The motives were grouped into six categories:

1. Interesting (e.g. 'interesting in its own right', 'cool');
2. Uninteresting (e.g. 'I am not particularly interested in this so it doesn't matter to me', 'I haven't thought about it and do not find it exciting');
3. Useful (e.g. 'we can learn from them', 'exchange of knowledge');
4. Useless (e.g. 'what is the point', 'irrelevant to my life');
5. Economic reasons (e.g. 'we have more pressing problems to spend our money on', 'unnecessary expense');
6. Other reasons. This category consists of a number of different motives that were stated by too few students to count as their own categories in the statistical testing. It can roughly be divided into the following subcategories:
 - a. Low probability of success (e.g. 'because we will probably never find anything', 'why to look for something that does not exist?');
 - b. Risk (to us or to them) (e.g. 'they may be dangerous to us', 'we would just exterminate them');
 - c. Risk management (e.g. 'if there is extraterrestrial life it is important to find them before they find us', 'need to find somewhere we can move when our earth is no longer habitable');
 - d. Loneliness (e.g. 'I feel isolated', 'I long to meet an alien');
 - e. We are not ready (e.g. 'we do not have the necessary technology to search beyond our solar system', 'it will not happen until we are ready');
 - f. Sci-fi related (e.g. 'cf. the game Mass Effect', 'want to know if the worlds in Star Wars really exist').

The dominating category in total as well as for all subgroups was No. 1 'interesting'. No. 3 'useful' was the second most important positive motive (i.e. motive for assigning a high priority to search for extraterrestrial life) for all subgroups. The second most common motive overall, and most common negative motive (i.e. motive for assigning a low priority to search for extraterrestrial life), for all subgroups except for engineering majors was No. 4 'useless'. For the engineering majors, No. 5 'economic reasons' was the most common negative motive. For all other subgroups, 'economic reasons' was the second most important negative motive.

When we looked at the data in greater detail, we found that high school students were motivated by interest (45%) to a higher degree than university students (34%), and also that the former were motivated by the potential usefulness of finding extraterrestrial life (25%) to a higher degree than university students (17%). University students were, on the other hand, more often than high school students motivated by a judgement that the knowledge would be useless (26 versus 19%) and by economic reasons (12 versus 9%).

We could also note that women were more motivated by a judgement that finding extraterrestrial life was interesting (40%) or uninteresting (10%) compared with men (33% and 6% respectively), that men were more strongly motivated than women by the potential usefulness of finding extraterrestrial life (25 versus 16%) and that women were much more strongly motivated than men by its potential uselessness (29 versus 18%).

When divided based on major area of study, we found that science and humanities majors were the most likely (45 and 44% respectively), while social science and engineering majors were the least likely (29% for both) to find interest a major driving force behind their answers. Social science and engineering majors were also more likely motivated by the conviction that it was uninteresting (13% for both). Engineering majors were more likely than others to be motivated primarily by economic costs (18%) and by a low probability of success (9%) when deciding how important it was to search for extraterrestrial life. On the other hand, they were also the least likely to be motivated by a judgement that finding extraterrestrial life would be useless (16%).

Risk and low probability of success are quite often aired in the public discussion and mass media as motives for not engaging in a search for extraterrestrial life. In this study, both were present among the answers but none of them was particularly common in any of the subgroups (0–5% and 2–9%, respectively). The risk in the form of risk management was seen by some respondents as a reason in favour of searching for extraterrestrial life.

Only the differences between men and women were statistically significant ($P = 0.003$).

Discussion

Belief in extraterrestrial life outside our planet (Table 1)

The fact that an overwhelming majority of students believe that there is life outside our planet clearly indicates that the idea of life existing outside our planet is very well established in the student body. We have also observed that there is no significant difference between student groups, either between high school and university students, between male and female students, or between different fields of study. This indicates that the confidence that life exists outside our planet is both high and quite independent of gender, study level and major field of study.

Even though we explicitly asked about life outside our planet and the question was asked in a questionnaire dealing with attitudes towards the scientific search for extraterrestrial life, we can of course not know whether some of the respondents were actually thinking of extraterrestrial life visiting the Earth rather than about the life we are looking for off our planet. This could be the target of future studies. Another question arising from these results that would help us understand the respondents' attitudes to the search for extraterrestrial life, and that needs to be targeted for further studies, is why the respondents believe or not believe in the existence of life outside our planet.

Students' self-assessment of how well informed they are regarding the scientific search for extraterrestrial life (Table 2)

When it comes to how well-informed students assess themselves to be, the result is much more to the negative. For obvious reasons, it is not possible to draw any conclusions regarding how well informed they actually are based on this type of self-assessment. Yet, what is relevant here are their attitudes and the result strongly indicates that most students do not feel very well informed. This, in turn, indicates that there is room for more outreach and education efforts regarding the scientific search for extraterrestrial life, in particular, since there seems to be a large gap between the large interest in the subject and the low degree to which the students feel informed about it.

The positive connection between students who describe themselves as well informed and their belief in extraterrestrial life is not very surprising. It is not clear, however, whether it means that being better informed or feeling better informed increases students' belief in the existence of life outside our planet, whether it means that a belief that there is life outside our planet make students feel better informed, or if it means that a belief in extraterrestrial life inspires students to find out more and to pay more attention to information about the search for extraterrestrial life. It can also be that other factors are driving both the belief and the feeling of being well informed on the matter.

The sum of percentages for 'yes and no' answers in some of the rows in Table 3 does not add up to 100%. This is because not everyone who answered the question of how informed they were, also answered the question of whether they believe in the existence of extraterrestrial life.

The finding that men's self-assessment of how informed they are, is more positive than women's seems to conform with general knowledge of gender differences regarding their own assessment of their level of knowledge (e.g. Miller *et al.* 2006; Ross *et al.* 2012; Litzler *et al.* 2014) and might be best explained by other factors than an actual difference in how informed the two groups are about astrobiology.

The high school students' judgement of how informed they are, is also higher than that of university students. This might be because university students have come to realize their limits to a higher degree than high school students. It can also be that the high school students, in spite of them studying different programs, have not yet specialized to the same degree as university students who probably have less time to learn about things that are not directly relevant to their studies. We have not looked into this question in any detail, however, and cannot propose a definite explanation for this difference. Either way, it is, just as with the gender difference, quite probably a general difference between the groups, and thus not directly related to the search for extraterrestrial life as such.

Interestingly, students of the classical ‘artes’, or curiosity based disciplines (science and humanities) judge themselves to be better informed than students from the more applied disciplines. Though not surprising, considering that astrobiological research typically is a curiosity-driven rather than applied discipline.

More research is needed, however, to determine which, if any, of the proposed reasons for the differences between groups (high school – university students, women – men and different study subjects), is correct. More research is also needed to determine the relation between the self-assessed level of knowledge and actual knowledge in the respective group.

How long it will take to find life outside our planet (Table 4)

The most common answer to how long it will take to find life outside our planet is ‘more than 100 years’. This might possibly be best explained by the so far lack of success in finding any life outside our planet. It should also be noted that despite being statistically significant, the difference between subgroups is not very large, with the exception of the two extremes (‘Maximum 10 years’ and ‘Never’).

The fact that only a small number of respondents think we will never find life outside our planet suggests that there is a certain optimism regarding the successful outcome of the search even though it might take some time to achieve a positive result.

The percentage of students who think there is no life out there is higher than the percentage (and also the absolute numbers, see Table 7) of students who believe we will never find life outside our planet. This finding is rather puzzling considering that it is possible to fail to find life even if it is out there, but not the other way around. It is particularly puzzling that this trend is consistent for all subgroups. Since the answers are anonymous we have no possibility of following this up by asking the students in question about their answers. Future studies could explore this motive. It would also be interesting in relation to our main question to know more about the reasoning behind all the respondents’ answers to this question.

The importance of searching for extraterrestrial life (Table 5)

The most common answer to the question of how important it is to look for extraterrestrial life both in total and among almost all

Table 7. Belief in extraterrestrial life versus belief in finding extraterrestrial life

| | No life to be found (%) | No success in finding life (%) |
|------------------------|-------------------------|--------------------------------|
| University students | 9 | 6 |
| High school students | 11 | 6 |
| Women | 10 | 5 |
| Men | 10 | 7 |
| Science majors | 7 | 6 |
| Humanities majors | 7 | 5 |
| Social science majors | 11 | 5 |
| Medicine/health majors | 13 | 4 |
| Engineering majors | 15 | 9 |
| Total | 10 | 6 |

subgroups is that it is quite important. This result clearly indicates that the interest in the matter is rather large. It can be noted, however, that for most of the subgroups, the slightly negative answers ‘does not matter’ and ‘something we should not prioritize’ taken together are more common than the more positive answers ‘Very important’ and ‘Quite important’ taken together. Perhaps this finding is not too surprising considering a large number of other worthwhile or even pressing research questions (such as climate change) one can engage in. In fact, considering this, the percentage of respondents who were to some degree in favour must still count as rather impressive. It should also be noted that very few respondents are expressively against searching for extraterrestrial life. All in all, the distribution of answers to this question seems to indicate that the present quantity of research aiming (explicitly or implicitly) at finding extraterrestrial life is probably not in excess of what high school students and university students like to see. If anything, there could be room for more such research to satisfy the interest in the question.

The only significant difference between subgroups regarding the question of how important it is to search for extraterrestrial life is between high school students and university students. High school students are in particular more prone than university students to answer that it is very important to search for extraterrestrial life and less prone to answer that it is something we should not prioritize. We can of course only speculate about why. It might be that as a university student, one’s values change slightly, or it might be that it is a generational difference, in which case we can expect that the new generation of students will carry this interest with them to university. This will have to be the subject of future studies. The most important conclusion here must be that the overall trend is the same in both subgroups.

In future studies, it would also be interesting to put this question into different contexts by providing the respondents the opportunity to compare the importance of searching for an extraterrestrial life with the importance of other issues, including other interest driven research as well as different projects of more practical importance. The challenge will be to do that in a way that does not convey the impression that we necessarily have to choose between astrobiology and other worthwhile projects.

Motives (Table 6)

We received many and varied motives for why the respondents answered the way they did to the question of how important they think it is to search for extraterrestrial life. The most important motive is a positive interest in finding out about extraterrestrial life, and the second most important motive is a negative assessment of the usefulness of knowledge about extraterrestrial life. Some examples of the former are motives such as: ‘Interesting!’, ‘Curious!’ and ‘An interest in understanding the world’. Examples of the latter are: ‘Irrelevant to my life’, ‘How will this affect our development?’ and ‘Because it just doesn’t interest me’.

We may also notice (even though the difference was not statistically significant) that interest plays a larger role for the artes (science and humanities) majors than for those majoring in the more applied disciplines, a result that seems to follow almost by definition from this division.

Economic concerns play a relatively strong role as a motive for being less enthusiastic about the search for extraterrestrial life. The search is described for example as ‘unnecessary expense’, ‘There are many other things to use our resources here on the

earth' and 'humans are starving or dying from diseases and I think we should put our money there first'.

It might be that the two most influential negative categories of motives, 'useless knowledge' and 'economic reasons', are in fact just different ways of airing the same concern. This is not something we can draw a definitive conclusion about based on the data, however.

Among the motives that are not common enough to be classified as their own categories, it can still be interesting to notice that risks seem to play a marginal role as motives for how high the students think we should prioritize searching for extraterrestrial life. This is not least important in relation to recent debates in popular media regarding potential risks involved in searching for extraterrestrial life (e.g. Moskowitz 2010; Schlesinger 2010; Westerberg 2010). We do not know if the fear for our safety that a small number of the students feel, is primarily triggered by a belief that the life we find will be in the form of infectious or invasive microbes or if it will be in the form of intelligent lifeforms with vastly superior firepower. It is clear from the answers, however, that not all who state 'risk' as the primary motivation for their answer were concerned about our safety. In some cases, the concern is instead for the safety of the extraterrestrial life, as one student put it 'we would just exterminate them'.

It is also worth noticing that risks are not only used as an argument against searching for extraterrestrial life. Some respondents have given positive answers to whether we should search for extraterrestrial life based on ideas of risk management. Some entertain the idea that if there are dangerous aliens out there, we need to be able to keep track of them. Others are motivated by an idea that one day we will have to leave our own planet because it will no longer be habitable. (Against the latter one might, of course, argue that for that purpose it is even better to find habitable but not inhabited worlds if they exist.)

Either way, it should be remembered that the fact that so few students state a risk as the primary motive for their answer does not mean that they do not care about the risks at all. Risks may still be an important motive even if it is not the main motive.

Another reported reason for not searching for extraterrestrial life that is relatively visible in the public debate takes the form of a low probability of success. This is, however, not a big motivational factor for the students, which of course fits well with the high percentage of students who have expressed belief in the existence of extraterrestrial life, and the low percentage of students who express the belief that the search for extraterrestrial life will never be successful.

The idea that popular science fiction is influencing the students' understanding of science (e.g. Barnett *et al.* 2006) also gets rather weak support with only a few answers along those lines. For example, one of the students wants to 'know if the worlds in Star Wars really exist'. There were not many answers of this kind, however. On the other hand, the study has not been constructed to test the role of fiction in the understanding of science and it is not unreasonable to assume that many of the students who did not explicitly mention science fiction as their main motive were still inspired by it at least to some extent.

Conclusions

A key finding of this study is that the majority (90%) of the 492 students responding to the question regarding belief in extraterrestrial life outside our planet believe that it exists. Another key finding is that a large proportion of respondents consider the

search for extraterrestrial life to be quite important, and only very few students think it is something we should actively avoid. The most common reason for why students think we should search for extraterrestrial life is that it is interesting. The most important reasons for why students think we should not search for extraterrestrial life is that such knowledge would not be practically useful or that the money would be better spent elsewhere. We have also found that most students do not see themselves as very well informed regarding the search for extraterrestrial life and those students who judge themselves to be well informed more often believe in the existence of extraterrestrial life. For further analysis, the students have been divided into subgroups according to their level of study, gender and major field of study. Some differences between subgroups (men/women, high school students/university students and different fields of study) are identified, but the differences are typically small in comparison with the overall trends, and typically matters of degree rather than direction. One tendency that could still be detected was that differences we did find between fields of study were typically not so much between STEM and humanities/social sciences but more between the interest-driven artes disciplines (science and humanities) and the more applied disciplines (e.g. engineering and social sciences).

The existence of a large gap between the positive interest among the students and how well informed they see themselves to be indicated that there is room for more science education programmes and outreach activities aimed at students concerning questions related to the search for life beyond our planet.

Some important conclusions were also reached regarding future research. We found a need to look more deeply into what kind of life students think of when asked about extraterrestrial life. We also found a need to follow up on why students believe in the existence of life outside our planet and to motivate their assessment of how long it will take before we find life outside our planet. In addition, we found a need to further investigate why different groups (men/women, high school/university students and majors of different fields) differ when it comes to how well informed they judge themselves to be regarding the scientific search for extraterrestrial life.

A natural progression of this work, in addition to taking on the questions mentioned above, is to also target students in different countries and other groups than students.

The insights about the students' perceptions of the importance of the search for extraterrestrial life gained from the study could be particularly useful in designing strategies for educating and recruiting students. In general, the results indicate that interest, usefulness and economy are areas that play a key role in students' attitudes regarding the importance of searching for extraterrestrial life. The focus on economy indicates that it might be important to explain how relatively little money is actually used in the search for extraterrestrial life. It has been shown that most Americans tend to overestimate NASA's share of the US national budget (Launius 2003; Cook *et al.* 2011). We have no numbers regarding our respondents' estimation of how much money is spent on the search for extraterrestrial life, but it might be a reasonable assumption that it is skewed in the same direction. However, if the aim is to increase the funding, a better strategy has to be to produce good reasons for why money used for searching for extraterrestrial life is actually money well spent, which brings us back to the previous point about it being interesting and/or useful.

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