English translation of Tancoigne, E. & Baudry, J. (2019). “La tête dans les étoiles ? Faire sens de l’engagement dans le projet de science participative SETI@home.” *Réseaux*, 214-215(2), 109-140. https://doi.org/10.3917/res.214.0109

STARS IN THEIR EYES?

Making sense of involvement in the citizen science project SETI@home[1]

Élise TANCOIGNE
Jérôme BAUDRY

Translated from French by Cadenza Academic Translations

[1] This study was funded by the project ERC/SNSF BSCGIO_158887, The Rise of Citizen Science: Rethinking Public Participation in Science (2015–2020), led by Bruno J. Strasser (University of Geneva).

DOI: 10.3917/res.214.0109

Whether they are counting birds (eBird), classifying photographs of galaxies (Galaxy Zoo), solving 3D puzzles (Foldit), or enriching medical databases (PatientsLikeMe), more and more people are getting involved in research projects in spheres as diverse as climatology, astronomy, medicine, and even history. While popular engagement in scientific production is nothing new, today's "citizen science" is steeped in a discourse that makes some particularly far-reaching promises (Strasser et al., 2019). Not content with "democratizing" science and reducing, if not eliminating, the gap between citizen and expert, amateur and professional, citizen science is also presented as a new way of producing scientific knowledge: more horizontal and decentralized, and therefore leading to more new ideas (Nielsen, 2011; Lievrouw, 2010). By creating the conditions for a completely new division of scientific labor, new information technologies play a central role in this discourse (Flichy, 2010). Ultimately, science may be just one more profession to be destabilized and then reconfigured by the internet, like journalism (Aubert, 2009), web development (Aguiton and Cardon, 2008), and even cartography (Haklay and Weber, 2008).

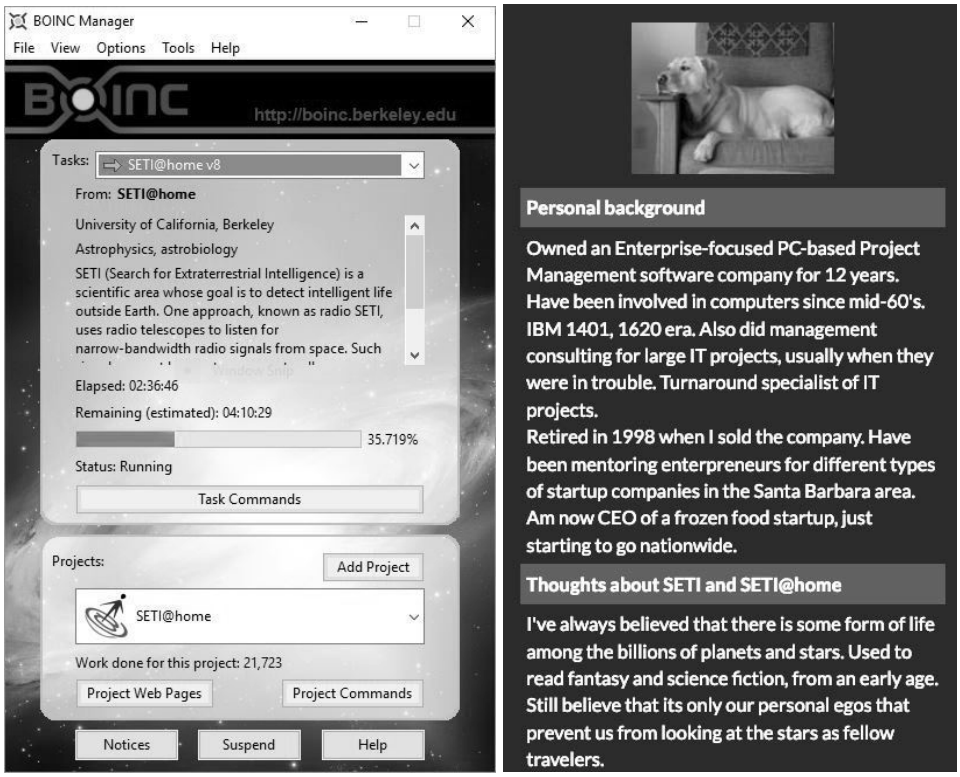
The reality is that the kind of "crowdsourced" science projects featured in the case study in this paper—top-down, with public participation limited to carrying out certain predefined micro-tasks within a framework determined by the researchers—may not be reconfiguring science as a professional activity so much as the role of the amateur scientist and the meaning that he or she attaches to that role. We might therefore wonder about the degree of continuity or discontinuity between traditional forms of participation in science and the digital experience offered by citizen science. What happens to amateur science when it goes online? Amateur science often takes the form of a long-term engagement that we might call "serious leisure" (Stebbins, 1992) or even, at its most intense, "devotee work," where the boundary between work and leisure becomes blurred. Astronomy (Stebbins, 1982), with its long tradition of amateur involvement, is a perfect example, as participants themselves have developed a hierarchy that not only distinguishes between "amateur astronomers" and "astronomy amateurs," but also pits "observers" against "armchair astronomers," regarded as occupying a more lowly position in the scientific pecking order (Williams, 2000). The act of observing (producing data, as opposed to passively consuming astronomical knowledge) is as crucial as the collective nature of the activity (compared to the solitariness of reading) in defining the amateur astronomer, a definition that implicates the participant in a system of moral and social regulation exercised by the community of peers (Howe, 2009).

But how do participants in online citizen science projects, in contrast, make sense of their involvement, in relation to both themselves and their peers? Is this involvement understood as a form of amateur science, or is it a category apart, with its own internal logics? Here, we approach these questions through a case study of a unique project, SETI@home (SETI being an acronym for Search for Extraterrestrial Intelligence), that stands out due to both its remarkable success and its compelling origin story that, through repeated retellings, has become part of the founding narrative of today's citizen science (Scoles, 2017). Launched in 1999 at the University of Berkeley in California, SETI@home harnesses a global distributed computing network that allows participants to analyze signals from space captured by the Arecibo telescope, in the hope of picking up traces of an alien civilization. The project, funded by Paramount as part of its publicity campaign for the film *Star Trek*, attracted more than 1.5 million participants in its first few months, far beyond the 100,000 anticipated by its creators (Benjamin, 2004). SETI@home is still going strong and since 2004 has been part of the BOINC platform (Berkeley Open Infrastructure for Network Computing), which brings together various distributed computing projects in fields including molecular biology, environmental science, and even particle physics, as well as astronomy and the search for alien life. Today, it takes the form of a lightweight application that participants install on their own computers after registering on the project website (an image of the user interface is shown in figure 1A). The site also provides information on the status of the project, the science behind it, and, in particular, its "community" of

citizen scientists.

Figure 1.

A - User interface for SETI@home in BOINC.
B - Example profile: participant no. 206



Source: screenshot taken by the authors.

Since the project was launched in 1999, participation in SETI@home has been framed as a collective activity that has given rise to a "virtual community" (Rheinold 1993): an amateur public enlisted with a view to popularizing a specific scientific vision and to fueling an enthusiasm comparable to the intense public interest once galvanized by space exploration (Benjamin, 2004; McCray, 2008). Membership of this virtual community is therefore not only a matter of donating spare computing power, but also involves earning points, perhaps joining a team, posting in forums, contributing to individual and collective performance rankings, translating the site into various languages, showing individual status with badges, and creating a public profile. All of these activities further the construction of a particular participant identity (Georges, 2009) that is inextricably declarative (through the production of a text, photograph, or alias), performative (through active engagement with the platform), and quantified (through the set of metrics that measure this engagement). Furthermore, these activities all leave multiple textual traces that offer a particularly rich source of empirical data, notably because this data has not been constructed through direct interaction with the researcher, as with traditional methods such as interviews, participant observation, and sociological questionnaires (Holohan, 2013; Curtis, 2018). These traces and the methods used to study them also differ from attempts to codify the motivations of participants in online citizen science projects, predominantly issuing from the fields of psychology or Human–Computer Interaction (HCI) (Jennet et al., 2014; Nov et al., 2014). Such studies intentionally reduce the dynamics of participation to the exercise of a form of disembodied individual rationality (regardless of whether the declared motivation is love of science, the sense of belonging to a community, or even the pleasure of an intellectual challenge). In contrast, we seek to situate these dynamics in relation to, first, the individual identities and forms of self-presentation that participants construct through their involvement and, second, the specific practices or

modes of participation in which they are invited to engage.

To explore how SETI@home participants forge their identities as participants, how they construct and showcase their individuality, and how they make sense of their involvement in a scientific project, we draw on a corpus of tens of thousands of profiles voluntarily completed over the years and linked to a series of activity metrics that serve as a public scoring system. We analyze this corpus using a distant reading tool (Moretti, 2013), namely the IRaMuTeQ program (Ratinaud and Déjean, 2009). This allows us to pursue a dual line of inquiry, looking at both the biographical information through which participants make sense of their involvement in an online science project and what makes it possible for them to form a meaningful community with other users of the platform. Our findings are presented in two stages. First, we offer a more detailed description of the source data and our chosen methodology, which allows us to identify five different modes of connecting self-presentation and involvement in an online science project. Second, we adopt a more qualitative approach to gain an in-depth understanding of two particular modes of constructing a participant identity, selected because they allow us both to extricate and question the delineation of the relationship between amateur science and online citizen science. The first mode embodies a fascination with the object of scientific inquiry itself (space), comparable to that of traditional amateur astronomers, while the second is concerned with a technological affinity for the very medium of the project (distributed computing), an affinity characteristic of the world of "makers," "overclockers," and other hardware enthusiasts.

IDENTITY AND INVOLVEMENT IN AN ONLINE CITIZEN SCIENCE PROJECT

In terms of its online presence, the SETI@home project is an intricate network; it spills over from the project's own website and the public profiles and forums that it hosts to an immense maze of websites. Some of these were created by the many competing teams, some by participants of a statistical bent interested in comparing, classifying, and showcasing the work of the most committed individuals or the highest performing teams. The result is a lattice of potential spaces in which participants can display and construct their identities. Yet, despite the number and diversity of these spaces, not all the connections between self-presentation and participant involvement are observed here. The discursive field of possibilities is primarily shaped by the highly specific demography of project participants, 90 percent of whom are well-educated males (see box: Who posts an online profile?) and who are much more likely to be employed in the IT field compared to the general population (Curtis, 2018). However, their options for showcasing their identities are largely centered around the participation metrics set by the project itself, which highlight certain forms of engagement to a greater extent than others. These metrics intricately blend accumulation, competition, and collaboration, and we need to start from here if we are to understand what it means to take part in an online citizen science project.

Collaboration, accumulation, and competition

Like many other collaborative platforms and online games, SETI@home is built on the logics of accumulation (Martin and Dagiral, 2016) and peer-to-peer competition. The platform rates each participant in various ways, some quantitative (for example his or her point score) and some ostensibly more qualitative (such as badges, which do not so much reward a given quantity of work as reflect the participant's rank in relation to others, indicating that he or she is in the top 1, 5, or 10 percent). Like motor racing, this is not just a competition between humans, but between human/non-human assemblages: human–machine dyads. The SETI@home culture differs to that of other citizen science contexts (such as mass science portals like Zooniverse or science-based games like Foldit or EyeWire) that tend to focus more on rewarding individual performance than on rankings, even if the latter are still considered important. Points are allocated through a calculation that distinguishes between "total

credit" and credit earned over the last thirty days ("average recent credit"). This formulation makes for dynamic rankings that allow the competition to unfold in real time, without unduly favoring long-term participants with higher accumulated capital. This competition quickly pushed participants into forming teams based on nationality (e.g. SETI.USA, SETI.Germany), institution (e.g. UC Berkeley, Boeing), or more personal characteristics (e.g. Raccoon Lovers).

As we will see, the process of constructing an identity as a participant in a citizen science project, and making that participation meaningful both for oneself and for others is not just about rehearsing normative visions of science—that is, engaging in a scientific endeavor as a commitment to the public good. It involves subscribing to a specific logic of participation as competition, a logic that comes with an entire system of representation that at times runs counter to the way science and research are understood by amateur scientists. To guide us in our inquiry into how participants themselves conceive their involvement, we took their written online profiles as our main unit of analysis (see box: Who posts an online profile? and figure 1B), together with the metrics published on the SETI@home website. These include data such as total number of points, team (if applicable), and the number of messages posted in discussion forums. Such profiles are visible to a large audience (all visitors to the website, in this case), in accordance with the "beacon" model in Dominique Cardon's (2008) typology.

Who posts an online profile?

In the period between the launch of the project in 1999 and 2016, SETI@home attracted a total of 4,754,118 participants.[2] The application was available as a stand-alone version called SETI@home Classic until 2004, when it migrated to a multi-project platform developed by its creators, BOINC. Two thirds of participants took part only through this earlier version of the program, while a quarter signed up directly on the BOINC platform. The remainder (8 percent) made the transition from SETI@home Classic to SETI@home on BOINC. Of the total number of participants, 99,343 (2 percent) have completed a personal profile (figure 1B). Each profile comes pre-divided into two sections: "background" and "thoughts about the project."[3] In the "background" section, new recruits are invited to share where they come from, their age, what they do for a living, what their hobbies are, and any other information they choose. In the "thoughts" section, they are encouraged to give their reasons for running SETI@home and their general observations on the project.

Participants who complete a profile are typically more heavily invested in the computational tasks (with a median of 660 points compared to 355) and more likely to be part of a team (61 percent versus 25 percent). They also tend to have been involved with the project for a longer period of time (a median of six years compared to one year for those who choose to remain anonymous).

The kind of information prized by sociologists or demographers (age, gender, profession, etc.) is scant. After assigning gender categories through automated coding based on a database of first names, and age categories based on regular expressions, we estimate this group to be 90 percent male, with a median age of 32 (around half of all profiles disclose the participant's gender and a third give his or her age).

[2] In order to qualify as a participant of SETI@home, an individual must have completed at least one computational task. We were given access to metrics for participants who registered under SETI@home Classic after contacting one of the project's founders. Data from BOINC is available to download on a daily basis. The two data sets were assembled in 2016.

[3] The only condition for completing a personal profile stipulated by the site is that the participant must have carried out at least one computational task in the preceding thirty days (in other words, he or she must have an "average recent credit" of at least 1). The same condition applies to those wishing to post in forums. This means that participants must have shown a degree of commitment to the work of the project before they can gain access to the site's social features.

We developed what we would describe as an exploratory approach to textual analysis, offering a framework that would resist preconceived ideas and allow us to develop our own interpretations of participants' words. Known as the ALCESTE method, this approach produces a diagram from the text that identifies common classes of words or "lexical worlds" (Reinert, 1983). It involves applying a particular form of statistical analysis to text segments cross-tabulated with words taken from a dictionary. By applying this method to our corpus (see box: Distant reading: Overview of a methodological path), we were able to identify a number of different lexical worlds within SETI@home associated with how participants present themselves and account for their choice to take part in the project.

Distant reading: Overview of a methodological path

We downloaded the available profiles of those who have taken part in the project since its move to BOINC (n=65,954), retaining only those written in English (n=39,699). As a general rule, these profiles are concise, with a median of 38 words (about three sentences); the limit initially set by the site was 2,000 words. The majority of profiles retained (61 percent) belong to participants who first signed up through the Classic program and have followed the project to its new home on BOINC. As IRaMuTeQ's text detection method is dictionary-based, we seeded this dictionary with specialized terms (such as "radio amateur"). These terms were identified beforehand by running a term extraction script on the full text of the profiles using the Cortext Manager program.[4] We also normalized the activity metrics (total number of points, number of forum posts) according to each participant's period of activity (in months).

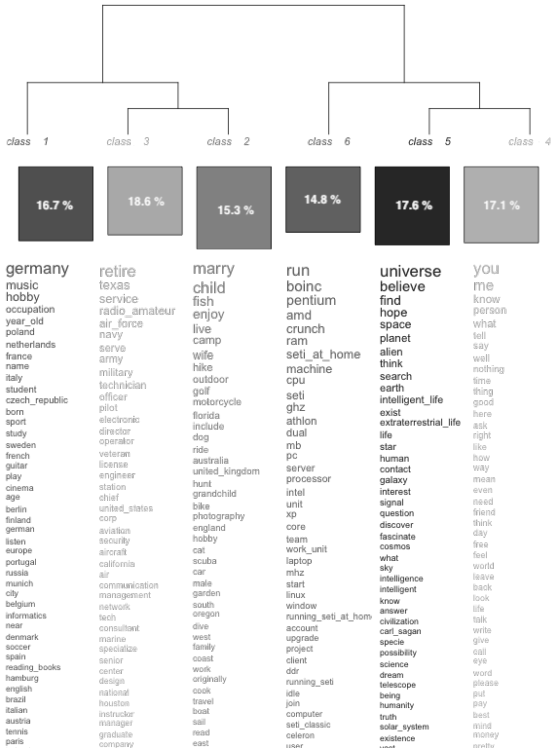
The first stage of analysis was focused on the "background" section, where participants identify themselves (figure 1B). Taking the entire profile as our unit of analysis, without splitting it into segments, we identified six main lexical classes that account for 87 percent of the corpus (see figure 2 for the final dendrogram and appendix A for further information on parameters). IRaMuTeQ automatically labels each class based on a set of additional variables—the individual activity metrics, in this case. The median age of participants in each class was also calculated. It is important to note that seventeen years elapsed between the launch of the project and the date on which we obtained our data. It is possible that some participants have matured with the project and amended their profiles accordingly, whereas others may have never updated their information. It is therefore difficult to account for how dynamics of engagement (or disengagement) with the project may have changed over time, or to demonstrate generational effects (Donnat and Lévy, 2007).

The second stage was to conduct a new analysis for each class, this time based on text segments from the "thoughts about the project" section, where participants are invited to explain their reasons or motivations for taking part (figure 1B). This section was simplified as part of the transition to BOINC; in the Classic version, participants were asked for their opinions about the existence of extraterrestrial life forms and how we might communicate with them[5] as well as their reasons for joining the project. Each of these additional classifications accounted for around 90 percent of its corpus (see appendixes B and C for the parameters of the classification and the dendrograms for two of the profile classes identified).

[4] Script "Terms extraction," see https://docs.cortext.net/lexical-extraction/. Accessed March 19, 2019.
[5] http://setiathome.berkeley.edu:80/user_profile/index.html. Accessed October 8, 2018 on http://web.archive.org/web/.

Figure 2. Classes identified by IRaMuTeQ

For our basic unit of analysis, we took the full profile rather than dividing it into segments. Further information on the parameters used can be found in appendix A. The words listed under each class are those most specific to that class, based on chi-squared values.



Source: IRaMuTeQ; analysis conducted by the authors.

Following the ALCESTE method, we identified five profile types (figure 2),[6] which we will call *family man*, *European student*, *retired technician*, *hardware hacker*, and *space buff*. The median ages of those in the *family man* and *retired technician* groups (38 and 39 years, respectively) are distinctly higher than those of the *European students* (28) or *hardware hackers* (29). *Space buffs* fall between the two, with a median age of 34. As we will see, the relatively low median age for *retired technicians* can be explained by another feature specific to this profile type.

Each of these profile types corresponds to a particular form of self-presentation and a particular pattern of activity, which shed light on both how people engage with the project and how they make sense of this engagement. Two in particular—*space buffs* and *hardware hackers*—strike us as crucial for understanding the continuities and discontinuities between amateur science and online citizen science. Before looking at these two profile types in greater depth, we will briefly present each type derived through the ALCESTE method.

[6] We have ignored a slightly different class that we might call *anonymous mavericks* (class 4, figure 2). These participants fill in profiles, but do so tongue in cheek. Rather than following the guidelines provided by the site, they use the space to display their wit or pose questions that mock the reader's curiosity. Invariably, these texts tell us nothing about their authors' interests or biography: "that's me," "I am me, you are not," "E.T., where are you?" "If you know me then fine, you know enough." The words "you" and "me" are the most characteristic of this class. Here, a dialectic is established between author and reader, locking them into a game of mirrors that allows the author to evade the disclosure demanded by the site.

Word of mouth, aesthetics, and curiosity

Those in the *family man* category present themselves primarily through their private lives: their family and their hobbies (figure 2, class 2).

> Im 31 years old. I live in the middel of Norway near to Trondheim. I have a wife and two fantastic kids. I love to be outdoors hunting, fishing, kayaking, skiing or just watching stars [...]. – *Profile no. 31364*[7]

These participants mention their wives, children, and grandchildren, often attaching a positive evaluation to their family circumstances: "happily married," "wonderful wife." The adjectives associated with this class are generally positive: "beautiful," "lovely," "sunny," "pleasant." Among the leisure activities mentioned, outdoor sports feature strongly: "fish," "camp," "hike," "golf," in direct contrast to the kind of indoor activity involved in SETI@home. For this group, compiling a personal profile is a chance to showcase a successful private life that helps them distance themselves from the "techie" image we might expect to find among participants in a distributed computing project. These participants tend to be lone wolves; while reasonably invested in terms of computational activity, they mostly work alone and not as part of a team. Their profiles conform to the guidelines provided by the site, and so they are also likely to respond to questions about extraterrestrial life; yes, they believe that aliens exist ("exist," "believe," "think"), but they are more circumspect about the possibility of communicating with them (the word "if" is strongly associated with this profile type).

A number of these *family men* signed up to SETI@home because they were drawn to the screensaver it offered and the idea of putting unused resources to good use. In the first few years of the project, SETI@home held particular appeal on account of the screensaver it made available to participants, at a time when these were not so easy to come by. The program runs while the computer is not otherwise in use, tracking its output in a dynamic graph, colorful and vividly designed. Here, two other logics of engagement come into play: one aesthetic and one utilitarian (the desire not to waste available resources). Other participants indicated that they were introduced to SETI@home by friends (often for the purpose of building up a team). Recruitment by co-option is typical of voluntary projects in general (Simonet, 2010). Here, it has less to do with enjoyment and more with giving (time, material resources, etc.). These profiles are a good match for the kind of participant envisaged by the project's creators. When asked what they think of SETI@home, they overwhelmingly respond that it is "important" and it allows them to "contribute," "participate," or "help" "science." Such rationales are found in other classes as well; in fact, all of the profiles studied invoke the social norm of the common good, typically found in accounts of volunteer activity (Simonet, 2010).

This comes through strongly in another of our five profile types, the *European students*, who also describe themselves in terms of civil identity but do so through the use of markers of geography ("Germany," "Poland," "the Netherlands," "France," etc.) and status, namely their status as students ("student," study," etc.) (figure 2, class 1).

[7] Profile numbers at the end of this and subsequent quotations have been assigned by the authors of this article. Any emphasis of particular words or phrases is also theirs.

> I come from **Czech Republic**, country often called **Heart of Europe**. I'm 22 **student of computer science** and boinc.cz team member. My hobbies are computers, **music, sport shooting and good movies** (esp. Czech and French). I like to search for alternatives, don't like to hear that only one way is right :-) – *Profile no. 19139*

European students state their first names and define themselves primarily by their country of origin and their student status. This form of self-presentation links back to both the competition between teams identified with particular countries and SETI@home's US roots. By declaring their (European) nationality, these participants signal their otherness on a platform developed in the United States. Cultural pastimes (Donnat and Lévy, 2007) typically favored by adolescents and young adults (reading, making music, watching movies, gaming, etc.) are also very well represented in this class. As with the previous profile type, these participants often mention a friend or colleague who introduced them to SETI@home, and they tend to make a more modest contribution than other groups.

Technology as a vocation and as a medium

A third type, the *retired technicians* (figure 2, class 3), brings together those profiles that mention both retirement and a career in a technical field (technician, engineer, pilot, etc.). These participants frequently refer to the US armed forces:

> Born in Brooklyn, NY a few years ago (1938) and now live in a very small town in Arkansas. **Aircraft mechanic and flight crew** in **the US Navy** and **retired** as an ADC [. . .]. Hobbies are Competitive pistol shooting, **woodworking, wine making**, helping folks and trying to learn computers **by running a small farm of them** in the BOINC system. Started with SETI in Aug.99. – *Profile no. 23199*

These references to the military undoubtedly explain the relatively low median age of this profile type, given that members of the armed forces can retire after fifteen or twenty years of service. In this type we also find a sizeable group of radio amateurs ("ham radio") in addition to various other skilled hobbyists, such as model makers and woodworkers. Writing about their involvement in the project, these participants stress their status as long-term contributors and the enjoyment that it brings them. Along with the *hardware hackers*, they tend to have been particularly early adopters. They earn the most points per month and are the most active in discussions about the potential benefits and risks of an alien encounter. *Retired technicians*' professional careers help them to position themselves and gain recognition (Casilli, 2012).

As for the *hardware hackers* (figure 2, class 6), their profiles are focused on their machines and the computational tasks themselves: "run," "pentium," "amd," and, indeed, "crunch," used as shorthand for the data processing work, are the terms most strongly associated with this class.

> Currently in school taking a **Java** Enterprise **Developer program**. I currently run Seti@Home at school 24/7 on an **Intel 1GHz/512MB RAM system** and at home on an **Athlon 1.0GHz/512MB RAM desktop** and a **900MHz/512MB RAM laptop. What else can I say?** – *Profile no. 8841*

These participants may refer to themselves and each other as "crunchers." What makes their involvement meaningful to them is the chance to show their computer equipment and the amount of data they can process. Their relationships with other participants are built on a common passion for computers and IT hardware. They contribute twice as much as the others in terms of computational tasks and are more likely to be part of a team. The appeal of the project for these participants has little to do with curiosity or aesthetic appreciation for its screensaver. On the contrary, a number of them indicate that their main motivations are enjoyment and competition:

> I started running SETI@HOME **to compete with two friends in work unit crunching**. They put up a

> **good fight**, but realistically **could not beat me**. Seti is a **fun** project, and I am glad that they have gone BOINC as it brings new possibilities to the program. Still, they will never capture the character of the original Seti, or **the fun of competing for time, speed, and numbers**. *Profile no. 2439*

Their enthusiasm for the project may, therefore, be an extension of their enthusiasm for what we might call the SETI@home apparatus—not only in the classical sense of technical apparatus, that of machinery, but in the broader sense of the global, competitive networked apparatus that it embodies.

Passion for space: Another logic of engagement

It is in the final profile type, the *space buffs* (figure 2, class 5), that we find those participants whose interests most directly align with the objective of SETI@home: astronomical knowledge. Observations about the search for intelligent life feature prominently in these profiles, and their authors display a keen and sometimes fanciful interest in space and the cosmos:

> Hi, my name is Chris and I come from Hannover/Germany. I'm very **interested in anything about space**. For example **extraterrestrial life, black holes, how begans a star** and everything else physical and biological about space [. . .]. – *Profile no. 33038*

Space is envisaged less as an object of scientific inquiry than the stuff of fantasy and dreams; it is the participant's own subjective construct that is at the heart of this discourse, rather than space itself. Here, participants often position themselves as the grammatical subject of verbs such as "believe," "hope," "find," or "think." Participants in this profile type tend to have fewer points than the others and are seldom affiliated with a team. They are less heavily invested in the computational tasks than the *hardware hackers*. In the "thoughts about the project" section, their reflections are often linked to themes of extraterrestrial life, although they also emphasize the idea of making a contribution: "help," "work," "part," "participate." This contribution matters to them, at least in discursive terms. In practice, they perform fewer tasks (and are almost certainly working with more modest hardware) than the *hardware hackers*.

From choosing a pseudonym to writing their profile (sometimes accompanied by a photograph), participants forge strategies to distinguish themselves first as individuals, then as groups (through teams). These strategies, in turn, are what mark out the various categories into which they fall (Béliard, 2009). They appear to reveal a more complex map of participation in an online citizen science project than we might expect if we were to assume such projects to be mere digital extensions of offline amateur astronomy. Still, it would seem reductive to regard their success as evidence of a new wave of public enthusiasm for science, contrary to the initial hopes of SETI@home's creators. Yes, there are plenty of new recruits to be found, but the majority of profiles—spaces where participants construct a public identity and account for their involvement—tell a story of co-option by word of mouth and curiosity about the medium itself (i.e., the aesthetic appeal of the screensaver) rather than an interest in science and astronomy. Even the substantial group of *space buffs* seem to be wedded to a fantastical vision of space that has little in common with the "serious leisure" interest of amateur astronomers. Moreover, their contribution fades into insignificance compared to that of another amateur group, the *hardware hackers*, who shoulder the bulk of the computational work carried out through the platform. Just like earlier communication systems (Beuscart, 2002), SETI@home attracts those who declare a passion for the apparatus itself, regardless of purpose: devotees of machines and competition between machines. While we do not mean to reify the analytical classes identified through the ALCESTE method, they do appear to be useful devices for further investigation, allowing us to gain a clearer understanding of the object of inquiry. The next section explores two of these classes in greater depth, representing two figures that seem to play a crucial role in the project: the *space buff* and the *hardware hacker*. In order to do so, we adopt a more qualitative approach that draws on empirical data derived from a purposive reading of participant profiles and discussion forums hosted on the main SETI@home website.

STARS IN THEIR EYES. UNEARTHLY FANTASIES

To what extent do participants in SETI@home invoke an interest in space and astronomy in making sense of their involvement, and in what ways is this interest expressed? What is the relationship between the pursuit of amateur astronomy and engagement with a distributed computing project aimed at producing astronomical knowledge? Do the two form part of a continuum of practices within the same field of "serious leisure" (Stebbins, 1992)? Stebbins explores the boundaries between leisure and work and the interlinkages between the public, amateurs, and professionals. He posits a continuum of activity running between two extremes: "dabblers" and "professionals," with "hobbyists," "apprentices," "journeymen," and "masters" in between (Stebbins, 1982). In the specific context of astronomy, this continuum can be coupled with an epistemic distinction adopted by amateur astronomers themselves, between "armchair astronomers," who indulge their passion mainly through reading and attending lectures, and "observers," who roll up their sleeves and set out to gather their own empirical data (Williams, 2000). SETI@home's *space buffs* both reflect and challenge these divisions, leading us to question the rigidity of Stebbins' classifications when we attempt to apply them to online citizen science. It seems clear that these participants are distinguished less by their degree of commitment, understood in terms of steps on a career ladder, than by their relative affiliation with different epistemic practices.

Never far from my telescope

> Hi! I am a 52 year young computer consultant from NJ. Ever since i was very young, i have walked around at night **looking at the stars**. I have tripped too many times to count doing this. I have always been interested in Science and **especially astronomy** and **ran a local Astronomy club** for 4 years. One of the **greatest thrills** I have ever had with **my telescope** was the first time. I **spotted comet Haley** in early December 1985. – *Profile no. 3123*

This participant has chosen to construct his SETI@home identity around the central motif of the telescope, a personal tool for observation that he is happy to transport in order to watch interesting astronomical phenomena unfold under the best possible conditions. His involvement takes on a collective and educational dimension through the astronomy club he has founded. However, the thing that marks him out as an amateur astronomer is his strong attachment to specific experiences of observation, whereas professional astronomers tend to see their observational findings as part of a normalized data series (Stebbins, 1982). References to telescopes and their use appear infrequently in the profiles studied but are systematically associated with the pleasure of observation. Very rarely, we find profiles that mention building telescopes—all belonging to men whose professional lives involve assembling optical or electronic instruments and who thus use the same skills in their hobby that they have acquired over the course of their career. It is striking that very few of the leading contributors to the project conform to this profile of an amateur astronomer who makes his or her own observations; there appears to be no correlation between the amount of effort put into SETI@home's computational tasks and that expended in other aspects of astronomy. There is virtually no real overlap between the practices of amateur astronomers and the kind of astronomy-based citizen science offered by SETI@home. The distributed computing that drives the project represents an astronomical epistemic practice with no connection to the core activities of the amateur astronomer, most notably with respect to observation. Moreover, among those profiles that do mention observational activity, there is no clear link with the field of professional astronomy (conferences, journals, etc.) of the kind we would need to see in order to classify their activities as "serious leisure," following Stebbins (1992), rather than mere "dabbling." In fact, within SETI@home, the identities of *space buffs* and their engagement with the project are played out on a rather different stage.

Geek culture: Sci-fi, Carl Sagan, and *Star Trek*

> Hello Earth! [. . .] When I was a little boy I always tried to watch the **Carl Sagan's TV-Series "Cosmos"** as it was broadcasted quite late in the evening. The **pictures** and the **used upcoming synthesizer music** for its **soundtrack** infected my 9 year old mind with the **wish to explore the universe** [. . .]. Since then I've viewn Carl Sagan's work as selfless, progressive and good for all mankind. [. . .] – *Profile no. 14663*

Participants often trace their fascination with space back to a specific individual, whether a brother, father, friend, or camp counsellor, who sparked a childhood interest in the cosmos through stargazing sessions or books. There is one name, however, that crops up again and again in these gatekeeper narratives: that of the American astronomer Carl Sagan. Sagan, who died at the end of 1996, two-and-a-half years before SETI@home was launched, is most widely known as the creator of a popular science series that aired in 1980, *Cosmos: A Personal Voyage*, and the author of a science fiction novel called *Contact*, published in 1985 and adapted for cinema a year after his death. This movie plays a crucial role in the system of representation displayed by many SETI@home participants, not only because its release happened to coincide roughly with the launch of the project but also because of its plot. It tells the story of an encounter between an alien civilization and a young female scientist listening out for signals from the Arecibo telescope, amid tight governmental and military scrutiny. More generally, Carl Sagan was instrumental in educating the public about astronomy, as well as the question of alien life, at a time when SETI research programs were funded by the US government (Garber, 1999). If we examine the lexical class associated with *space buffs*, it is clear that these participants have a particular affinity with a brand of popular culture that has grown up around science fiction literature and films (Onnion, 2016), and with a characteristically American zeal for science and technology (Hughes, 1989), both of which are invoked when they elucidate their interest in the SETI@home project.

The film *Contact* and the *Cosmos* series are not the only points of cultural encounter mentioned by project participants; the futuristic world of *Star Trek*, a foundational part of geek culture that helped bring it into the mainstream (Peyron, 2014) is a theme common to many profiles. From the very beginning, *Star Trek* won a broad fan base who have actively contributed to the series' longevity (Jindra, 1994). Just like the "Carl Sagan generation," (Davidson, 2000) these "fandoms" helped foster support for SETI@home in a way that traditional astronomy clubs and magazines could not (Coppa, 2006). The site contains a plethora of cultural products that participants have contributed to the SETI@home universe, including illustrations, screensaver graphics, poems, and even songs, like this elegy or epitaph for the defunct SETI@home Classic, now superseded by BOINC:

> I've been a classic-cruncher for many a year
> and I've spent all my money on electricity and gear
> now I'm returning with WU's [work unit] in great store
> and I never will run seti-classic no more[8]

Sic itur ad astra

What most of the *space buffs* who make a substantial contribution to the project seem to have in common, and which they share with the *hardware hackers*, is a taste for competition and tinkering with their hardware and a determination to seek out increasingly sophisticated techniques in the race for points. Indeed, the highest-ranking participant in this class (the one with the greatest number of points per month) describes himself as a "budding amateur astronomer" who has always "dreamt of building [his] own telescope, although yet to realise it." This participant frequently posts in project forums, and almost all of his posts are on the "number crunching" technical message board, which is

[8] http://members.chello.nl/p.goolaerts/SetiClassic/mp3ss4.htm. Accessed October 8, 2018

dedicated to computation. He relates that he has installed BOINC on two computers in his office, on his partner's computer, and on five machines at home. These machines are basically computer components without a keyboard or monitor, networked and given over exclusively to the project's computational tasks. He notes that he often needs to turn on the air conditioning to keep the room cool, as these machines run twenty-four hours a day, seven days a week. Rather than putting together his own telescope, this enthusiast has put together his own hardware suite, and he devotes time to discussing future purchases and offering advice to newcomers, particularly those interested in building "SETI farms" like his. The goal here is to earn more points while experimenting with hardware, if, indeed, it is not possible to commandeer all computers belonging to family, friends, and colleagues; one third of SETI@home participants have installed the program on two or more machines. The trend for installing BOINC on a large number of computers even has its own moniker among the "cruncher" community on SETI@home: "borging." However, as we will see, this kind of effort is particularly typical of *hardware hackers*.

We would have expected that *space buffs*, who present themselves and make sense of their involvement by reference to space itself, would have been the link between traditional amateur science and online citizen science. Ultimately, however, they have only a distant relationship to offline amateur astronomy communities. Only a very small proportion of participants mention amateur astronomical observation in constructing coherent biographies and proffering their reasons for taking part in SETI@home. Paradoxically, it is as if the moral hierarchy implied by the epistemic distinctions mobilized in traditional amateur astronomy communities has been adopted in the SETI@home universe in inverted form. The link to observation is weak, although this element is a defining part of offline astronomy, while the consumption of cultural products, regarded as ancillary and passive offline, is given a central role. Finally, these participants frequently engage in experimenting with and customizing their machines, something that is viewed as a fringe subculture in the offline world (Williams, 2000; Howe, 2009). Certainly, there are some participants who show an interest in space as well as an enthusiasm for technology, and for whom the appeal of the object of inquiry is therefore combined with that of the medium. However, it is essentially the *hardware hackers* who are the powerhouse of the project, with their discursive focus on the technical data processing driving it.

SCREWDRIVERS AT DAWN: HARDWARE HACKERS

The *hardware hackers* group represents those profiles in which participants opt to give center stage to the "nuts and bolts" of their contribution to SETI@home, which often have very little to do with science in general or astronomy in particular. Rather, their efforts are channeled toward the project medium itself. If we look at SETI@home's migration to BOINC, it is clear that certain users select their projects not on the basis of scientific field (astronomy, biology, physics, etc.) but because of the technical features of the "work units" involved and the speed with which they can be completed. Ultimately, the research objective has little importance for these *hardware hackers*, who are far more concerned with the apparatus itself. Indeed, in their ways of presenting themselves and describing their involvement in the project we can identify—in contrast to a retrospective discourse that aims to frame SETI@home as a pioneer of today's citizen science movement—a hazier and more fragmented conception, where the project's scientific dimension is of secondary importance.

"Show and tell your machine. Here's mine." E.T.: end or means?

> I've been **running SETI** for almost a year now. I am currently running it on **7 machines** ranging from a **PII-333** to a **Pentium IV-200** all of which **process** an average of 6 **units** per day! I really enjoy trying to process as many **units** as I can each day, and hopefully, I'll be able to **upgrade** these **machines** to **CPUs** that will really make a difference! **Donations of old computers** and cash are welcome ;-) – *Profile no. 3328*

As we have observed, *hardware hackers* devote significant effort to SETI@home, and the success of the project can largely be attributed to their involvement. Beyond their point scores, discussion spaces like the forums demonstrate this clearly; more than half (57 percent) of all threads are posted on the "number crunching" board, where conversations center around metrics, rankings, and microprocessor performance. In the thread entitled "Show and tell your machine. Here's mine," participants show off their hardware in meticulously staged photographs. These images testify to the artistry of these experimenters: open chassis, spare parts fresh from the box, assemblages held together with tape, makeshift fans, casings with holes punched in them . . . here, it's not just make and model that matter, but also the user's inventiveness in finding solutions to technical problems, most importantly the difficulty of getting enough airflow through the equipment and cooling the room it occupies. These participants will pay for top-of-the-range equipment and weigh up the necessary investment against the performance they can expect. This investment may be substantial, amounting to hundreds, if not thousands of dollars (Curtis, 2018). For crunchers, taking part in the project is about far more than donating unused computing capacity; they are prepared to invest both time and money in assembling a state-of-the-art hardware suite. Their DIY methods and the attendant narrative established on the forums help mark them out as different. Each machine or suite of machines is unique, just like its designer. In some participants, an enthusiasm for crunching is combined with an aesthetic sensibility; flaunting windowed side panels and LEDs that glow in synchronization with processing activity, they display a knack for the live theater of computation (Giraud, 2005). Beyond the hardware set-up itself, another technique involves overclocking the microprocessor or graphics card so that it runs at a higher speed, a practice that also differentiates participants and helps them move more quickly up the leaderboard.

As more participants engage in crunching and in building their hardware, the purpose of SETI@home may eventually be turned on its head. We can imagine a near future where the processing work is no longer a means to the end of tracking down E.T., and instead the search for E.T. has become a means to the end of calibrating computational power. Indeed, when we examine the profiles of those individuals with the highest monthly scores, we see that they use the platform in a very specific way. The current top-ranked participant in terms of points uses the program for testing hardware in a data center, according to a post written at a time when he was taking part in a competition.[9] By virtue of the fact that it offers a simple, free platform that happens to be particularly effective in gauging how quickly a CPU can perform computational tasks, SETI@home is sometimes used as a tool for benchmarking machines and comparing their performance. Of course, this is a source of frequent debates over whether such users should be eligible to take part in the competitions organized by certain teams.[10] Thanks to sociological studies of technology use, we have known for some time that users of a given technology often invent new usages that supplant its purpose as originally conceived (Akrich, 2013). SETI@home is no exception to that rule.

Machines and masculinity

> Hello, my name is Daniel [...]. I manage one **IT company**. I am a member of **BOINC.SK crunching team**. I love **computers** and **nice girls**. I don't like buying with **my woman** :(– *Profile no. 32326*

"Show and tell your machine. Here's mine.": there is surely no need to linger on the inherently masculine connotations of this expression. This is not a direct consequence of the fact that 90 percent of participants in SETI@home are male, but rather of the way the platform attracts those who move in circles that cultivate certain forms of masculinity. Coming across almost as a caricature, the individual who began this thread is strikingly fond of terms such as "feminist cabal" or "feminazis" to describe militant feminism; this aggressive masculinity is rooted in his military service, which women, unfairly

[9] http://setiathome.berkeley.edu/forum_thread.php?id=75223&sort_style=8&start=75. Accessed October 12, 2018.

in his eyes, are not obliged to undertake. While admittedly an extreme example, this profile is by no means an isolated case. We have seen that the military is a recurring theme among *retired technicians*, as is scouting, which this group is more likely to mention than any other. The system of rankings, badges, and competition devised by the creators of SETI@home is not entirely dissimilar to the normative framework associated with scouting (Rosenthal, 1984); like the army, it represents a crucial site for the construction of American masculinity (Barrett, 1996; Jordan, 2016).

In the context of SETI@home, these relatively closely related forms of masculinity are interspersed with another, more strongly associated with the IT professions. It is a form of masculinity that has developed as more and more men have begun to pursue careers as programmers—a role originally envisaged for women (Ensmenger, 2015). Scruffy dress and a zest for "battles" that push people to their physical limits (the idea being to code for as long as possible without stopping to sleep or even eat) are both telltale signs that a participant embraces this particular form of masculinity. Essentially, building customized computers, a pastime that is the defining feature of *hardware hackers*, is one more practice through which men express their masculinity, especially in a domestic setting. While some participants reveal that they have installed BOINC on workplace computers, the many photographs of IT equipment posted are overwhelmingly taken in a home environment, whether in a living room, bedroom, or dedicated computer room—the equivalent of the DIY or ham radio enthusiast's garage or attic (Gelber, 1997; Haring, 2007). These are privileged, masculine spaces, set apart from the usual milieu of family life. Rather than constituting a digital extension of traditional amateur astronomical science, SETI@home is best understood through this distinct strain of DIY spirit and technical handiwork. At the intersection of these hobbyist cultures, all imbued with a particular form of masculinity, a material engagement with technology (the computer) cannot be separated from—and is, in fact, reinforced by—a concomitant social engagement (the battle for points). Through this nexus, SETI@home becomes a remarkably effective socio-technical assemblage.

CONCLUSION

SETI@home offers participants a virtual space of self-presentation that, insofar as it suggests a certain set of pre-defined variables, appears very similar in structure to the open questionnaires well-known to researchers in the social sciences, minus the usual difficulties of administration. Where it differs from these questionnaires is the way in which responses are produced through a public dialogue between actors, rather than through an interaction with the researcher. First, these responses reflect questions posed by participants themselves; second, they are made in a public way. These two aspects of the context in which these texts are produced makes them a very specific kind of resource that merits a tailored approach. It would be tempting, for example, to seek to derive from them a sociodemographic portrait of project participants, or to compile lists of off-the-shelf motivations that simply require some kind of synthesis. However, much to the researcher's chagrin, this material is stubbornly resistant to any form of predefined analysis. Conversely, it seems a particularly promising source for understanding the real processes at work in the construction of participation and participant identity in an online citizen science project such as SETI@home.

To its creators, the idea of setting up a distributed computing network was more than a tempting technical challenge: it was also a response to two aspirations that we might describe as political. The first of these aspirations, steeped in a self-confessed nostalgia for the glory days of the space age, was to enlist the American public to come together around an ambitious scientific project and transform a passive TV audience into a nation engaged in the advancement of science. In quantitative terms, the launch of SETI@home in 1999 was a decisive success; it attracted so many participants that the infrastructure at the University of Berkeley initially designed to support it was frequently overwhelmed in the first few months. Beyond the numbers, the relational dimension of the project, the sense of uniting a nation, can also be seen in the tendency for participants to form teams. The vast majority of those battling it out at the top of the leaderboard display a national flag, with teams united

by a love of astronomy itself trailing behind. The emergence of the SETI.USA team in 2005 is a perfect example, because it came about as a result of an explicit desire to challenge the prevailing champions, predominantly German, and to dethrone SETI.Germany.[10] Thus, far from promoting the ideal of global scientific collaboration and citizens of all nationalities working together toward a common goal, SETI@home reproduces nationalisms and rivalries between countries, much like the great space exploration programs did during the Cold War (McCray, 2008).

The second aspiration was to provide US citizens with a means of conveying, through action rather than votes, the kind of science they would like the government to fund. By offering a wide choice of different options, creating a kind of "decision market," the BOINC platform allows users to express their priorities through the projects they support, shifting decision-making power from governmental bodies to the public (Anderson, 2004). In 2020, BOINC is set to be replaced by a new platform, *Science United*, that will enable users to indicate which fields of research, rather than individual projects, they would like to see supported.[11] Just as before, this initiative aims to "educate the public" and to "foster public interest in science." Education, democratization, and the advancement of science—the three promises made by today's citizen science (Strasser et al., 2019)—are frequently put forward by participants themselves in their responses to questionnaires on their motivations and sociodemographic profile (Curtis, 2018; Holohan, 2013; Jennett et al., 2014; Nov et al., 2014).

Our analysis of textual evidence produced by SETI@home participants in building their public profiles sheds light on the tension between this imagined public and the public that chooses to get involved in this kind of digital astronomy project. It allows us to sketch out distinct forms of commitment and modes of engagement that are quite removed from both this imagined public and the world of amateur astronomy, which represents a traditional model of non-professional involvement in science. To understand the socio-technical assemblage formed by SETI@home, we must untangle the very different lineages of its tribes of users, ranging from sci-fi fans to retired soldiers/engineers to amateur computer builders. Equally crucial are the routes to adoption generated by the project's own mechanisms of competition, which have nothing to do with the goal of identifying alien life. Nor is this goal a priority for hardware testers, who put SETI@home to a very different use than initially intended, or for the friends and family enlisted to help pick up some extra points in the general hustle for credit that is the hallmark of this assemblage. While "contributing to the advancement of science," the most frequently cited motive in closed-question surveys, rings out across all profile types, the fact remains that interest in science is very much an incidental driver, accounting for only 3 percent of posts in the SETI@home forums. The heaviest users, those who form the mainstay of the project's work, are less likely to have stars in their eyes than a screwdriver in hand, forging their own customized machines as they forge their masculinity.

In light of the very broad spectrum of users, we might well ask what it is that holds this heterogeneous community together. Contrary to the designs of the project's creators, who sought to promote the unifying power of "science," we would argue that it is the SETI@home apparatus itself, with its screensaver, its gamified competitiveness, and its discussion forums, that makes this sense of commonality possible. The way in which participants construct their identities *as participants* and formulate and display their individuality cannot be extricated from the medium—that is, SETI@home as a socio-technical assemblage. The story of SETI@home is therefore not a tale of the democratization of astronomy, but the story of a new kind of technological artefact capable of pooling the output capacity of computers all over the world. This artefact cannot be uncoupled from the common normative order by which it is governed, which takes the form of a vast, competitive game. Rather than bringing humans face to face with alien lifeforms, this order establishes a rivalry between human users operating through their machines—or, perhaps, between machines operating through their human users. In seeking to ground the origin story of citizen science in the specific evolution of

[10] https://www.setiusa.us/showthread.php?186-SETI-USA-Team-History.Accessed October 5, 2018.
[11] NSF Grant no. 1664190 "Collaborative Research: SI2-SSI: Expanding Volunteer Computing" awarded to David Anderson, 2017–2020.

SETI@home, by virtue of its irrefutable quantitative success or its lofty foundational goal of uniting the American people through science, we overlook the very thing that has allowed the project to endure for so long, piling work units onto work units—namely, the commitment of a small number of participants with a passion for the apparatus itself. Looking beyond SETI@home, there is no doubt that our understanding of a significant part of the world of online citizen science could be enriched by focusing less on participation or science and more on the technology itself, asking not “who is taking part?” or “how is knowledge being produced?” but rather, “what is the apparatus sustaining this project?”.

REFERENCE LIST

AGUITON C., CARDON D. (2008), "Web participatif et innovation collective", *Hermès*, n° 50, pp. 75-82.

AKRICH M. (2013), "Les utilisateurs, acteurs de l'innovation", in M. Callon, B. Latour (ed.), *Sociologie de la traduction : textes fondateurs*, Paris, Presses des Mines, pp. 253-265.

ANDERSON D. (2004), "Public Computing: Reconnecting People to Science", in *Conference on Shared Knowledge and the Web*, Madrid, Spain, Nov. 17-19 2003. Available at: http://www.apisindustries.com/Seti/boinc2.pdf, accessed 15 February 2019.

AUBERT A. (2009), "Le paradoxe du journalisme participatif", *Terrains & travaux*, n° 15, pp. 171-190.

BARRETT F.J. (1996), "The organizational construction of hegemonic masculinity: the case of the US Navy", *Gender, Work and Organization*, n° 3, pp. 129-142.

BÉLIARD A.-S. (2009), "Pseudos, avatars et bannières : la mise en scène des fans", *Terrains & travaux*, n° 15, pp. 191-212.

BENJAMIN M. (2004), *Rocket Dreams. How the Space Age Shaped Our Vision of a World Beyond*, New York, Simon & Schuster.

BEUSCART J.-S. (2002), "Les usagers de Napster, entre communauté et clientèle. Construction et régulation d'un dispositif socio-technique", *Sociologie du travail*, n° 44, pp. 461-480.

CARDON D. (2008), "Le design de la visibilité", *Réseaux*, n° 52, pp. 93-137.

CASILLI A. (2012), "Être présent en ligne : culture et structure des réseaux sociaux d'Internet", *Idées économiques et sociales*, n° 169, pp. 16-29.

COPPA F. (2006), "A brief history of media fandom", in K. Hellekson, K. Busse (eds.), *Fan Fiction and Fan Communities in the Age of the Internet: New Essays,*North Carolina, McFarland, pp. 41-59.

CURTIS V. (2018), *Online Citizen Science and the Widening of Academia. Distributed Engagement with Research and Knowledge Production*, London, Palgrave Macmillan.

DAVIDSON K. (2000), *Carl Sagan: A life*, New York, Wiley.

DONNAT O., LÉVY F. (2007), "Approche générationnelle des pratiques culturelles et médiatiques", *Culture prospective*, n° 3, pp. 1-31.

ENSMENGER N. (2015), "Beards, Sandals, and Other Signs of Rugged Individualism: Masculine Culture within the Computing Professions", *Osiris*, n° 30, pp. 38-65.

FLICHY P. (2010), *Le sacre de l'amateur. Sociologie des passions ordinaires à l'ère numérique*, Paris, Seuil.

GARBER S. J. (1999), "Searching for good science: the cancellation of NASA's SETI program", *Journal of the British Interplanetary Society*, vol. 52, n° 1, pp. 3-12.

GELBER S. M. (1997), "Do-It-Yourself: Constructing, Repairing and Maintaining Domestic Masculinity", *American Quarterly*, n° 49, pp. 66-112.

GEORGES F. (2009), "Représentation de soi et identité numérique", *Réseaux*, n° 154, pp. 165-193.

GIRAUD N. (2005), "Quand l'ordinateur se dévoile. Entre immédiateté et ralentissement perceptifs", *MEI "Transparence & communication"*, n° 22, pp. 167-176.

HAKLAY M., WEBER P. (2008), “OpenStreetMap: User-Generated Street Maps”, *IEEE Pervasive Computing*, vol. 7, n° 4, pp. 12-18.

HARING, K. (2007), *Ham Radio’s Technical Culture*, Cambridge, MA, MIT Press.

HOLOHAN A. (2013), *Community, Competition and Citizen Science. Voluntary Distributed Computing in a Globalized World*, Londres, Routledge.

HOWE B. (2009), *Stargazers’ Anonymous. An Examination of Amateur Astronomy in New Zealand*, master’s dissertation, Victoria University of Wellington.

HUGHES T. (1989), *American Genesis: A Century of Invention and Technological Enthusiasm*, New York, Viking Press.

JENNETT C., FURNISS D., IACOVIDES I., WISEMAN S., GOULD S., COX A. (2014), “Exploring Citizen Psych-Science and the Motivations of Errordiary Volunteers”, *Human Computation*, vol. 1, n° 2, pp. 199-218.

JINDRA M. (1994), “Star Trek Fandom as a Religious Phenomenon”, *Sociology of Religion,* n° 55, pp. 27-51.

JORDAN BR. (2016), *Modern Manhood and the Boy Scouts of America: Citizenship, Race, and the Environment*, Chapel Hill, University of North Carolina Press.

LIEVROUW L. (2010), “Social Media and the Production of Knowledge: A Return to Little Science?”, *Social Epistemology*, vol. 24, n° 3, pp. 219-237.

MARTIN É., DAGIRAL O. (2016), *L’ordinaire d’internet. Le web dans nos pratiques et relations sociales*, Paris, Armand Colin.

McCRAY P. (2008), *Keep Watching the Skies! The Story of Operation Moonwatch & the Dawn of the Space Age*, Princeton, Princeton University Press.

MORETTI F. (2013), *Distant Reading*, London and New York, Verso.

NIELSEN M. (2011), *Reinventing Discovery: The New Era of Networked Science*, Princeton, Princeton University Press.

NOV O., ARAZY O., ANDERSON D., BAR-ILAN J. (2014), “Scientists@Home: What Drives the Quantity and Quality of Online Citizen Science Participation?”, in *PLoS ONE*, vol. 9, n° 4, e90375.

ONNION R. (2016), *Innocent Experiments: Childhood and the Culture of Popular Science in the United States*, Chapel Hill, University of North Carolina Press.

PEYRON, D. (2014), “Les mondes transmédiatiques, un enjeu identitaire de la culture geek”, in *Les Enjeux de l’information et de la communication*, vol. 15, n° 2, pp. 51-61.

RATINAUD P. et DÉJEAN S. (2009), “IRaMuTeQ : implémentation de la méthode ALCESTE d’analyse de texte dans un logiciel libre”, available at: https:// docplayer.fr/10422759-Iramuteq-implementation-de-la-methode-alceste-d-analysede-texte-dans-un-logiciel-libre.html, accessed 19 March 2018.

REINERT M. (1983), “Une méthode de classification descendante hiérarchique:application à l’analyse lexicale par contexte”, *Les Cahiers de l’analyse de données*,vol. 8, n° 2, pp. 187-198.

RHEINGOLD (1993), *The Virtual Community. Homesteading on the Electronic Frontier*, Reading, MA, Addison-Wesley.

ROSENTHAL M. (1984), *The Character Factory: Baden-Powell and the Origins of the Boy Scout Movement*, New York, Pantheon Books.

SCOLES S. (2017), “A Brief History of SETI@Home”, in *The Atlantic*, available at: https://www.theatlantic.com/science/archive/2017/05/aliens-on-your-packard-bell/527445/, accessed 15 February 2019.

SIMONET M. (2010), *Le travail bénévole : engagement citoyen ou travail gratuit ?* Paris, La Dispute.

STEBBINS R. (1982), “Amateurs and Professional Astronomers. A Study of their Interrelationships”, *Urban Life*, vol. 10, n° 4, pp. 433-454.

STEBBINS R. (1992), *Amateurs, Professionals and Serious Leisure*, Montréal, McGill-Queen’s University Press.

STRASSER B., BAUDRY J., MAHR D., SANCHEZ G., TANCOIGNE É. (2019), ““Citizen Science”? Rethinking Science and Public Participation”, in *Science & Technology Studies*, (forthcoming).

WILLIAMS T. (2000), *Getting Organized: A History of Amateur Astronomy in the United States*, doctoral thesis, Rice University.

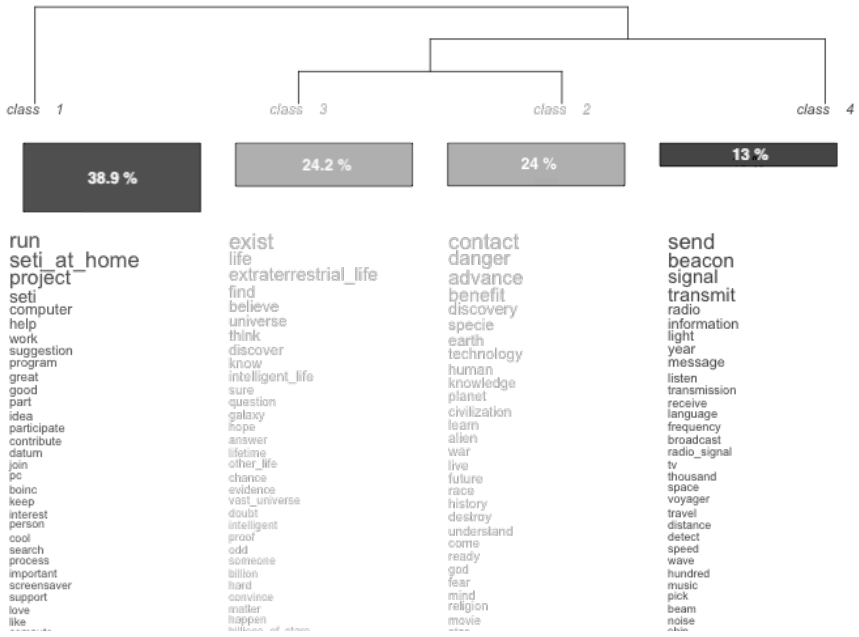
APPENDICES

A. Parameters for figure 2

Simple classification of profile texts. Elimination of unrecognizable textual forms.
Number of texts: 39,699
Maximum number of classes = 10
Minimum number of segments per class = automatic
Number of classes derived: 6
34,711 texts classified out of 39,699 (87.44%)

B. Parameters for classifying texts produced for the "thoughts about the project" section and dendrogram for class 5 (*space buffs*)

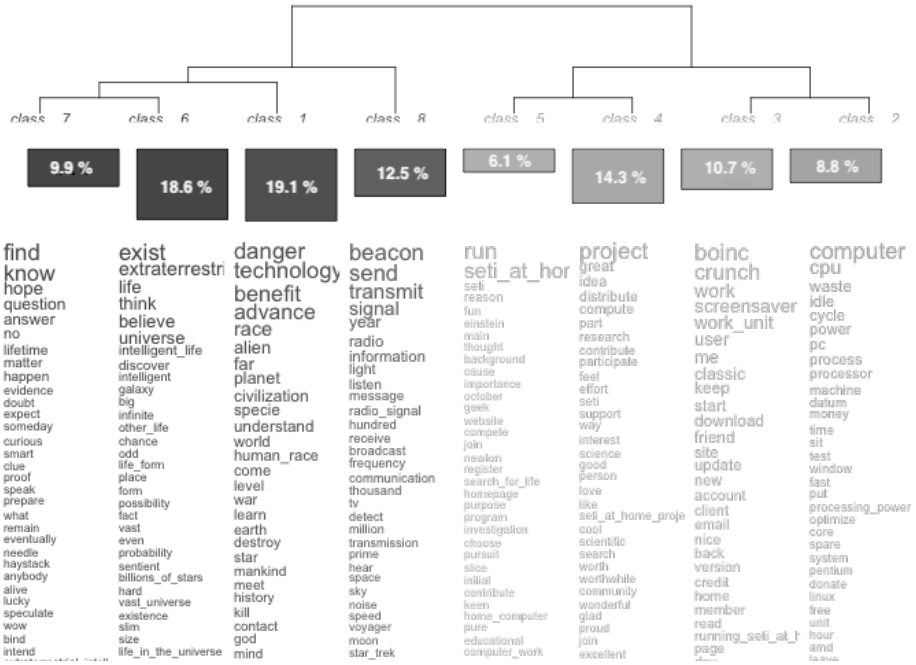
Simple classification of text segments. Elimination of unrecognizable textual forms
Number of texts: 4,297
Maximum number of classes = 50
Minimum number of segments per class = 43
Number of text segments derived: 33,070
Number of classes derived: 4
29,771 segments classified out of 33,070 (90.02%)



Source: IRaMuTeQ; analysis conducted by the authors.

B. Parameters for classifying texts produced for the "thoughts about the project" section and dendrogram for class 6 (*hardware hackers*)

Simple classification of text segments. Elimination of unrecognizable textual forms.
Number of texts: 3,588
Maximum number of classes = 50
Minimum number of segments per class = 36
Number of text segments derived: 25,471
Number of classes derived: 8
22, 349 segments classified out of 25,471 (87.74%)



Source: IRaMuTeQ; analysis conducted by the authors.