TECNOSCIENZA

Italian Journal of Science & Technology Studies

1/2022

Remembering Trevor Pinch,
Platforms for Higher Education,
Urban Gardening,
STS from Mars

Vapetron Megaloman (2022) by Petr Válek

Petr Válek is an experimental musician, painter, and inventor, who has released over 100 albums under different monikers. He has gained international recognition for his music created from homemade mechanical and electronic instruments or self-propelled kinetic objects, constructed from trash and found household items.

He regularly publishes "instructional" videos on Facebook and YouTube, recorded in his technologically dense studio stacked with an assemblage of objects, instruments, books, drawings, tubes of paint, along with his computer, through which he shows the results of his experiments with constructing, deconstructing and reconstructing sound technologies.

Vapetron Megaloman is an analog modular synthesizer created by Válek.

https://www.facebook.com/profile.php?id=100006843614951
https://www.youtube.com/channel/UCSHUTLKvHJq6PYf1OnEQWCQ
https://www.instagram.com/the.vape.noise/

Photocredit: Petr Válek

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Cover *Vapetron Megaloman* (2022), by Petr Válek

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Doing STS in Times of Crises

This issue marks the beginning of *Tecnoscienza*'s fifth three-year cycle and, on the basis of the journal's alternation policy, inaugurates a new Coordination Board. We would like to thank the two previous members of the Coordination Board, Attila Bruni and Paolo Magaudda, for their invaluable contribution to the journal since its conception.

When the journal was first published, twelve years ago, it represented an example of alternative and independent scientific publishing practices, in a context where open access practices were in their early days. With the support of STS Italia and the volunteer work of a group of Italian scholars, *Tecnoscienza* introduced a radical platinum/diamond Open Access (OA) model, in which neither authors nor readers were required to pay any fees, to make scientific work freely available under the Creative Commons license. Against the odds and in a landscape where several STS open access journals have emerged, this joint effort and hard work has been rewarded by a growing readership and, more recently, international indexing. In addition to our previous acknowledgment as "Classe A" (top journals for the Italian research evaluation body ANVUR) in Sociology of cultural and communicative processes and in the WOS Emerging Sources database, since 2021 *Tecnoscienza* is also indexed in Scopus.

Nowadays, with the pressure of initiatives like Plan S – forcing research funded by public grants to be published in compliance with OA principles without paying direct fees – the OA landscape has changed significantly, with most of the leading commercial publishers introducing OA routes in their subscription journals. In this regard, it is widely recognised that OA policies, jointly with digital repositories and knowledge bases, may play a pivotal role in disseminating knowledge for free to all potentially-interested researchers and concerned groups of stakeholders. In its putative figuration OA is indeed expected to make scholarly knowledge a sharable resource, that is a *knowledge commons*. The mainstream narrative on the public governance of knowledge-making practices

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(e.g., EU's open science policy) seems to consider OA a context-free arrangement, able intrinsically to promote intellectual exchange among researchers and societal actors, thus increasing the visibility and impacts of science. Alas, despite this narrative's depiction as an intriguing and desirable politics of knowledge, it conceals a highly-questionable soft determinism. In fact, it neglects to consider how OA framework, in its chains of translation from putative figurations up to specific editorial policy practices, displays some degree of ambivalence and pitfalls, being subsumed strongly within the current academic economisation. This is a crucial point to be considered by those, such as like *Tecnoscienza*, currently endorsing OA policies, so as to reflect under which conditions such policies may effectively democratise the access to knowledge.

In this regard, at least for the last three decades, the economisation of scientific knowledge has configured the domain of academic publishing, in which OA in embedded, as a highly asymmetric and, to a certain extent, exploitative market. It is well known that scholars, acting as referees and journal editors, provide intensive free work to commercial publishing companies. At the same time, public academic institutions and research organisations are mobilising a growing amount of financial resources for paying Article Processing Charges (APCs) to the publisher for releasing research outputs in OA.

Hence, OA is reflecting the power asymmetries between universities and private publishers operating in a concentrated market that ensures large profit margins for a small group of publishers. It is not by chance that both European and US-based universities cancelled some of their journals' subscriptions. However, it is important to point out that the most interesting and, maybe, sharp challenge to the dominant business model of academic publishers is related to some out-of-law innovation (e.g., Libgen and Sci-Hub), that are putting in the foreground the need to define public policies for coping with the regime of knowledge commodification operated by the major for-profit publishers.

So, OA – far from being an inherently liberating tool – strongly ask to reconsider carefully issues related to the public value of science and scientific knowledge, as well as the kind of assemblage public academic institutions are drawing with academic publishers, where OA is enabling the dissemination of research for free for its readers, but authors (and their institutions) are in charge of paying for expensive APCs for OA publishing.

Against this backdrop, and echoing Donna Haraway, endorsing a free-of-charge OA implies "staying with the trouble", thus enhancing connectedness, unusual and unexpected collaborations for re-imaging the

future politics of knowledge outside the current regime of academic commodification.

To stay true to our platinum/diamond OA model and strengthen *Tecnoscienza*'s position in the STS landscape in times of crisis, we needed to find allies to maintain our self-supported publishing practices. We are happy to announce that, from our next issue, *Tecnoscienza* will have an academic publisher: AlmaDL Journals. This is an OA e-publishing service of the University of Bologna supporting scientific, peer reviewed journals. The partnership between journal founder STS Italia and AlmaDL will allow us to continue with our platinum/diamond OA model and to maintain intellectual and editorial independence, while receiving support for publishing practices.

In the next three years, we plan to consolidate our position as an international platform that offers a space for novel intellectual inter and cross-disciplinary thinking. In addition to being a venue for publishing original research in the forms of essays, we continue to promote the debate on emerging topics in contemporary STS thorough the publication of special issues or thematic sections, along with our "Scenarios" and "Crossing Boundaries". Our effort will be especially directed to make *Tecnoscienza*'s sections a space for contributions by plural forms of engagement with diverse social worlds.

As part of the STS community, we have rarely witnessed such a massive deployment of STS at work as in current times. The more climate, health, social and political crises are connected, the more STS themselves seem fully entangled with them and the boundaries between engagement and commitment, knowledge and practice are increasingly blurred within our field. At the same time, the whole theoretical and methodological repertoire of the last decades erupted worldwide, making visible at once and to all the technoscientific controversies, lay and expert knowledge, the laboratories and their actor-networks, the epistemic cultures and communities, the categorical work and socio-material practices, and all the components that feature the field. Walking through the perfect storm for STS in the years to come requires the utmost responsibility and thoughtfulness. Rephrasing Lucy Suchman, this involves to put to the test how our scientific community is ordered, to proclaim the fragility and openness of its existence, and to explore alternatives.

Our journal will continue to promote what we consider good scientific work without taking for granted the publics and the communities that we are addressing. With the transition to the new publisher in the next issue, further ways of engagement with our readership will be introduced. We will keep supporting the voices of early-stage and independent research-

ers, extending the invitation to practitioners, journalists, and non-academics around the planet. That gives us the opportunity to thank once more the guest editors, external anonymous reviewers and all the authors whose voluntary contributions have made *Tecnoscienza*'s journey possible and supported its resilience and maturation, despite the challenging times. Just like STS, *Tecnoscienza* is a collective and distributed endeavour.

Trevor Pinch (1952-2021) has been a brilliant example of how STS could mingle and engage with art, science, technology, everyday life, and make the difference in the academic/scientific as well as personal spheres. In remembering Trevor and the huge contribution he made to the field, we are going to follow his path for doing STS in times of crises. Would you like to join the walk? There will be fun.

Claudio Coletta, Stefano Crabu, and Manuela Perrotta

Remembering Trevor Pinch

Attila Bruni
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Abstract: Like the many fortunate enough to cross his path, the STS Italia community and Tecnoscienza are particularly indebted with the sociologist of science and technology – and Moog synthesizer player – Trevor Pinch (1952-2021). Our journal gratefully remembers his human and intellectual generosity through the words of four researchers who encountered Trevor as a mentor, supervisor, colleague and source of inspiration for their life and work.

Keywords: Trevor Pinch; mentoring; The Electric Golem; sound studies; STS Italia.

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"So, keep up the good work and don't forget to have fun!": Remembering Trevor

Mariacristina Sciannamblo and Chris Hesselbein

Much has been written about Trevor Pinch since his passing in late December of 2021. Italian STS scholars are of course very aware of his role as one of the founders of the Social Construction of Technology approach and the field of Sound Studies as well as his contributions to research and teaching in the form of articles, books (and book reviews!), lectures, summer schools, and podcasts. Many of you have had the good fortune of meeting Trevor in person, and some of you have had the pleasure of seeing him play his beloved synthesizer. Something that is less

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often reflected upon, but that is equally important to his role as a scholar, is the way in which he supervised his students and how he helped them become STS scholars in their own right.

Everyone who has ever been around Trevor for even a short period knows that he was able to strike up a conversation and build a connection of some sort with almost anybody, any time. His curiosity, generosity, and adventurousness allowed him not only to be open to what other people had to say, but also to know how to make an apprehensive student feel heard and appreciated by someone whom they might never have dreamt of meeting let alone receiving a helpful reference from. In other words, Trevor was a great scholar because he was also a great mentor and supervisor, which is something that needs to be emphasized when reflecting on his contributions to the field of STS. This is therefore not a celebratory tribute to an academic super(rock?!)star, but an acknowledgment of Trevor's humbleness and the spaces and opportunities he provided for his students to follow in his footsteps. Our joint piece highlights the interpersonal qualities of Trevor as a supervisor who built bridges for his students, gave constructive criticism as well as critical support, and therefore helped us to stand on our feet and follow our own intellectual pathways.

Trevor as facilitator of social connections and builder of intellectual bridges. As PhD students, we met at Cornell University in the autumn of 2014. At that time, Trevor and Chris were planning to do an "independent study" class on the use of everyday technology. The main reason for this was that Chris came to the conclusion that he no longer wanted to work on the project that he had been developing for his PhD, which was partially caused by an interesting but otherwise dispiriting summer school that he'd just attended with Trevor in Paris (where, perhaps entirely unsurprisingly, Trevor has introduced him to "his friend Bruno"). In other words, Trevor created space for Chris to take the time and figure things out again. In true Trevor style, Mariacristina was invited to join the reading group with Chris. We collectively read and discussed several works by classic STS scholars (e.g., Ruth Schwarz Cowan, Lucy Suchman, and Judy Wajcman) as well as beyond (e.g., David Edgerton, Tim Ingold, and Wanda Orlikowski). Most of our meetings were held in one of Trevor's favourite meeting spots, namely *Gimme! Coffee* in downtown Ithaca. While assembling the reading list for our meetings, Trevor, in his typical casual manner, put us in touch with Nelly Oudshoorn, who co-edited the *How Users Matter* volume with Trevor, and pointed us towards new and exciting work that was being done in the field of user innovation in Denmark.

A similar story involves Mariacristina, who first met Trevor in June 2013 at the STS Italia summer school in Ostuni to which he was invited as a keynote speaker (Fig. 1). Grappling with the frustration and confusion that comes with just having started a PhD, Mariacristina unexpectedly found herself sitting next to Trevor during the summer school's first

collective dinner where she was posed that dreaded question that every new PhD student wishes to avoid: "So, Cristina, what is your research about?" After listening to Mariacristina splutter the words "gender", "technology", "computing", Trevor rattled off a series of books, articles, and authors on "such an interesting topic", specifically mentioning a book on ham radio by Kristen Haring (the sister of Haring Keith the artist), inspired by the t-shirt that Mariacristina was wearing, which featured a design by Keith Haring. This first friendly meeting with STS continued the following year at Cornell University, where Mariacristina spent a semester as a visiting PhD student with Trevor's crucial help.

Figure 1. Trevor Pinch with students during a break at the
STS Italia summer school in Ostuni, 2013.
Picture by Assunta Viteritti.

Trevor's generosity and openness paired with his sharp critical wit and knowledge of STS. Many months after the reading group, Chris presented Trevor with a paper on mundane technologies that he hoped would be the basis for one of his upcoming qualifying exams. Although Trevor enjoyed a reference to the Italian soccer player Balotelli putting on his bib and an argument about the problem with crispy fried eggs, he gave Chris a firm kick in the butt ("I have the feeling you're coasting, and that's not going to get you very far"). To drive a point home about the importance of context, Trevor lifted up his leg to demonstrate how he had used a paper clip to repair the zipper of his winter boot ("Users subvert technologies all the time!"). We also fondly recall his critical remarks about the collapse of categories that some analytical approaches threatened to lead to ("I don't agree for a second that this table can have the same agency as a human actor!") as well as his genuine curiosity, mixed with amazement, about the evolution of STS from the 1970s to the present, including his

amused surprise at learning that the abstracts of some (very prominent) fellow STS scholars had been rejected at recent 4S conferences.

His intellectual journey in STS can be read in his fascinating book/conversation with Simone Tosoni (2017) that traces Trevor's deep sense of belonging to STS, which is reflected in his commitment to building STS communities across the world ("I'm off to Kumamoto University on Kyushu Island Japan on Tuesday for a week. Helping them build a new program around STS and sustainability. Should be fun and interesting!"). Trevor's intellectual and professional commitments were never separated from his personal curiosity and pleasure in interacting with people and the many social relationships that he built over the years, which was highlighted when winning the 4S Bernal Prize in 2018 ("It was great seeing people and Lucy gave me lots of hugs").

Having met Trevor during our doctoral training, we cannot but emphasize his dedication to teaching and the support he gave to his students whose stories and work were featured in almost every conversation with him. Trevor's willingness and desire, perhaps even need, to continue teaching did not cease even during the most difficult times of living with cancer. And his interest in and commitment to teaching and mutual learning did not stop at giving lectures and classes, but continued even while sharing drinks or soups (with chips!) and hanging out at concerts or participating in jam sessions (Fig. 2).

Figure 2. Trevor with students during a concert by 100% Black at the Bowl-O-Drome in Ithaca, NY, in June 2019. Picture by Mehmet Ekinçi.

In this respect, we very much recognize him in the words of his colleagues and friends Wiebe Bijker and Karin Bijsterveld (2022), who write that there was "for Trevor, no bigger compliment for his research than being compared with a young PhD student".

We see him having fun in one of his "crazy busy summers" or winters, joining STS workshops in Paris, going to 4S in Buenos Aires, performing with Electric Golem at the GrassRoots Festival in Upstate New York, challenging muskox in Trondheim ("that muskox ran right towards us and the guide kept saying 'Don't challenge the muskox!' I was taking photos of course"), helping students with accommodation at Cornell and providing them with bicycles ("Nelly Oudshoorn rode this one while we were writing *How Users Matter!*"), enrolling students to be his roadie and buying them a beer afterwards ("Don't tell Bruce!" [department chair]), walking around Trumansburg as a "Moog aficionado" and remembering his earliest times at Cornell while building the STS programme, playing guitar hero with his daughters, running a DIY synth building workshop, and lapsing into Donna Summer and Giorgio Moroder while emailing us. Ciao Trevor, you are missed ever so much.

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The Electric Golem

Attila Bruni

When I was invited to write this short text about Trevor, I felt obliged and somehow happy for having the opportunity of publicly expressing the great fascination he had for me. As for all kind of fascinations, it happened all of a sudden and it rapidly grew. It did not happen through the reading of his books (in that period, I was much more fascinated by actor-network theory, theoretically speaking), but at the 4S/EASST Conference in Copenhagen, in September 2012, thanks to Sally Wyatt. She invited me to join and intervene in a small session celebrating the publication of the second edition of the famous book *The Social Construction of Technological Systems* (Bijker, Hughes and Pinch, 1987/2012). More people than I expected were there and the atmosphere was very joyful and relaxed, but I started feeling a bit nervous when I realized that Wijebe Bijker and Trevor Pinch were also there, so that they would have had listen to me. My short intervention was intended to be ironic and provocative and (believe it or not) I still hold the notebook where I sketched it (Fig. 3).
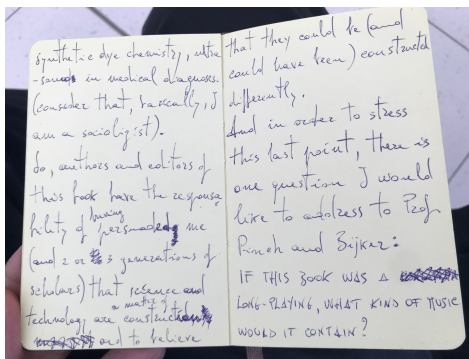
Figure 2. Notebook.

The point was that it was the first time I was meeting Trevor and Wiebe Bijker, so that I had no clue about their sense of humor, but for sure I did not want to sound silly or disrespecting. Then I noticed that Trevor was wearing the same sneakers I had (Converse All Star, white), and I felt reassured. So, I concluded my short speech addressing to him the following question: "If this book was a long-playing, what kind of music would it contain?"

"Some kind of Pink Floyd-Van-Der-Graaf-Generator-psychedelic-rock", Trevor replied smiling. I was fascinated by that smiling, which I would not know how to define. Once the meeting was finished, Trevor approached me directly, and we chatted a lot about music. I told him I spent a couple of years playing in a rock band after graduating at the university, and he replied saying he was still playing in a band. And this was the beginning.

Approximately six months later, in February 2013, I met Trevor again, this time in Trento and thanks to Massimiano Bucchi, who set for him a quite peculiar situation. At that time, Trevor was doing some work on the tacit and embedded dimension of expert knowledge, so we had a "seminar in the kitchen". We were in a separate area of a cafè/restaurant, with a couple of tables equipped with various ingredients (salt, oil, water, flour) and cooking instruments at our disposal. Instead of giving a lesson or a formal speech, Trevor asked us to give him instructions on how to make some fresh pasta and cook it. Although we were just fifteen people (and all Italians), we immediately started to disagree with each other about the right procedure and to give to Trevor opposite advices. Moreover, after a while, more than one person started picking up instruments and ingredients showing in practical terms (e.g., rolling out the dough with a rolling pin) what s/he meant by "thin", "thick", "soft" or "porous". There were also people who had simply no idea of how to make fresh pasta, nor they declared themselves in terms of experts or passionate cookers, but for some reason they also started to give their opinions,

suggesting things they heard or saw other people doing in other occasions.

Thus, without the need of introducing any particular concept or theory, Trevor threw the participants in a typical technoscientific controversy: who was right? Who could claim to be right and on what basis? Was there a unique cooking technique or were there more options? On what basis was the knowledge deployed legitimated? Moreover, as it sometimes happens when you have different groups of actors referring to different sources of knowledge and techniques, the pasta we made was not that good, as everybody were probably concentrated on demonstrating the "truth" of their procedure, more than on making some good fresh pasta.

That evening, Trevor and I had dinner together. This time, we chatted a lot about music and food as well, and I was surprised by how easy it was to conversate with him: he always had a story to tell, but he was curious about other's people experiences; he was ironic and provocative but never disrespecting his interlocutor; he had his own convictions, preferences and tastes, so that he was ready to argue about that until exhaustion; most of the time, he smiled and seemed extremely at ease and this contributed in constructing a good conversational atmosphere. Last but not least, it was possible to converse with Trevor almost about everything: literature, cinema, tv series, music, alternative movements, sociology, history, philosophy, food, drinks, sports, politics, personal relationships… and, of course, science and technological processes in society.

During that dinner I asked him to join the next STS Italia Summer School, which was supposed to take place in the Apulian courtyard a few months later, in a *masseria* (a typical old Italian farm) now refurbished as an artistic residential space. This meant, for example, that all the main sessions would have had taken place in a large hall which was basically a space for theatre workshops and rehearsals. So, basically no chairs (people had to sit on some cushions, directly on the floor), and given that there was the parquet, everybody had to take off their shoes, speakers included (Fig. 4). Moreover, we would have all ate together (the cook of the *masseria* would have been in charge of our meals, mostly vegetarian) and slept in the same space, although participants would have had to sleep in shared spaces, whereas speakers would have had their own private rooms.

Figure 3. Seminar Room.

To say it explicitly, it was not everybody's cup of tea. But Trevor was so enthusiastic, that he immediately accepted, with that undefinable smiling which already caught me the first time I saw him. And this was the second time.

Now it is mid-June and we are in the Apulia region (South-East of Italy), in the countryside just near Ostuni, surrounded by olive trees, 6 km from the sea. It is hot but windy, and during the afternoon everybody have finally reached the *masseria*. The only missing one is Trevor, whose flight was late and who is in a car (my car, actually) with Paolo Magaudda driving him to his final destination.

We are about twenty-five people altogether (participants, invited speakers, and organizers) and we are going to have our first dinner sitting in the garden of the *masseria*. We are already sat down and Trevor and Paolo arrive precisely in the moment when three enormous cups of *orecchiette alla crudaiola* (typical Apulian pasta seasoned with fresh tomatoes, basils, and grated ricotta cheese) are brought to the table by our cook. Everybody is smiling and looking at each other, but we basically do not know each other, so that somebody has to break the initial embarrassment, take one of the spoons on the table, and start filling his/her or somebody's else plate. And the one who takes the spoon, largely smiling, is Trevor; and needless to say, he serves all the people on the table, before serving himself. So that the welcoming for the participants of the summer school is Trevor Pinch offering them a plate of *orecchiette alla crudaiola*. Too brilliant to be planned, but thanks to the spontaneity of Trevor and his playful attitude (Fig. 5).

Figure 4. Summer School lunch break with Trevor.

In the following days, the school articulated through various sessions and structured speeches, but the added value was clearly the serendipitous discussions that take place not just in dedicated times and spaces, but also in the shade, by the sea, or at night, while having a drink. And the added value of the added value was Trevor, who ineffably participated to all the discussions, listening and giving suggestions to all the participants, while making fun of the absurdities and the contradictions of academia, and struggling every time somebody mentioned ANT or "interspecies ethnography".

Some of the discussions we had during those days translated into a "conversation" who appeared on Tecnoscienza (Bruni, Pinch and Schubert 2013), but on the last evening, we nearly quarrelled, because in my opinion Trevor was too "straight" with one participant who was observing ethnographically the life of flies in a Brazilian laboratory working on a new malaria vaccine. But he kept saying: "As my friend Harry Collins says, of course there is a difference between a person and a dog: the dog doesn't laugh, doesn't dress, and doesn't ride a car, so… why should we bother about the distinction between humans and non humans, given that there is a distinction?!".

But that was it: Trevor was authentic and had no doubts in acting and/or speaking his mind directly, no matter if the issue at stake was serving the orecchiette or arguing about the relation/distinction between humans and non-humans.

At the end of the summer school, Trevor gave a present to me, something really precious and which I would have never expected: a copy of a CD of the band he used to play with (Fig. 6), the Electric Golem (such a perfect name!). It is definitely one of the CDs I am most proud to hold and in its title is the clue about the peculiar smiling of Trevor. The music is "some kind of Pink Floyd-Van-Der-Graaf-Generator psychedelicrock". And I will keep on listening to it. Thank you, Trevor!

Figure 6. "Smiling like an angry turtle", by the Elecric Golem.

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Trevor Pinch in Three Episodes

Paolo Magaudda

I decided to write this piece because Trevor Pinch has been quite an important and positive person in my academic and para-academic trajectory. At a careful inspection of my memory, for several reasons that also include a good dose of coincidence and serendipity, I realised that Trevor has had an influence on several choices I have made in my scientific life. As I will recall, during my days as a university student in communication studies, more than 20 years ago, the discovery of the Social Construction of Technology (SCOT) approach he developed with Wiebe Bijker (Pinch and Bijker 1984) was the first step to meet the science & technology studies (STS) field. At the same time, his personality and academically eccentric interests (such as his passion for analogue music synthetisers) resonated a lot with my own (for instance, I too played and still have a real passion for this musical instrument), including his trajectory within the alternative music scene in the late '60s in London before enrolling in a master's degree at the University of Manchester: this, no doubt, led to some of my identification with his interests and inclinations, which also reinforced my affinity with his scientific work. Moreover, all my opportunities to spend time with him allowed me to deeply enjoy his personal attitude and easy-going personality. Thus, I have several memories that I would like to share about him and his work.

To make sense of them, in the next few pages, I will put in practice C. Wright Mills's (1959) *sociological imagination*, especially his invitation to

intersect individual biographies with wider patterns in social dynamics. Hence, I will recall three specific episodes in my biography that involve Trevor in different ways and attempt to connect them with wider dynamics in STS and in scientific dynamics at large, in the hope that some of my personal experiences could resonate more broadly with those of other scholars who have crossed paths with Trevor.

1. On a Book

The first episode I will recall is perhaps the most basic and simple one, but it is important because it represents my first encounter with Trevor's work and with STS in general. This occurred at the end of 2000, when I was a master's student in my final year at the University of Bologna, approaching the decision of having to pick my final thesis topic. As an amateur electronic musician and DJ, I started to cultivate the idea of focusing my thesis on the social and cultural implications of electronic music technologies. Thus, I engaged several teachers in conversations for suggestions and support. In one of these talks, Giuliano Pancaldi, a professor of the history of science and among the earliest Italian scholars to turn an eye to STS (see Pancaldi 2020), suggested checking out a book that could help me with my endeavour. That book was an edited collection of chapters written mainly by historians of technology and edited by Robert Fox (1996), which included as an opening chapter a review written by Trevor, in which he outlined the evolution of the SCOT approach, also addressing its developments and some of the criticisms raised over the years (Pinch 1996).

This episode was not just my first encounter with Trevor but also my very first dive into science and technology studies at large. This original imprinting was possibly also a reason why, in the following years, I had a particular attachment to the original approach to technology elaborated by Trevor and Wiebe Bijker, even though in that period SCOT was probably being superseded as the major approach to technology by Actor-Network Theory (ANT), which was much less schematic and more fascinating. However, for a novice ANT was also less easy to implement than SCOT, which, on the contrary, offered a straightforward approach to address the evolution of technological innovation in relation to social groups and the wider social context.

Anyway, this chapter by Trevor and the discovery of the SCOT approach in general imprinted me to STS, and I think all this deeply influenced not only the development of my thesis, but more generally, some of the subsequent choices in my academic career, mostly because this was the moment in which I understood that it was possible to focus a scientific trajectory on technology from a social and cultural point of view. Overall, this episode possibly reflects the huge influence that Trevor's work on SCOT has had on many young students keen to focus their in-

terest on technology in a period in which this was a not-so-common choice in the social sciences.

2. On a Journal

The second episode I want to recall is related to the moment in which I definitely decided on the research topic of my PhD dissertation on music listening technologies and how another trajectory in Trevor's scientific work – sound studies – was instrumental in my final decision. It was the end of 2004, it was also the end of my first year as a doctoral student in the Sociology Department of the University of Padua, and I was still focused on working on music technologies. This topic was not a simple choice because at that time common subjects for a PhD thesis in my department were, much more than today, rooted in traditional sociological paths. Therefore, issues such as MP3 music files and iPod players looked quite eccentric. One of the strategies that I explored to negotiate my interests within this relatively traditional context was to connect them to other perspectives considered more sociologically sound at that time, such as the role of music in social movements or the economic and organisational dimensions in music production.

Quite coincidentally, just when I had to present my final research plan to the PhD board, a special issue of *Social Studies of Science* edited by Trevor and Karin Bijsterveld came out, focusing on sound studies, with a strong emphasis on music technologies (Pinch and Bijsterveld 2004). At that time, I had already read Trevor and Frank Trocco's book on the analogue synthesizer (Pinch and Trocco 2002), and I was appreciating the book on users Trevor and Nelly Oudshoorn had edited the year before (Oudshoorn and Pinch 2003). In any case, this perfectly timed special issue on sound studies was crucial to my decision. The special issue explicitly declared a new field of study, sound studies, which fully corresponded with my interests in music technology and was published by a leading journal in the field in which I was hoping to focus my PhD research. When I read that special issue published just a few weeks before I had to lock in my choice, it was a sort of revelation: if the renowned Trevor Pinch was working on these topics, then it would be fully legitimate for me to follow the same path. A few days later, I went to my probable supervisor, Federico Neresini, who was already working in STS, to discuss the special issue, and he could not but agree with this view: in just a few days I submitted my research proposal on music technologies to the PhD committee.

This personal episode does not just reflect the contingencies of my choices or the overlapping interests between Trevor and me. Rather, I think it reveals more broadly the role that Trevor played in that period to help STS embrace not just the study of sound technologies, but more generally media technologies and topics more directly related to cultural

phenomena. Indeed, up until that moment, the incursions by STS scholars on the terrain of media-related phenomena and cultural contents were quite rare and disjointed. Relevant books, such as the edited collection of essays by Tarleton Gillespie and others (2014) on media technologies, were still a decade away, and topics like music, movies and other cultural practices were mostly absent from the landscape of STS, with very few exceptions. At that time, I think the core trend in STS was still to invest in topics considered more "serious" and as part of a process of disciplinary boundary work, which was implicitly focused on positioning STS more as an interface with hard sciences and well away from any sort of "cultural studies" of technologies (the so-called "Sokal affair" was at that time still quite present in the evolution of the intellectual relationships between human, social and hard sciences; see Hilgartner 1997). In those years, Trevor's work played an important role in supporting a more inclusive view of which topics could be considered plausible in STS. In doing so, he also contributed to supporting eccentric and still not fully legitimised research patterns within STS.

3. On a Car

Let us go to the third and last episode I want to recall about Trevor. This episode is much more personal, and I decided to focus on it because I think that Trevor would have liked to be remembered not just for his important scientific accomplishments but also for the kind person he was, something that is, of course, strongly connected to the great scholar and mentor he also was.

To recall this episode, we need to take a step forward in time. During the decade that followed my PhD, I met Trevor on different occasions. For example, in 2006, I had the opportunity to do a long interview with him when we were both in Montreal, where I was attending the graduate course in sound studies held by Jonathan Sterne, and Trevor had been invited as a speaker. During this interview, Trevor presented a narrative of his entire career and his own views about the evolution of science studies and STS. This interview was published in Italian in the journal *Studi Culturali* (Magaudda 2008) and in an updated version in English in *Cultural Sociology* in 2014 (Magaudda 2014a; 2014b). This interview was another very important moment in my relationship with Trevor, but the episode that I want to share here is another one.

It was the summer of 2013, when STS Italia organised its biannual summer school at which Trevor was one of the speakers, I was one of the organizers (a version of his speech was later published in *Tecnoscienza*; see Bruni et al. 2013). This summer school featured a residential approach and was settled in a "Masseria", a farmhouse in Puglia's countryside located in the south of Italy close to Ostuni. Students, tutors and speakers spent several days living together in the same place (Fig. 7).

Figure 7. The "Masseria".

As the school was organised with a grassroots approach, to manage participants' transportation, we rented a minivan for the students, and we had a car for the speakers. One afternoon, I was the driver in charge of conducing that car.

That late afternoon, we spent some time visiting the enchanted town of Alberobello, but it had become quite late, and we needed to bring someone to the train station, hence, we had to drive very quickly in our vehicles. I was driving the car with Trevor in the passenger's seat and two other colleagues in the back seat. I was following the minivan driven by Attila Bruni (a distinguished car driver), who was driving very fast, well above the speed limit, pushing the limits of my driving skills. Therefore, I had to employ extreme concentration as I drove quickly across those narrow and twisting country roads. At a certain point, the colleagues in the back seat started to be quite worried (if not literally scared) about the speeds at which we were driving, a worry that was expressed both on their concerned faces and with quietly voiced complaints. It was not a comfortable situation; I had to follow the minivan at a high speed, and it was vital to remain concentrated on the road. However, I was distracted by the worries coming from the back seats.

In that situation, Trevor's presence was of great help. Not only did he appear to be the only relaxed person in an otherwise tense environment, but he seemed to really enjoy that adventurous ride, as his attitude resembled that of a pupil on a sort of funny carousel ride. That evening, after our lively journey, he even invoked that episode as the local version of The Italian Job, a blockbuster released the year before featuring a crazy car chase scene in the inner city of Milan. In such an uncomfortable situation, Trevor put his trust in my driving skills, providing reassurance to the other people sitting in the rear and putting people at ease in that typical way of his. That really was one of those circumstances in which having a

person who believes in what you are doing at your side, when even you yourself is questioning what is going on, is of great importance. And Trevor was really the right person to play that role.

I recall this episode because it reflects quite well the positive and supportive presence that Trevor was able to be in many situations. This especially included the occasions when Trevor was dealing with students and other colleagues as they opined about their work, when support from a well-established scholar was not in any way granted; thus, it was an even more important resource. I experienced this several times when I discussed my work with Trevor, but I also saw him do the same on many occasions when talking to other people. I think this was part of Trevor's subtle and distinctive talent, both personally and scientifically, when interacting with others. This rare quality of Trevor's is what I will remember most fondly, together with the memories of our discussions about science, technology and our analogue music synthesizers.

Figure 8. VII STS Italia Conference, 2018 (Padova, IT): warm greetings from the STS Italia community to Trevor Pinch, invited as keynote speaker but ultimately not able to participate to the conference.

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The Exploration of the Earth Subsurface as a Martian Analogue

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Abstract: This paper describes the conceptual effort and scientific practices though which space analogues – i.e. material settings in which one or more analogies between Earth and outer space are embedded – are built, sustained and experienced. Based on my ethnographic study of astrobiologists' and speleologists' analogue fieldwork activities in Sardinian subsurface environments, I claim that analogues are part of the process of making astrobiology as a discipline: they do not only constitute fundamental heuristics to understand Earthly – and perhaps one day extra-terrestrial – life, but they also reframe disciplinary boundaries and imagined futures on Earth and elsewhere in the Universe.

Keywords: extreme environment; space analogues; astrobiology; scientific fieldwork.

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1. Introduction

The breeze was warm and filled with the subtle aroma of the myrtle that in the late spring punctuates the gentle slopes of the southern Sardinian hills. The bushes and short trees did not offer much of a shelter from the sun shining high in the clear sky constantly swept by the Mediterranean air currents. Earlier in the morning, we had been warned to wear heavy clothes as the mine temperature is significantly lower than the temperature outside; in the rocky darkness of the mine, it barely varies between winter and summer. The water, copiously dripping from the rocky walls, keeps the humidity high and covers the muddy floor with stagnant water, creating the conditions for bacteria to recolonize what humans had ap-

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propriated in 1880s and then abandoned a century later. The Su Zurfuru ("sulphur" in the Sardinian language) mine had been depleted of lead, iron, and fluorine for decades, before being deserted along with the adjacent small village where miners used to live and process the raw materials extracted from the nearby deposits[1].

Our hiking boots were already sinking into the muddy soil just in front of the tunnel mouth, a regular opening excavated in the rock, almost completely covered in Mediterranean vegetation. Gabriele[2], an experienced member of the local speleological team, started the engine of his jeep, packed with scientists and their equipment, and slowly turned the car toward the entrance. The wheels sank into a deep puddle as the car moved into the tunnel, plunging into the reddish water. A small wave preceded us, rippling the silky surface of the water lit by the car's headlamps. Thus, we moved onwards, deeper and deeper into the abandoned mine.

When the car stopped, we heard the voices of the group that entered the mine before us. "Don't walk alone" Gabriele said with an affable smile, "it takes nothing to get lost here". Then he turned the car and drove back to the entrance to carry the last group of scientists still waiting outside. Somebody approached us, lighting the space where we were standing with a cone of light shining from the top of her helmet. Laura, one of the organizers, joined our small group and showed us how to switch on the light on our hats and then led us to where the others were gathered, in a different tunnel, where the walls had been further excavated to almost form a chamber. John, a geologist from the University of Bologna, was casting his helmet light on a white and blue jelly substance formed around the groove excavated by the water gushing through a crack. He poked his finger into it; "this is biology", he claimed.

This paper is based on the second workshop organized by the Geo-Biology for Space Exploration (GESE) ESA topical team and held in Sardinia[3] (Italy) in the Spring 2015. The workshop, titled "Extraterrestrial Subsurface Exploration and Geomicrobiology", aimed to encourage the development of a new interdisciplinary community focused on the study of possible uses and implication of mineral-microbe interactions in subsurface environments. These processes have a number of applications that can be linked to a broad range of space-related activities such as the search for evidence of life elsewhere in the universe; human and robotic space exploration of celestial bodies; and long-term settlement scenarios. This variety mirrors the multiplicity of scientific and technological endeavours funded by space agencies. By putting together experts in such different fields, ESA hopes, on the one hand, to optimise financial resources invested in emerging realms of inquiry and, on the other hand, to create or strengthen research collaborations. The participants to the workshop – biologists, biochemists, geologists, speleologists, astrobiologists, astronaut trainers, etc. – were charged with the compiling of a road

map that would both set the direction of further studies and make the case for additional investments in this polyhedric field.

I participated to this workshop as part of my multi-sited ethnographic project on astrobiology. i.e a discipline committed with the study of life elsewhere in the universe. After eight months of participant observation of astrobiology laboratory activities, I had the opportunity to join two fieldwork training events attended by some of the laboratory members. Astrobiology fieldwork activities have often been framed in semiotic and representational terms (for example using the Peircean vocabulary of signs and indexes, see e.g. Helmreich 2006); in my project, I aimed at moving beyond such frameworks to pay attention to the situated and embodied dimension of practitioners' knowing (e.g., Goodwin, 2000; Gherardi, 2000). Fieldwork training activities opened a window on how participants practice experiencing their objects of interest through the socio-material infrastructures by which they are surrounded. I consider the analogies described in this article as a fundamental dimension of these infrastructures. Such narratives are produced and reproduced in astrobiological practice-based knowledge.

Astrobiologists often describe the quest for extra-terrestrial life as something that has only recently been included within the realm of scientific investigation. For centuries, philosophers and fiction writers indulged in bold speculations about exotic forms of life and civilizations that might populate distant celestial bodies (Blake 2006; Crossley 2011; Dick 1982). The situation changed during the 20th century, when extra-terrestrial life increasingly came to be considered an object of scientific inquiry; toward the end of the century, astrobiology, the study of life in the universe, was born[4]. As often happens, this process was more complex than it may seem at first glance. For several decades the discipline, once called *exobiology*, the study of extra-terrestrial life (Lederberg 1963, 1126), was blamed for being a field of inquiry that "has yet to demonstrate that its subject matter exists!" (Simpson 1964, 769) and therefore, according to some, did not have the status of a science at all. When NASA funded the National Astrobiology Institute at the end of the 90s, the term exobiology was partially discarded and a new one, in which the prefix *exo-* (outside) had been replaced with *astro-*, was adopted (Dick and Strick 2005). What appeared to be just a mere rephrasing was in fact due to – and at the same time contributed to draw people into – a different way of studying and searching for life in the cosmos, defining the discipline in a way that would also include Earthly life as an object of interest. To pursue the study of life in the cosmic context, astrobiologists become equipped with "at least one data point of the life that we know: life on Earth" (Cockell 2015, 1).

Today, the study of extreme (i.e., unusual and unfriendly from a human perspective, requiring microorganisms to adapt and develop efficient physiological mechanisms to survive) environments[5], shapes the design of

space missions and how the data collected during those missions are interpreted[6]. Despite being considered to be hostile for most of the forms of life we know, these environments revealed that they could host thriving ecologies sustained through a number of adaptations. Extreme environments have become an object of intense scrutiny to understand how life behaves in circumstances that, even if very unusual on Earth, might be comparable to average conditions on other planets.

Because many of the microorganisms living in extreme environments are still unknown or very hard to culture in the laboratory under standard conditions, the study of extremophiles (i.e., organisms able to live in extreme environments) has required astrobiologists to periodically vacate their lab benches to set foot (and hands, eyes and all the rest of their bodies and instruments) onto their chosen field sites.

In fact, not every astrobiologist engages in long and adventurous field trips: some of them focus on computer models and simulations, others are satisfied with doing experiments in the laboratory with samples that other scientists collected in the field. Nevertheless, a growing portion of those who would call themselves astrobiologists have started engaging in field work activities, and the resulting knowledge has been used to confirm the validity and legitimacy of what is done in other experimental spaces. "The field", Paxson and Helmreich note, relies "on the promise of microbes as revelatory entities that might reveal life's universals with reference to unexpected particulars." (2004, 181). The astrobiologists' engagement with extreme environments as analogue field sites thus informs the establishment of a new paradigm for what constitutes astrobiological research today. The present work investigates one of these analogue field sites and the experience of analogue making that scientists engage with.

By drawing on my ethnographic study of astrobiologists' and speleologists' fieldwork activities, I am looking into the use of *space analogues*, material settings in which one or more analogies between Earth and outer space are embedded. In particular, I will focus on how the analogies through which these scenarios are turned into epistemic tools to investigate life in the universe are built, sustained and experienced. I will argue that it is the multiplicity and redundancy[7] of the analogies that the field site is imbued with that keep its validity as a heuristic tool in place. Analogies between specific Earthly environments and their Martian counterparts are not a given a-priori; they are negotiated and made relevant through the scientists' experience of them which, at the same time, creates a dialogic space to envision, explore and negotiate tensions and alignments between alternative futures for space exploration.

During the time I spent with astrobiologists working, talking, and thinking through terrestrial analogues of Mars, I came to realize that astrobiology is a discipline deeply infused with a sense of place: researchers, research practices and the material settings mutually define each other. By taking the conceptual efforts and scientific practices that turn Earthly en-

vironments into space analogues as the focus of this paper, I investigate this process of mutual production.

By examining the embodied dimension of analogue making, I join scholars pursuing two contemporary projects. On the one hand, this article brings together experience, embodiment, and the communitarian dimension of science in the context of knowledge making practice. The Science and Technology Studies (STS) traditional focus on the laboratory has helped deconstructing the purported universality of science by casting a light on the social construction of the laboratory's rigid boundaries, oversimplifications and standardizations (Latour and Woolgar 1979; Knorr-Cetina 1981; 1995; Crabu 2014; Sormani 2014). On the contrary, with only few exceptions (for example Kohler 2002; Livingstone 2003), field sciences have enjoyed scarce attention. Fieldwork-oriented disciplines can tell a different (and complementary) story about science, a story in which the body of the scientist cannot be easily removed from the picture, and in which rhetoric and practice are stitched back together.

On the other hand, I join the debate about the sociological importance of space exploration and outer space technological activities. Olson and Messeri have recently problematized the spatial "inner/outer split" (Olson and Messeri 2015), the supposed division between what counts as the normative terrestrial sphere of human experience and what counts as outer space. They have argued for the inclusion of all those non-Earthly places (and maybe, one day, non-Earthly beings) whose conceptualization has been fundamental for the creation of contemporary perspectives on Earth but that, paradoxically, have been neglected because of the current "Earthbound turn", the inward orientation of what counts as the environment. To question the contemporary inner/outer dichotomy and its rhetorical topologies it is important to pay attention to how knowledge is made, to the contingency of what counts as Earthly or otherworldly, but also to what "does not quite fit" (Bertoni 2016) in the contemporary discourses about perceptions of the environment and the possibility of knowing Earthly and alien microbes. More generally Space analogues present an interesting case because of the twofold process through which scientists get to understand certain environments and through which their physical presence and lived experience of these very environments makes their identity as astrobiologists.

The embodied experience of analogues – and more in general, of knowledge making practices – is at the very core of this paper. Embodied experience, nevertheless, is not just an object of analytic interest, but also the dimension that substantiates this piece of research methodologically. The emphasis on embodied experience is thus echoed in how the ethnographic data were collected and how they are presented to the reader: this paper's argument is never detached from the embodied experience of the ethnographic fieldwork, which is granted a central role throughout the entire article. In drawing extensively from my fieldnotes, I hope to convey

the sense of curiosity and affection toward *what we have not understood yet* that strikes the ethnographer from the field to the writing of her findings – what Jane Guyer (2013) called the "epistemology of surprise". In turn, this approach finds its parallel in the purposeful search for what we have not encountered yet, what is not-known (see also Marcheselli 2020) and unforeseen, that characterizes astrobiological fieldwork.

2. Analogies and Space Analogues

Analogies are ubiquitous in science[8]. We all – scientists included – think about gravitational waves in terms of *ripples in the fabric* of time, evolutionary phylogeny in terms of *branches of a tree* and light in term of *waves and particles,* to mention just a few examples. "Without models", Mary Hesse wrote in 1966, "theories cannot be genuinely predictive". Analogies, she claimed, provide the only effective way to search and test for new hypothesis to expand the explanatory power of a theory. Similarities and differences between the two terms of an analogy are not fixed, but they are object of testing and debate and in this very process lies the predictive power of analogical reasoning (1966, 51-100). Nancy Leys Stepan reminds us that scientific metaphors and analogies, unlike those used in literature, must not be considered arbitrary nor merely personal to come to count as valid epistemic tools. On the contrary, they require to be agreed upon by a community and their cultural sources have to be made unrecognizable. "Nevertheless," Stepan writes, "because a metaphor or analogy does not directly present a pre-existing nature, but instead helps *construct* that nature, the metaphor generates data that conform to it, and accommodates data that are in apparent contradiction to it, so that nature is seen via the metaphor and the metaphor becomes part of the logic of science itself" (1986, 274).

In their sociological analysis of scientific knowledge, Barnes and colleagues (1996) emphasize that, despite seeming obvious, the identification of modelling[9] in science as a contingent action is crucial. "When it is overlooked, the result is typically a purely formal account of modelling, which fails to grasp its purposive and goal-oriented character, and hence how it comes to be recognized as successful or unsuccessful. There is no perfect model […] A successful model is a pragmatic accomplishment, something which those who evaluate it take to serve their purposes" (1996, 108-109).

The literature on outer space analogies that emerged in the last decade is broad (for example Battaglia 2005; Helmreich 2009; Launius 2014; Praet and Salazar 2017; Salazar 2017), but caves and mines as analogue field sites for space exploration and settlement are fertile terrain to carry on with the work of unpacking the set of related questions on the inherently cultural sources of scientific analogies (Battaglia 2005), their role in

making forms of life and life forms (Helmreich 2012), their normative consequences (Olson 2012), and the ongoing process by which they are agreed upon or changed. Because analogies are not *found,* but *made* – and, at the same time, *making* what counts as valid and legitimate – in astrobiological practice, the investigation of their conditions of possibility cannot be conclusively settled. On the contrary, the social scientists interested in how knowledge is made out of experience can extend the principle of finitism (Barnes et al. 1996, 53-59), which states that future applications of a term are open ended and no application is indefeasibly correct, to the making and use of analogue sites and the analogies embedded into them.[10] Space analogues raise continuous problems of correspondence and reconciliation between the meaningful relationships among the features of the surrounding environment and the ones that can be found within another – real or imagined – setting. Indeed, despite their being "extreme", no place on Earth is inherently Mars-like (or Moon-like or like any other body of the Solar System). Earth's atmosphere, soil composition, gravity, tectonic dynamics, just to mention a few features, are not the same[11]. Nevertheless, a number of these extreme environments are today used as analogues of other outer space environments[12], Mars in particular. These analogue sites are said to have characteristics that are *so* similar to the ones we would find on the red planet, that they can be considered valid Mars analogues. But how *similar* is *similar enough*? There is no one single answer to this question. Indeed, as it emerged during my field research, each analogue field site has its own history of why, how and when it was selected, and "its own stories about life to be told"[13].

3. Three Analogies between Outer Space and Subsurface Environments on Earth

There might seem to be an unbridgeable distance between the depth of a cave and the deep space where astrobiologists hope, one day, to find life. To understand how these *loci* have become thinkable within the same astrobiological discourse, we need to disentangle the narratives[14] – a rhetorical device that "unsettles landscapes as static images" and "structures both place and time as they manifest in landscape" (Messeri 2016, 31) – that are deployed by scientists when talking about and experiencing caves as Mars analogues.

Fieldwork is rarely a solitary experience: a small handful of scientists from a wide spectrum of disciplinary backgrounds join forces to understand multiple aspects of the environment and make them significant for reasoning about life beyond Earth. Very often, their collaborations are driven by logistics and by the necessity of optimizing resources as reaching remote and barely accessible sites requires laborious planning and preparation. Nevertheless, once in the field, their collaboration becomes

part of how the science is done. The interaction among people with heterogeneous experience and expertise often leads to the mingling and intertwining of several analogies.

3.1 Caves as Microbial Habitats

The presence and activity of microorganisms underground became an object of interest in astrobiology when decades of data on the Martian soil and atmospheric composition made scientists agree that it is today very unlikely to find either presence of extant or traces of extinct forms of life *on the surface* of the red planet (Westall et al. 2021). The atmosphere on Mars is today about a hundred times thinner than the one shielding the Earth. Because of the low pressure, what was a landscape shaped in ancient times by rivers and lakes does not, at present, offer the conditions for liquid water anymore – except for flowing brines saturated in perchlorates, highly oxidizing salts that only very rarely form on Earth. What is more, the amount of UV radiation would constitute a severe threat for the stability of any organic compounds. Even if there was, once upon a time, life on Mars, astrobiologists think it would be very hard to find any trace of it left on the surface. Nevertheless, based on observations of how life behaves on Earth, they consider the possibility that there were residue colonies hidden underground for much longer after the surface had become uninhabitable, and their traces might be better preserved (for example Cockell 2003). Some astrobiologists have actually made the claim that some microorganisms might still be there, adapted to a niche where UV radiation is lower and where there seem to be reservoirs of liquid water (for example Mhlmann 2003; Bandfield 2007).

Astrobiologists are thus interested in the cave as an environment in which most of the solar radiation is filtered out and in which microorganisms have lived undisturbed and isolated for thousands or millions of years. On Earth, these conditions are *extreme*, while on Mars they are seen as the last bulwark to offer refuge from even more hostile surface conditions. Despite what every microorganism living on the Earth's surface would consider highly hostile conditions, caves are teeming with life forms capable of optimizing the resources available. If they do so on Earth, why they shouldn't act the same way on Mars, astrobiologists wonder. This unexpected multitude of microorganisms adapted to the deep darkness of Earth's caves reinforced the hopes of many astrobiologists. They conceive them as instances of life's great capacity for survival, despite the darkness, isolation, and lack of nutrients – conditions that might all be similar to those in the Martian subsurface. The differences, for example the copious presence of water which is indeed the primary force giving shape to caves on Earth, are considered negligible, and thus disappear into the background of what astrobiologists observe within the framework of the analogy.

3.2 Caves as Human Shelters

In the early 2000s, for the first time, satellites orbiting Mars sent pictures of possible cave entrances back to Earth (Cushing 2012). Speleologists suggested these might be used as shelters in the future human exploration of the red planet. The lava tubes, caves formed during volcanic eruptions, might offer a cost-effective solution to the danger of UV radiation exposure which is one of the main obstacles that will have to be faced when planning the establishment of long-term settlements on Mars (Boston et al. 2004). From 2002 to 2004, NASA funded the Caves of Mars Project, as part of the Institute for Advanced Concepts[15] to assess the best place to situate the research and habitation modules that a human mission to Mars would require. Microbiologists' and speleologists' interests have always been deeply rooted in understanding adaptive solutions that would allow microbes to thrive in caves. But to investigate them, they had to develop a parallel branch of expertise: during the long expeditions bringing these teams to still unexplored hollows, they live inside the cave for several days. In building up a network of people interested both in speleological themes and in the possibility of extending their technical and scientific expertise to space exploration, they had traced a second relationship between exploring caves and inhabiting other planets.

3.3 Caves as *Topoi* for Astronaut Training and Exploration

Sardinian caves have become periodically populated by groups of astronauts for training purposes[16]. In 2011 ESA established a training program called CAVES, acronym of "Cooperative Adventure for Valuing and Exercising human behaviour and performance Skills". Every year, the training happens in a different cave; avoiding contamination and keeping the environment pristine is one of the imperatives of the training. The depth of the caves had been chosen for their "dark and alien underground environment with *many analogies* to space" ("Why caves?"). The analogies here mentioned have nothing to do with microbes or UV radiation; they were relative to the astronauts' training needs.

> One of the terrestrial environments which best mimics a planetary world, such as the one on Mars, is without any doubt the cave: darkness, constant temperature, limited visibility, physical obstacles, strict safety rules, isolation, loss of temporal cognition, difficulty in supplying materials and food, the necessity of working in a team. If exploration and documentation tasks and scientific sampling and experiments are added to those factors, the similarity of a cave mission to an extraterrestrial one becomes even more striking. (Bessone 2013, 56-57)

Since the beginning of the space program, astronauts have been selected according to criteria that evaluate both technical skills and personal temperament[17]. Because of the stressful conditions they will be continuously exposed to during space missions, among all the applicants only those who demonstrate a high tolerance to demanding endeavours are considered for selection. Yet, for training purposes, they have to be exposed to conditions that exceed their tolerance, which are very hard to simulate in a controlled environment that does not present any real danger. As demonstrated by Olson (2010), during their career, astronauts are re-made into environmental subjects, or bodies whose performance require to be evaluated within the context of its functioning (namely, the hyper-technical space of the International Space Station). One of the strategies adopted is to bring small groups of them into unfamiliar contexts, where they feel uncomfortable, "where they have to *adapt*"[18]. Placing them in these alien conditions is, indeed, another form of "ecobiopolitics" (Olson 2010), that is the disciplining of the astronauts' bodies through the temporary remaking of their relation to a new and otherworldly environment.

During the six days of cave mission, the astronauts cannot be left idle, as this would be too inconsistent with the tight schedule of a space mission. For this purpose, ESA trainers asked speleologists to provide a number of scientific goals the trainees would have to achieve once into the cave. Each year the team is thus given a series of scientific projects they need to learn how to carry out to completion. The assignments usually take the form of collecting samples and specimens and making maps of the chambers that are still uncharted. What is at stake is not merely the survival in a cave by following standardized safety procedures, but being able to apply them while *exploring*. "Who's the real explorer?" asked Laura, one of the ESA trainers. Her goal is to turn the engineers into explorers, teaching them how to be attuned to what is new and surprising, to step inside the unfamiliar, inhabiting – sensing and dwelling in – an isolated space, with no weather or days, alien and alienating.

Through the experience in these particular field sites in Sardinia, the scientists were involved in the production of these three analogies at the same time: i) they were thinking about the field sites we visited as isolated subsurface microbial habitats; ii) as shelters protecting humans from the dangers of the Martian atmosphere, and; iii) as isolated enclosed spaces that reproduce some of the features specific of space journeys. The three analogies, in the lived experience, overlapped and became, at times, almost indistinguishable.

The workshop talks and presentations were carried in the auditorium of the local mining school, founded in 1871 in the attempt to improve the economy of a region still considered poor, but rich in raw materials. Mining represented, for several decades, the only industry of the region that

employed and sustained the local people. The Art Deco building hosts, in the basement, the museum of mining. Established during the decline of the extractive sector, the museum is located in multiple smaller rooms and is arranged around different aspects of local mining life. It includes the 400m practice mine tunnel excavated by the students under the school and the nearby square. During the Second World War, the tunnel was used as an air raid shelter, infirmary and operating theatre, directly connected to the old hospital. More than only in strictly economical terms, mining and survival, in Iglesias, were deeply interrelated. During the 1990s almost all the mines of the district closed down and today the mining industry has mostly disappeared. The old buildings and tunnels remain there as ruins for industrial archaeologists, and attraction for the rampant tourist sector.

Lisa Messeri describes analogues as the successful super-imposition of planetary and local. In the Mars simulation facility based in the Utah desert that she gives an account of, this overlapping carves out "a unique place to inhabit and consequently forge a novel connection to or understanding of another world" (Messeri 2016, 26). The analogue is not just a simulation: the new way of thinking about outer space, both considered place-less and nevertheless deeply situated, is, according to Messeri, generative: "it creates a history even as it simulates the future" (ibid.). In creating a geo-microbiological history of the Earth within the broader Solar System, it makes it possible to think about the future inhabitation of other planets. Double exposure can be, in fact, multiple. By means of the first-hand experience and the group interaction, astrobiologists can quickly shift from one narrative to another and build up a shared vocabulary of *adaptation, isolation* and *exploration,* with which they can refer to all the three analogies, making the shift between one and the following even more immediate. The analogue was redundant in that even when one narrative failed to convince those involved in the analogue-making activity, others could support the legitimacy of the field site as a space of knowledge production about extra-terrestrial environments. In fact, the analogies drawn between a terrestrial cave and Mars might not have always been very strong or very obvious; but in the lived interaction the analogies were substantiated and tied together. Subsurface and survival – of microbes or humans – were superimposed in the analogue experience.

4. Co-presence, Colonization, Contamination

The GESE topical team's aim was to explore new research avenues and the ways in which mineral-microbe interactions might be put into use in future space exploration and settlement. Nevertheless, looking for life and establishing new settlements on Mars are based on different practices: biological (either astrobiological or speleological) approaches rely on

keeping life forms apart to validate their findings (Metzer 2011), whereas human spaceflight practices focus on putting life forms – not only humans, but entire ecosystems designed to sustain micro- and macrobiological communities – elsewhere.

The high vulnerability of some of these Earthly environments requires scientists and astronaut trainees to pay attention to the consequences (both on the epistemic and the ethical level) of their physical presence and calls for reflections about both the future of the human exploration of space (see, for example, Cockell 2007) and the present use of these environments as spaces of knowledge production. As Stepan (1986, 268) suggested, a metaphor is not a one-way knowledge-making device; on the contrary "by their interactions and evoked associations both parts of a metaphor are changed".

Caves and mines are, in this respect, very different settings which encourage different considerations. Mines are human made spaces, whose astrobiological relevance is due to the resistance and resilience of the microorganisms inhabiting them, which have survived the depletion of their environments and then re-appropriated the newly created surfaces and the cracks as soon as they became available. Astrobiologists observe their resilience and are keen on not changing the conditions that make the microbial re-colonization possible. Caves are valued for their pristine and isolated conditions instead. Access to pristine caves is highly regulated; for scientific as well as logistic reasons, the scientists do not spend more than a few days inside caves, and no long-term settlement is established in their depths. During these exploration trips, it is imperative to bring back outside everything that has been introduced as part of the astrobiologists' and speleologists' gear. Nevertheless, there are a few things that cannot be removed: footprints and marks (for example those created by the hiking equipment), and microbes. The former can be considered within a framework of geological dynamism: footprints and small blemishes will be, given enough time, eroded by the same processes that have carved the cave out of the rock. The latter, microbial contamination, has a different status, which has to do with the ambiguities of "colonization" when considered at the microbiological level to describe the opportunistic and efficient entering and settling of new organisms within a certain ecosystem, which might not have been previously inhabited. The potential for colonization is in fact twofold: the scientists' bodies could be infected by bacteria from the cave, and the cave could be colonized by bacteria spread by the scientists' presence (their touching, breathing, sweating). The body and the cave are thus two habitats for microbial communities[19]. The tension between the value they attribute to these field sites' being pristine and the threat to this very condition posed by the scientists' physical presence in the analogue sites, mirrors the same ethical concerns that trouble the astrobiologists about outer space missions[20]. These tensions are materialized during the fieldwork experience: space analogues often

raise both concerns and enthusiasm about the colonization of outer space, and they open up a discursive space within and outside the scientific community (McKay 2009; McKay and Zubrin 2002), a space where to negotiate alternatives and tame challenges to the science.

5. Back to Planet Earth

At the end of a walk in Is Zuddas, a show cave whose first kilometre has been equipped with steel stairs and neon light to become a tourist attraction, we were told that the key of the gate securing the entrance had been lost and the gate could not be re-opened to let us out until someone would come and fix it. A group of us stopped and waited on a terrace a few meters below the cave mouth. We started jokingly talking about how would we survive in the cave for a long time: would we need to hunt bats, collect bugs, drink the water dripping from the walls? Would our grandchildren evolve to see in the dark? Would we, like in Jules Verne's *Voyage to the Centre of the Earth*, discover prehistoric landscapes in the depth, moving in space and travelling in time? The expert guide looked at our faces and laughed: when the astronauts come for the training, she always plays the same trick to see their reactions. After many days of isolation, how do they cope with the impossibility of getting outside, metaphorically returning to Earth? For us, the gate had always been open anyway; we got out of the cave and started walking in the large path under the tree shade. Some veteran speleologists chat about how getting out of a cave makes the surface feel different and indeed very chaotic: the wind moves the leaves, birds tweet and insects fly and land on our clothes; the warm sun, high in the sky, suggests that it is time for lunch. I wonder whether we are back on Earth, or if we have travelled even further on a terraformed Mars, "This cannot be Mars," someone tells me, "too many mosquitoes. Who would want to put mosquitoes on Mars?!" The analogue experience overturned our idealistic conceptions of both Earth and other possible habitats. Earth is the only planet we know we can live on, but indeed what makes it feel unique are its many (perhaps imperfect) environmental relations.

This brings us back to the above-mentioned principles of finitism: if the first thesis says that the future applications of terms are open-ended, the last thesis says that the applications of different kind terms are *not* independent of each other. It follows that any act of use of a term "is liable to condition all subsequent acts of use of all those associated terms." (Barnes et al. 1996, 58-9) Even when stepping outside the analogue field site, the analogy keeps on its generative work: it has not only made Mars a little closer, but also the Earth surface and atmosphere unfamiliar and new, and a cave in southwestern Sardinia richer in interesting life forms.

Su Zurfuru mine does not seem *abandoned* anymore, but repopulated and given new life by different communities of microbial miners and dwellers.

Thinking about ecological futures in outer space unsettles visions of the Earth as well, in a way that is not dissimilar from the so-called "overview effect" (White 1987), the cognitive shift of awareness reported by some astronauts that, in the late sixties and seventies provided one of the conceptual bases for environmental movements[21]. Astrobiology and human space flight overlapped again in unexpected ways. "The [extraterrestrial] realm is not 'other' than earthly but acts back on and unsettles assumptions about commonplace brands of knowledge" (Battaglia 2005, 11), as a resource to articulate different ways of being humans on Earth, and also being humans on a planet shared with other micro- and macrobiological life forms. If ecological understandings of space are continuously being negotiated through analogues field sites (among other things), so is the other term of the analogy: Earth.

6. Conclusions

This essay focused on the ethnographic account of astrobiologists' and speleologists' analogue making activities. By moving beyond analogies as rhetorical tools and focusing on the lived, practical, situated and embodied experience of analogy making, this essay aims to cast a light on analogue making practices as fundamental tools to (re)define a discipline and to explore and negotiate tensions and alignments between different (and not always compatible) directions for future space exploration.

The first part of the essay focused on three scenarios that scientists embraced when exploring caves and mines in Sardinia during the GESE workshop, i.e., caves and mines as: 1) microbial habitats; 2) shelters and; 3) sites for astronaut training. I investigated their overlaps and consequences of the multiplicity and redundancy that keep the validity of the analogy as a heuristic tool in place. I then explored some of the issues and social dynamics involved in the shared experience of analogue fieldwork.

It is in the collective experience of otherworldly scenarios that analogues are negotiated and turned into collectively relevant epistemic tools. Once descended into the darkness of a cave, peripheral vision is completely inaccessible and what could be seen is always and only a sharp cone of light pointing straight. Seeing is a combination of the skilled art of pointing one's light in the right direction and involuntary movements, for example when stumbling on a rock and pointing the light downward, maybe to notice the presence of something unexpected, standing out against the surrounding darkness such as the unexpected view of a jelly substance, triggering the astonishment of the scientists who immediately claimed "this is biology". The possibility of unexpected findings is not unique to the field as opposed to the lab – even in the controlled and

standardized space of the laboratory people are sometimes led to unexpected breakthroughs. What fieldwork provides is the possibility of *purposefully* searching for the unforeseen and unforeseeable. In fact, serendipity plays a significant role in laboratory or archival research as well, and nevertheless, in these contexts, the dominant narrative reconstructs findings (often in retrospect) as obtained through hypothesis testing. Astrobiological fieldwork (like many other field disciplines), on the contrary, rejects this narrative in favour of a more open-ended and less deterministic research trajectory. The non-trivial combination of skilled observations and serendipity is considered one of the features that make fieldwork experience a valuable analogue for the search for life in space.[22] The field, which represents the renewed encounter with a nature not allowed within the strictly filtering boundaries of the laboratory, "is believed to harbour a surplus of multiplicity, abundance, and potentiality humans have not yet discovered or characterized" (Paxson and Helmreich 2004). It is through the scouting for what is still *unknown* (Marcheselli 2020) that astrobiologists carve a space for their discipline within the broader academic landscape.

Accordingly, one of the issues that caves and mines uncover, is the question of how disciplinary boundaries are defined or blurred in analogy making. The boundaries between disciplines, as well as between science and other realms of action, are social phenomena; they are a "contextually contingent and interests-driven pragmatic accomplishment drawing selectively on inconsistent and ambiguous attributes" (Gieryn, 1995:393). In making different analogies coexist, merge or conflict, caves and mines as space analogues are trading zones (Galison 1997) in which different research directions and priorities are discussed, explored and opened up for future negotiation.

Training to prioritize microbe detection and protection techniques and stories of mining, survival and change provide resources to further articulate the analogies, aligning visions or taming challenges. Extreme environments turned into space analogues are crucial sites for "examining practices of future imagining in social terms, and for anthropological engagement with these practices" (Salazar 2017, 72). What in the collective experience becomes a common imaginary mixes intentions and different timescales. The ESA astronauts training in caves, for example, includes exercises on how to collect astrobiologically relevant samples in sterile conditions, even before the existence of an actual proposal for manned space missions on other planets. The trainers are "testing the training" for those who, in an indefinitely far future, will become the first (European) astronauts on other planetary surfaces but, at the same time, are also informing the astronauts' view of Earth, space and ecosystems.

But analogue-making work is never completed: agreement on what constitutes a good analogue setting is an ongoing negotiation between the epistemic practices that are implemented by those who identify them-

selves with the emerging discipline of astrobiology and what counts as a meaningful present and future for space exploration. This opens up a space for sociological inquiry about the particular social processes through which analogue practices require collaborations to be made, allow for new interactions and evoke previously unforeseen associations, and thus constantly unsettle and reframe all the terms of the analogy and the actors involved (Stepan 1986; Franklin 2014).

Exploration of space, exploitation of its resources and settlement establishment are not necessarily compatible goals or perhaps joinable by the thread of mineral-microbe interaction, but they are made so when seen through the lens of Sardinian caves and mines as analogue field site. Finding life on Mars and establishing a human presence on it (either as scientific outpost or long-term settlement) are often thought of as incompatible tasks, since the economic profitability and colonization of space as an exercise of political power is at odds with the ethical concerns about these environments. But strategically, astrobiologists align with geomicrobiologists and position themselves as to be relevant actors in any of these possible alternatives. At the same time, they do not exclude any alternative, but they order them chronologically: it is shown in practice how microbes can both be invaluably useful to humans, and at the same time understanding them depends on prioritizing a certain empirical approach which privileges "surprise" over scrupulous planning, and human sensibility over robotic functionality. Conflicting futures are not neglected, they are performed and tamed.

Notes

[1] A brief introduction to the history of the Su Zurfuru mine can be found at http://www.parcogeominerario.eu/images/files/pagina%20633(1).pdf (in Italian).

[2] All the people mentioned have pseudonyms.

[3] The location, Iglesias, was chosen in function of the three sites we visited during the field trips: two caves, Su Mannau and Is Zuddas and an old mine, Su Zurfuru. The vignette refers to the last one.

[4] For a comprehensive account of the history of exobiology and astrobiology, see Strick 2004; Dick and Strick 2005; see also Impey 2010.

[5] A popular definition of this concept can be found in Rothschild and Mancinelli 2001.

[6] Some good examples of this feedback process can be found in the *JGR-Biogeosciences* Special Issue "Field Investigations of Life in the Atacama Desert" available at https://agupubs.onlinelibrary.wiley.com/toc/21562202g/2007/112/G4.

[7] The word "redundancy" is intended here with a meaning similar to the one the Oxford English Dictionary attributes to the engineering use of the word: "the deliberate duplication of parts in a system so that its function is not impaired in the event of a malfunction or failure" http://www.oed.com/view/Entry/160537?redirectedFrom= redundancy - eid.

[8] Different perspectives on analogies in science can be found in Hofstadter and Sander 2013; Lakoff and Johnson 2013; Holyoak and Thagard 1995.

[9] Modelling is defined as the establishment of a link between two things – which might range from mathematical structures to verbalized systems – by means of resemblance or analogy (Barnes et al. 1966, 107-9).

[10] As above, I define *analogue sites* as material settings in which one or more analogies are embedded and *analogies* as the correspondences between Earth and outer space.

[11] "Especially important to the functioning of interactive metaphors" Stepan writes, "is their ability to neglect or even suppress information about human experience of the world that does not fit the similarity implied by the metaphor. In their 'similarity-creating' capacity, metaphors involve the scientist in a selection of those aspects of reality that are compatible with the metaphor" (Stepen 1986, 272).

[12] The same use of the word "environment" to designate other planetary surfaces has not to be taken for granted. Planets have not always been considered *places*, but what is considered the correct way of thinking about planets has changed over time. See for example Alexander et al. 2009; Messeri 2010.

[13] Interview with BW (astrobiologist) 21/10/2015.

[14] Messeri proposes *narrative* as a device that "unsettles landscapes as static images" and "structures both place and time as they manifest in landscape" 2016:31.

[15] The Institute encouraged creative and innovative thinking about space exploration related issued. See http://www.niac.usra.edu/.

[16] More details on ESA's astronaut activities in caves can be found at: http://www.esa.int/Our_Activities/Human_Spaceflight/Caves/.

[17] The astronaut selection processes and the "American hero" narrative it reproduces is deeply normative. Most astronauts are white males, often with a military training or a degree in engineering. Despite the effort to reverse this trend, its limits are enduring.

[18] 25/05/2015 private conversation with LB (astronaut trainer).

[19] An interesting parallel with reference to the ISS can be found at http://www.sciencemag.org/news/2015/10/international-space-station-home-potentially-dangerous-bacteria.

[20] For further historical insight on this, see Wolfe 2002, Anker 2005, Daly and Frodeman 2008.

[21] Despite looking at the planet Earth from orbit seemed objective because detached, this perspective has been shown to be inherently situated, like any other perspective. See Helmreich 2011 and Poole 2010.

[22] When astrobiologists imagine what it takes to find life in an alien environment, they acknowledge that they should probably not expect to find exactly what they look for – but they rely on the idea, often repeated in formal and informal settings alike, that they will recognize life, despite the different forms it might take, once they encounter it.

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Exploring Multispecies Assemblages in Roman Urban Gardening Initiatives

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Abstract: In this article I will discuss the potential of using the assemblage thinking in multispecies ethnography, as a method for developing post-anthropocentric situated accounts. It is an extremely relevant tool with which to relate to make emerge how space is co-constructed through hybrid associations of human and nonhuman actors, which exceed human intentionality. Reading entanglements through a material-semiotic approach provides interesting analyses of the exploitation of the nonhuman on a global scale, but also offers stories of possible situated multispecies relationships of care. These relations are not universal essences, but situated entanglements in which nonhuman actors play an active role. Relying on STS feminist reflections, focusing on care could have the potential of unveiling less anthropocentric more-than-human relations, showing how beings depend on each other.

Keywords: urban gardening; post-anthropocentrism; Ailanthus Altissima; Mellifera Bee; multispecies ethnography.

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1. Introduction

I start watering and I realize how I fell back again in logocentrism. I still feel restless. After several minutes, the only human in the garden, I begin to slow down. Finally, the nonhuman presences that cohabit and co-build this place are opened to my gaze, to my touch, to my hearing, to my nose. In watering, my skirt gets wet, my hands get dirty with soil, which sticks to my wet skin, giving a feeling that my body perceives as anything but pleasant. But that reveals my contact with otherness. Plants have grown tremendously since the last time I saw them. The plot is teeming with plant

life, it is almost impossible to see the soil. It is a whole tangle of plants. Watering, I make my way through the chickpea plants. Many green buds have begun to form on the ends of their stems. In the ground, which is now muddy from the water I poured, thousands of ants move swiftly, creeping up my leg, pricking me. Still wet, I scratch my hands. As always, I perceive on the skin the physical layer that I am used to consider as the physical boundary between my body and the rest of the world, and I consider how the interaction with nonhumans, like any relationship, needs time, practice, attention and knowledge. (Field note, June 2018)[1].

In this article I will discuss the potential of reasoning *with* and *in* material-semiotic multispecies assemblages[2], relaying on an ethnographic research I carried out in a Roman shared urban garden named "Tre Fontane". In the text, I will present two nonhuman figurations that cross the garden, the *Ailanthus altissima* and the *mellifera* bee. In Haraway's terms (1985; 2016), figurations are not just metaphors. They are situated and embodied entities that can allow questioning anthropocentrism at a material and discursive level through multiscalar relational accounts of the world.

Figure 1. Mellifera bee in the
garden Tre Fontane.

Humans-plants relationships have been highly disregarded among social sciences till very recent times. In the last decade though, humans-plants assemblages started to be investigated, in particular by new materialist (Breda 2017; Mayers 2015), multispecies (Hartigan 2015), and more-than-human (Barua 2014; Hinchliffe and Whatmore 2005; Hinchliffe et al. 2006; Pellegrini and Boudry 2014) accounts. In this line, I will proceed to the analysis of the co-creation of the garden area as vegetal politics[3] (Head et al. 2014). On one hand, institutional policies and politics pursued by active citizenship groups "on" the vegetal – i.e. the transformation and management of green areas – can implement mechanisms of spatial injustice. On the other hand, the analysis of interactions between humans, vegetal, and other-than-human actors can demonstrate the nonhuman capacity for action and transformation, well outside the boundaries of human intentionality. In this sense, politics is disconnected from anthropocentrism and logocentrism. It becomes intended as the continuous interaction of different actors (both humans and nonhumans) in a public forum (Certomà 2016). Rather than focusing on narratives and universal ideologies, this material-discursive politics is relational, "embodied and embedded" (Braidotti 2013, 51). The interactions that emerge can be of alliance, indifference or conflict, but they necessarily question the exceptionalism of the human subject (Head et al. 2014).

Urban spaces are privileged sites where to study the intertwining between human and nonhuman actors within a historical perspective, investigating the nexus of cultural, material and discursive dimensions. According to European thought the city has been extensively conceived as a human space purified from nature (Rudolf and Taverne 2012), as the triumph of the Man (Franklin 2017). However, contradicting these narratives, other-than-human entities actually continuously cross and transform urban spaces, far behind human intentionality (Certomà 2016). For these reasons, the city turns out to be an interesting and relevant field of investigation to try to question the dichotomies between nature and culture/society, between rural and urban, between territories to be preserved and those to be exploited through post-anthropocentric accounts.
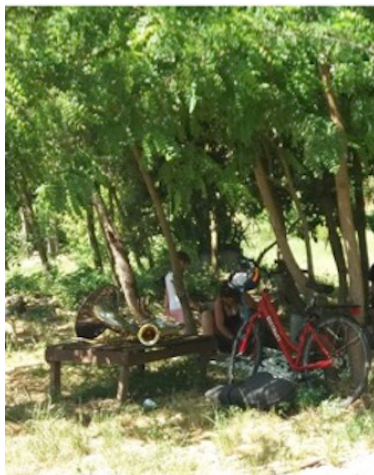
Figure 2. Urban garden Tre Fontane.

Shared urban gardens are a part of a broader range of environmental citizen-based activities (guerrilla gardening, movements for the right to access to lands, environmentalist *in situ* protests, animal sanctuaries) that take place more and more in everyday life spaces of highly urbanised industrialised countries (Marres 2012; Schlosberg and Cole 2015). There is a broad body of literature on urban gardens that recognises them as public spaces of social (Mougeot 2005; Ferris et al. 2001) and political (Certomà 2016; Follmann and Viehoff 2014; McClintock 2014) experimentation, individuating them as examples of "new commons" (Eizenberg 2012) that can contrast urban social injustice (Barron 2016). However, in this body of literature, there are also relevant positions that identify urban gardening as practices that could enhance the neoliberalisation of cities (Pudup 2012) and green gentrification (Anguelovski et al. 2018; Dooling 2009; Holifield et al. 2018). Situating my view within this debate, I argue that urban gardening initiatives could also be investigated as differentiated products of continuous messy interactions, shaped by situated conflicts and alliances, collectively generated through relational modalities (Tornaghi and Knierbein 2016), and constantly re-defined through material-discursive practices.

Aiming at analysing vegetal politics of the multispecies garden assemblage through a post-anthropocentric approach, in the next paragraph I will start by providing some elements of my own positioning within the stream of STS, posthuman and new materialist feminisms (Alaimo and Hekman 2008; Bennett 2010; Braidotti 2013; 2016; Breda 2015; Coole and Frost 2010; Ferrando 2016; Haraway 2008; Oppermann 2016; Tsing 2015). That is, a stream of feminist and post-anthropocentric approaches,

which deconstructs and connects gender and species hierarchies, as culturally and politically shaped. The post-anthropocentric posture shared by this range of feminist approaches will drive my analysis of vegetal politics in Roman urban gardening. Entering a multispecies assemblage as a research practice is a descriptive and analytical attempt that seeks to respond to an urgent challenge that arises in the human and social sciences: to take seriously the role of nonhuman agency, understood as shared and relational, in the co-construction of the social.

In the text I will start by providing some theoretical and methodological positioning elements, focusing in particular on the difficulties and potentialities of reasoning with and in material-semiotic multispecies assemblages. Afterwards I will proceed by briefly outlining the ethnographic context in which I carried out the research, that is a Roman shared urban garden named "Tre Fontane garden". I will then move to present two nonhuman figurations that cross the garden, the *Ailanthus altissima* and the *mellifera* bee.

2. Theoretical Framework

STS, posthuman and new materialist feminisms reclaim a central role of materiality and the nonhuman in co-constructing the world and emphasize the importance of accounting for them in social inquiries. They give emphasis to the material relevance of both bodies[4] and the world, trying to move beyond discursive construction and materiality divisions. Particularly enlightening for the analysis I will carry out is the notion of "material-semiotics" proposed by STS feminist scholar Donna Haraway (in Alaimo and Hekman 2008), which, refusing to separate the two terms, clearly underlines their deep and continuous co-influences. Following Haraway's conceptualisation of material-semiotics, in the analysis I will attempt to frame nonhuman actors as capable of affecting and co-shaping our common world both at a material and discursive level. In fact, in this perspective, nonhumans are not simple objects of knowledge, but actors actively involved in more-than-human meaning and knowledge production processes (Haraway 2016; 1991). That is, "everything or every being is materially and discursively generated" (Certomà 2016, 82) relationally.

Because of their interest in materiality and the nonhuman world, and their wish to decentre the human subject from the core of action and social investigation, posthuman, STS and new materialist feminisms are also post-anthropocentric accounts. Post-anthropocentrism in general challenges the separation between human life (that is "bios") and animals' and nonhumans' life (that is "zoe") (Braidotti 2013; 2016). In this vision, life stops being "the exclusive property or the unalienable right of one species, the human, over all others or of being sacralized as a pre-established given", to become a "process, interactive and open-ended"

(Braidotti 2013, 60). The nature-culture divide is discarded as a ruinous dualism not only for "nonhuman nature", imagined as "an inert ground for the exploit of Man" but also for women, indigenous people, and other "marked groups" (Alaimo and Hekman 2008, 4-5). In this sense, the convergence between feminist and post-anthropocentric theories has been read as a radicalisation of "the very premises of feminist philosophy" (Dolphjin and Van der Tuin 2012, 25) and of its ethical and political commitments.

Agency is therefore disconnected from anthropocentrism, as it does not necessarily originate from a human intentional subject (Iovino and Oppermann 2012). It becomes the capacity to relationally affect the co-constructed world. For these post-anthropocentric approaches, nonhuman world is agentic, and its actions affect both human and nonhuman actors (Alaimo and Hekman 2008) at a material-semiotic level. Nonhuman actors can change the ways in which our social world is created, conceptualised and organised, however the fact of taking account of these dimensions does not mean ending up in a new "physical determinism of social phenomena" (Passoth et al. 2012, 6). In this perspective, also the classical sociological conceptions of power are decisively redrawn. Power is conceptualised as relational, situated, embodied and contingent, and so are power hierarchies. Power has to be researched and conceived as "radically empirical […], focusing upon the affects between both human and nonhuman relational materialities within events, actions and interactions (assemblages)" (Fox and Alldread 2018, 323), and deploys through material and discursive effects (Braidotti 2016). However, power differentials are not flattened (Braidotti 2013; 2016) and should be investigated and understood in their immanent and material becoming. Situating myself in this line, in my multispecies ethnographic research, I investigated agential power of human and nonhuman actors as immanent, emerging from the field, but not flattened, and eventually conflictual.

3. Methodology

Entering a multispecies assemblage as a research practice is a descriptive and analytical attempt that seeks to respond to an urgent challenge that arises in the human and social sciences: to take seriously the role of nonhuman agency, understood as shared and relational, in the co-construction of the social. This approach also aims to create transformation on an ethical-political level. In fact, describing and understanding the world through post-anthropocentric situated accounts, also means contributing on a daily basis to build possible alternatives through the relationships we make.

Feminist STS and new materialism therefore challenge the idea that structures and scales are given (Blok and Jensen 2019; Haraway 2016;

Tsing 2012; 2015), seeing them as emergent effects of heterogeneous interactions between human and nonhuman actors. The main limits of such an approach are the risk of flattening diversities and the difficulty of including nonhuman actors in the picture while avoiding determinism (Ferrando 2016). However, the desire to study multispecies assemblages requires modes of knowledge attentive to their emergent, heterogeneous and contingent gathering. This is the main challenge and contribution of using multispecies, non-universalistic ethnography as a method (Tsing 2012).

My fieldwork in the garden has been carried out between September 2017 and September 2019. While experimenting with multispecies ethnography, I followed the everyday life of human and nonhuman encounters in the garden, considering that unexpected assemblages that could challenge historicised hierarchies can always emerge. I decided to perform multispecies ethnography with a focus on material practices in the everyday life because it is particularly revealing in understanding space production and power dynamics between human and nonhuman actors. Moreover, participant observation allowed me to trace how more-than-human agencies, relations and affects co-shape multispecies assemblages. Throughout the research process, I have always explained my role as a researcher to the people I interacted with, actively participating in the Tre Fontane garden activities, on which I focused the main part of the ethnography. My involvement in the field, including material participation (cultivating, participating in initiatives, debates, and moments of space modification) throughout the research process, allowed me to experiment and learn by doing and being with, through what has been defined observing participation (Bastien 2017), emphasising the continuous interconnection of the researcher with the research assemblage (Fox and Alldred 2015).

3.1 Multispecies Ethnography

Multispecies ethnography is a research practice largely influenced by the Harawayan conceptualization of multispecies encounters (Haraway 2008; 2015) understood as meetings between fluid, relational bodies, in becoming. In this line, the role of human and nonhuman actors co-construct the world as a continuous flowing hybrid assemblage (Kirksey and Helmreich 2010; Tsing 2015). This is a post-anthropocentric gaze that decentre agency from logocentrism (Certomà 2016; Oppermann 2017), focusing on material-discursive practices as embodied processes. The purpose of this form of ethnography "is not to represent nonhumans by speaking for them, but to tell stories of them to enable others to discover [the political agency of nonhuman actors in world-making processes]" (Pitt 2015, 52). I conducted my fieldwork accordingly, by practicing participant observation, learning with and being in the entanglement of

human and nonhuman actors (Moore and Kosut 2013a). Being shaped myself by a humanist and logocentric background, during the first months on the field I struggled with learning how to reveal the presence of the nonhuman as significant (Hartigan 2015; 2017). Hence, at the beginning of my field research I decided to let myself be guided in the interaction with the nonhumans by some garden activists who had been practicing cultivation in the area for a few years and by an activist who is in charge of managing some hives in the "Tre Fontane" garden. After a few months, I learned through their mediation how to interact and read the entanglements with the nonhuman actors who co-build and cross the garden, which initially were almost invisible to me. Moreover, I had to constantly resist the risk of identifying nonhuman situated actors as universal representatives of the species in which they are categorized by the scientific taxonomic system. "Species are generally just specimens" (Bowker 2000, in Hinchliffe et al. 2005) and not universal essences.

Fundamental in learning how to decentralize my anthropocentric gaze was to start cultivating myself a piece of land within the garden, which I did from March 2018. This allowed me to experience the interaction with the nonhuman with a daily and material approach, learning to read agency no longer as an exclusive prerogative of the human, but as a widespread and relational mechanism. This approach, which includes material participation, allows the production of a situated knowledge based on a high level of involvement of the researcher in the studied assemblage. This implies that the result of the study is not a universal crystallised understanding of the experiences studied, but a relational, embodied and transformative knowledge. More specifically, I have been following the activities (from 2 to 4 times a week), conversations and daily interactions carried out inside the garden, following materiality of both human and nonhuman actors (mainly insects and plants). I took part in the activities of the greenhouse, in beekeeping, harvesting and in weeding groups in the garden on a weekly basis. I attended around 20 assemblies, meetings and public events taking place during the period of my fieldwork. I also carried out 18 semi-structured interviews with gardeners, collected 13 articles from local newspapers focusing on green spaces management and nonhuman actors appearing in the city, from April 2018 to September 2020. I also analysed official documents and regulations produced by public institutions in charge of the management of green spaces, such as the urban gardening regulation approved in 2015[5], the urban green spaces regulation draft (that has been definitively approved in April 2021) and the Planning Activities for the Coordination of Urban Decorum regulation approved by the municipality in 2018[6]. Between 2017 and 2019 I also conducted three interviews to the person in charge of the office for urban gardens of the Roman Municipality (the "Ufficio Orti Urbani"), one interview to one of the members of the Municipal Environmental Commis-

sion, one interview with a person from the Municipal Gardening Service (the "Servizio Giardini").

3.2 Translating the Research-Assemblage through the Writing Process

"Feminism loves another science: the sciences and politics of interpretation, translation, stuttering, and the partly understood" (Haraway 1991, 95). Positioning myself into the framework of feminist knowledge-practice, I experienced the process of doing ethnography and writing field notes as an interpretative translation path, which rejected objectivizing authority and reductionist universality, in favour of the production of a partial and situated knowledge (Haraway 1991). Translation is a process capable of tracing the connections, situated associations, in which the researcher also assembles. As detailed in an interview with the anthropologist Tsing (Lassila 2017):

> Translation can be a technology of colonial rule; it can impose power […]. At the same time, translation can create room for manoeuvre as new meanings and materials are brought into hegemonic formations. (…) It's also what makes "friction" possible. Messiness gets inside articulations, which work through their equivocations. New identities and trajectories are formed in the process, for better or worse.

This article is therefore an excerpt of an emerging translation process, which involved my activity with the materiality of human and nonhuman bodies in the garden and institutional actors, the discursive dimensions materialized in the interviews, in public documents, in local newspapers and regulations, that is a multispecies, material-discursive, open-ended assemblage.

4. Rome as a Multispecies City

The city of Rome has experienced a withdrawal by of the public administration in the management of green spaces, due to massive cuts to public funds and to a progressive decrease in the number of operative staff. This has been a particularly evident trend in the last decade, even though it could already be observed at least from the second part of the nineties[7]. Because of this lack of management of greenery, combined with other environmental issues (such as for example the increased blurring between urban space and countryside, the lack of trees and weeds cuttery, the lack in trash collection systems) the city is more and more crossed by plants and nonhuman animals, also by those traditionally categorized as wild and spontaneous. In the period of my field-study (2017-

2019) there were many cases of findings of wild boars and foxes reported by local newspapers, which today frequently reach the city centre, while in the past were mainly present in large parks and in the countryside. Plant species are increasingly present in the interstices of urban spaces, multiplying as a result of the reduced maintenance of trees, gardens, and flowerbeds by public institutions.

At the same time, there has been a strong increase in the willingness of citizens-based groups to participate in the management of public green areas, in part, as noted in the interviews I conducted, precisely to compensate the lack of management by the public administration. Self-managed shared urban gardens are a clear example of this tendency, beginning to spread in 2009 (Attili 2013) and reaching about one hundred cases at present (Lupia et al. 2014; 2016; Marzi 2018). The website "Zappata Romana"[8] (Roman Hoeing) published a map of the city where participatory experiences in the management of green areas are reported. The map currently (April 2021) indicates 155 green areas, 58 of which are dedicated to communal gardens, 30 are "spot" gardens (that is, flowerbeds and guerrilla gardening initiatives) and 66 are shared gardens. "Zappata Romana" is a project of the studio UAP (Urbanism, Architecture and Landscape) and being an on-going project the data provided has to be taken with caution but it still illustrates the vitality and the interest that urban agriculture arouses. It is a universe of more or less structured and extremely diverse contexts, ranging from informal groups that perform symbolic actions of guerrilla gardening, to neighbourhood committees that manage flowerbeds, small green areas or small parks[9]. The city is therefore experiencing unusual circumstances, which can, however, also open up to the possibility to fascinatingly investigate human and nonhuman shared agencies, conflicts and alliances in the urban spaces, and to envision more just ways of cohabiting in the city with the nonhuman world.

Figure 3. Tre Fontane garden.

4.1 The Urban Garden "Tre Fontane"

The urban garden "Tre Fontane" was created in 2012 as a shared gardening experience in the southern periphery of Rome, in the VIII Municipality, on an area previously used as an illegal dump. The garden is located within a public urban park, the "Tre Fontane" Park, it covers an area of 2.5 hectares and is managed by a local association of citizens. After a short period of squatting of the area by these citizens, it was allotted to them from the local Municipality. The association that manages the space currently has about 180 members. The garden activists created a self-regulation, which sets out rules for the methods of cultivation and management of the area. In order to obtain the possibility of cultivating a plot of land, it is necessary to become a member of the association. The enrolment must be renewed every year on a voluntary base, through a payment of 10 euros. To maintain the allotment of a plot, it is necessary to also be proactive in the management of common spaces dedicated to conviviality. Otherwise, the association assembly can decide to revoke the allotment the following year. The garden space, not surrounded by any fence, and therefore potentially always accessible, is divided into 150 plots cultivated by groups of 2-5 people each, a common area with fruit trees, tables and gazebos where parties and public initiatives are held, a school garden, a greenhouse and two beekeeping areas. In the garden there are sixteen beehives, located on two hills at the edge of the area, eight on each of the two hills.

5. Following Associations in the Garden Assemblage

Through the use of multispecies assemblage thinking, I will now present two nonhuman figurations (Haraway 1985, 2016) that I encountered in the garden assemblage: the *mellifera* bee and the *Ailanthus altissima*.

5.1 Alien Invasive Plants as Post-anthropocentric Figurations

Within the Eurocentric systems, plants represent otherness par excellence (Breda 2017). In particular, invasive alien plants are categorized by prevailing scientific taxonomies, institutional policies and media narratives as disturbing bodies, as enemies of the natives, to be removed from public spaces. The representations and policies of contrasting invasive species are based on a conception of nature in balance, and frequently mobilize contrasting metaphors taken from the military, xenophobic, nationalist field, so far as to speak of "biological invasions" (Kull et al. 2012). By investigating the symbolic and discursive dimensions clustered around these plants, many studies have opened controversies within biological invasion studies (Atchison and Head 2013; Frawley and

McCalman 2014; Kull and Pamard et al. 2012). The metaphors referring to these plants, metaphors used not only by public institutions, and by newspapers, but also frequently in vernacular and botanical language, are still often clearly anthropocentric. This is the case of terms such as "invasive" and "pest", to be eradicated, to be evicted. These are terms used to refer not only to alien plants, but also to those native plants that freely spread beyond the aesthetic and spatial boundaries imposed by humans' canons and intentionality (Kull and Tassin 2012). It is a categorization that conceives the nonhuman and nature as in a static condition, in equilibrium, a categorization now powerfully contested by postmodern ecology, which has instead shown how unstable ecosystems are, in chaotic transformation, composed of actors in flux. Yet, plants are never out of place (Head et al. 2015). They emerge where they find favourable conditions. If they manage to pop up and survive, it means that they are adapted to the new environment that welcomed them (Head et al. 2014).

Many of these plants were brought to and from colonized and subjected territories in the colonial empires Era, to be exhibited in the botanical gardens, in the large avenues of the cities, in the villas. Still, exhibited as exoticised and objectified bodies, they have spread to the new territories assembling in the arrival ecosystems and showing their agency behind human purposes, so much so as to be called "escaped plants" (Kowarik 2005; Ronse 2011). Moreover, these plants have been currently blacklisted (that is, they should not be planted and the eradication of them is highly incentivised) by the European Commission, or opposed within EU funded environmental projects, as primary enemies of local and native biodiversity. Examples are *Ailanthus altissima, Robinia pseudoacacia* (Black Locust), *Rugosa rose, Ambrosia artemisifolia, Fallopia japonica*[10].

5.2 The Symposium Tree

Among the plants that the scientific taxonomies categorize as invasive and that are present in the garden "Tre Fontane", the occurrence of *Ailanthus altissima* is a very interesting figuration. The *Ailanthus altissima* is also known as the Paradise Tree, as it is named in its lands of origin. Native from China and the Moluccas and widespread throughout eastern Asia, it was introduced in the United States in the eighteenth century, in Europe in 1571 and in Italy in 1760, as an ornamental plant and for cultivation. Its cultivation spread to favour the breeding of the *Ailanthus* silkworm, to replace the silk moth. Later the plant adapted very well in the new territories. It is a fast-growing species that easily adapts to the cold, to water scarcity, to pollution and to all types of soil (Patrick 2014). Precisely for these reasons, it grows very well in urban, ruderal spaces, and in areas of industrial archaeology. *Ailanthus* plants were initially widely used as ornamental plants, especially as trees, in avenues and in urban parks, and also to cover soils and rocky slopes, thanks to their great adaptability,

their superficial root system and their ability to spread numerous lateral shoots (Maxia and Maxia 2003).

Figure 4. The Symposium Tree.

I learnt that *Ailanthus altissima* is categorized as invasive only in July 2019. In fact, I attended a course for garden organizers in the city of Rome, and one of the lessons was held in the "Tre Fontane" garden. During the lesson we were asked to walk around and collect ideas to improve the state of the garden. After an hour of work divided into groups, we gathered under a large tree in the common area, as proposed by the person of the "Tre Fontane" association who was facilitating the lesson that day. Once there, we shared impressions about possible improvements to be made. I was struck by the suggestion of a young man and a young woman, a botanist and a landscape architect, who proposed to work to greatly reduce the presence of *Ailanthus altissima*, precisely because of its infesting "essence". I thus discovered that the large tree around which we were gathered, called by the "Tre Fontane" gardeners the *Ailanthus altissima* "symposium tree" (precisely because, several months before, they took the habit of gathering around this tree for meetings, assemblies or during public initiatives), is categorized by the scientific paradigm as "pest" and "invasive". Yet, in the "Tre Fontane" garden something unexpected happened. This tree has managed to grow so much, assembling with the other actors in the garden, that it is no longer recognized as an invasive and stigmatized species. Instead, it is considered by gardeners as an actor that is part of the garden, so much so that, in fact, when the two attendees addressed the suggestion of eliminating the *Ailanthus* to Francesco (the person of the association who was facilitating the lesson) he was visibly annoyed, and did not accept the recommendation. Even if

aware of scientific categorisations of *Ailanthus* as invasive, gardeners de-
cided to not eradicate it, as they recognise the tree as a member of the
garden. This happening shows how these categories are not neutral, im-
mutable essences of the actors to which they refer, but a political product,
a hybrid product of the interaction between culture, matter, and power
(Dalla Bernardina 2000, 2004; Kull and Tassin 2012).

Moreover, the *Ailanthus* plant is extremely well liked by a nonhuman
actor that crosses and co-builds the garden: the *mellifera* bee. In fact, bees
are highly attracted by the strong odour of *Ailanthus* flowers, especially
within urban environments (Aldrich et al. 2008). Inside the "Tre Fon-
tane" garden, as mentioned above, there are two areas for beekeeping.
Claudio, the person who coordinates the beekeeping project, in 2018 ana-
lysed the honey produced by the bees housed in the garden hives. The
botanical analysis revealed a strong presence of *Ailanthus* flowers. Below
I will briefly present the relationship between humans and bees in the
garden. The description of this relationship will help to highlight the mul-
tiplicity of human and nonhuman actors who cross the garden. I will then
devote the next section to an analysis of the interaction between the dif-
ferent actors in the field through a post-anthropocentric material-
discursive lens.

5.3 Human-bee Assemblages

The area of the beehives is placed on a rise at the edge of the garden and
is marked by a sign with the words "continuous buzz" ("ronza continua"
in Italian). The hives are in wood and laminated metal, they are eight,
painted in alternating blue and yellow. Following Claudio [a middle age
man, which is the coordinator of the garden beekeeping group] I lean on
a large wooden bench at the foot of the hill, and Claudio hands me pro-
tective clothing. Then he explains me step by step what kind of work we
are going to do. He explains that the bees present here belong to the most
common species in Italy, which is currently one of the species of nonhu-
man animals at highest risk of extinction.

Figure 5. Beehives in the garden.

This is due to environmental transformations for which human beings are mainly responsible. In the Italian context, the bee *mellifera ligustica*, the most widespread in the peninsula, is currently at risk of extinction due to the erosion of its habitat and to the spread of a parasite, named *varroa destructor*, which started to circulate in Italy from the 1980s, decimating in a few years the population of wild bees. This parasite is endemic in Asia, where local bees (*apis cerana*) have developed over time a relationship of equilibrium with their host parasite. However, in the 20th century the parasite came into contact with the European bee, following its worldwide marketing for honey production, causing its rapid decimation. In fact, the European bee had no time to adapt to the parasite. While Claudio is describing this historical process, I reflect upon how it clearly shows the environmental violence of capitalist human action. Being aware of the increasingly precarious situation of Italian bees, Claudio proposed starting a beekeeping area in the garden, taking responsibility for a species that has historically been highly endangered by capitalist human action. He explains that some beekeepers treat bees with chemicals to preserve them from the parasites. He is against it, and besides, the use of chemicals in the garden is forbidden. Instead, he treats bees with a mixture of water and thymol, which he sprinkles on them inside the hives. Then the bees, rubbing on each other spread the mixture to the whole hive.

After wearing the upper part of the protection, made of heavy and rough cloth, white, and surmounted by a hood with a metal net at the eye level, we head uphill towards the hives, through an earthy path that crosses a hill covered with "spontaneous" herbs. We carry with us a sack containing the solution, a syringe, and a metal tool with a spout, similar to a watering can. At the top, next to the hives, we climb over the wooden fence that borders the area and wear the hood, with the protective grid that falls before my eyes and blurs my view. The hives are numbered from 1 to 8.

Claudio opens the first apiary. At first glance it seems that around the hives everything is still. Then I try to calm down and begin to notice that there are many bees that fly around the hives buzzing, concentrating mainly at the front (Field note, December 2017).

Figure 6. Beehives in the garden.

I propose that the relation between bees and "Tre Fontane" gardeners can be read as a material-discursive situated alliance. As explained to me by Claudio, who coordinates the project, initially, many gardeners had disliked the idea of implanting beehives. They were afraid of bees, because of their capacity to sting. Actually, after a few years, the project is now very well liked in the garden, and the prejudice against bees has been overcome. Gardeners have started to interact with bees on a daily basis and to even modify the garden in less anthropocentric ways. That is for instance, as I noticed during my fieldwork, they appreciate the presence of the Symposium Tree of *Ailanthus*, also because they have noticed that this plant is particularly appealing to bees. Several of the gardeners now recognize the indispensable value of pollination done by bees, whom they know being at risk of extinction and that have contributed greatly to the garden space improving the quality of vegetable products through pollination. However, while building this alliance, the gardeners enter in conflict with the *varroa* parasite. I suggest that, due to the close, inextricable, connection between human-plants-bees' lives, this relation can be read as a capitalism-varroa-humans-plants-bees multispecies assemblage. My aim is not to provide any universal account, but to relationally translate a part of the story, as experienced in my relation with "Tre Fontane" gardeners and other nonhuman actors of the garden, who affect and are affected in this multiscalar and situated assemblage.

Reading the environmental history that led to the spread of *varroa* (Moore and Kosut 2013b), following the gaze of Claudio, it is clear how much the capitalist model of exploitation of other species has acted, threatening not only the lives of bees but also those of the human species itself. In fact, situated assemblages are inserted in multiscalar capitalist relations, but could become "interesting sites for watching how political economy works" not only for humans (Tsing 2015, 23), and to co-

construct material situated alternatives. Nowadays, according to the perspective of the group that manages the hives of "Tre Fontane" garden (but also of people from other groups that deal with beekeeping in the city, which I have met during the research) bees could no longer survive without human co-action, which, through response-abilities (Haraway 2015), that is through the possibility of being able to engage in mutual responses, creates safer spaces with them. Similarly, humans cannot potentially survive without the collateral pollination carried out by bees. That is, survival always involves others (Tsing 2015). So then, in the garden, a fragile but powerful multispecies assemblage emerges around the bee *mellifera* figuration, through the interaction of different actors, humans and nonhumans. These actors are strictly entangled by continuously creating and re-creating the space, in an indissoluble hybrid that comes to life.

5.4 The Agential Power of Nonhuman Figurations

A material-semiotic analysis shows that interaction between different actors builds an entanglement that continuously modifies the materiality of the garden and the embodied representations that gardeners mobilize around the ailanthus and honey bee figurations. The plant of *Ailanthus altissima*, gives us the opportunity to think how invasive plants could instead be conceptualized and supported within contemporary urban landscapes as witnesses – of European colonialism and environmental injustice perpetrated from colonial history to today (Di Chiro 2007). These are actors with whom to fruitfully reflect on the bio-colonial past in which the eco-social and climatic crisis we are going through has its roots (Ritvo 2018). As this *Ailanthus* plant has demonstrated, hierarchies are the result of relational processes, not ontological substantial statuses (Muller 2015). The tree challenges the dichotomic categorization of the scientific system that would categorize it as a bad invasive plant, to be eliminated. It becomes instead the symbolic centre of the common space for the members of the "Tre Fontane" association. It is precisely the materialisation and continual modification of the space of the garden put in place by this plant, which configures it as a social actor that contests an anthropocentric normative order. Its presence and capacity to co-transform and cohabit the space of the garden, which exceeds human intentionality, clearly question an anthropocentric conceptualisation of urban spaces and allow us to experiment multispecies collective modes of existence within troubled landscapes.

6. Conclusions

With this article my aim was to show the analytical and material power of multispecies assemblages. That is, post-anthropocentric political practices and lens of analysis that allow to creep in the folds of reality, giving emphasis throughout the whole research and analysis process on actors who risked otherwise being made invisible by the use of a fully humanist and anthropocentric gaze. By learning to use a situated gaze that deconstructs the concept of the human as a politically determined power device, the relevance of the nonhuman in the city becomes explicit.

Relying on the multispecies investigations that I have conducted so far, I advocate that, in the immediate future, further research on how a post-anthropocentric city can be imagined and materialized would be relevant. By this term I mean a city co-built and crossable by all those human and nonhuman bodies, who do not fall into the category of Man. Another issue essential for future investigations should be which conflicts could emerge in the co-construction of garden assemblages. For instance, in the bee-human assemblage in the garden "Tre Fontane", gardeners enter in a relation of alliance with bees, conflicting with the *varroa* destructor parasites. Moreover, material-discursive conflicts occur, for example, between gardeners, between some of the gardeners of "Tre Fontane" and other pollinating insects, with other invasive plants (even other *Ailanthus* plants non-recognised by gardeners as welcomed actors), with marginalized human actors. However, as I did in this article, I argue that it is extremely relevant and urgent to make visible micropolitics of mutual care enacted through situated relationalities. The ones described in this text are possible stories that make visible agencies often located at the margins of the social sciences, made significant in the emerging interactions. There may be many other ones. The analysis of entanglements of humans, plants, and other nonhuman actors shows the power and the capacity for action and transformation of the latter, which arise exceeding the boundaries of human normativity and intentionality. This descriptive and analytical attempt turns out to be fundamental in order to be able to build more just multispecies alternatives. In this regard, it becomes clear that agency is always shared and continuously negotiated, as I explored in the entanglements materialised around the *mellifera* bees and the symposium tree of *Ailanthus altissima*.

Notes

[1] These field notes are excerpts of a "multispecies ethnographic work" (Kirksey and Helmreich 2010) that I carried out in Rome as part of my PhD research between 2017 and 2019.

[2] Following Tsing, in this paper I will understand assemblages as open-ended gatherings that include human and nonhuman actors, which are constantly mutually transforming. This means wondering, in her words, "how sometimes gatherings become happenings" (Tsing 2015, 23).

[3] With this term I refer to the material-discursive assemblage of policies and politics implemented in the management of green spaces by public institutions and groups of citizens (vegetal politics on the vegetal) and of political interactions between human and nonhuman actors (with a specific focus on the agency of the vegetal) through which public green spaces are co-constructed in the Roman context (vegetal politics of the vegetal).

[4] As pointed out by Iovino and Oppermann (2012, 76) body does not only refer to "the human body but to the concrete entanglements (…) in both human and more-than-human realms".

[5] The Roman urban gardening regulation is available at the following address: https://www.comune.roma.it/web-resources/cms/documents/Delib_N_38_17.07.2015.pdf

[6] For more details on the planning activities of urban decorum regulation approved by Roman Municipality in 2018 see Deliberazione Giunta Capitolina number 222, 04 December 2018.

[7] For detailed information on financial cuts and staff decrease tendencies in the management of green areas and trees in the city see for example: Report 2018, Agenzia per il controllo e la qualità dei servizi pubblici di Roma Capitale; Report 2016, "Il verde pubblico di Roma Capitale, Municipal Statistics Office".

[8] English version of the website: http://www.zappataromana.net/en.

[9] See for example the report made by the Council for research in agriculture and analysis of agrarian economy (CREA - Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria) (2015)

[10] Here is a list of alien invasive plants present in the Italian territory, contrasted at the European Union level https://www.lifeasap.eu/index.php/it/specie-aliene-invasive/rilevanzaunionale. An English version of the website, which enlists some of the alien invasive species in Italy, is available at https://www.lifeasap.eu/index.php/en/invasive-alien-species/what-are-they.

More specific actions and restrictions are present at Italian regional level.

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Governing Through Interconnections: Interoperability and Standardisation in Higher Education

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Abstract: The global higher education (HE) landscape is changing today, with HE systems facing similar dilemmas. Italian HE is characterised by a hybrid arrangement in which bureaucratic and neomanagerial features are coexisting. Recent scholarship has highlighted the role of digitalisation processes and interconnectivity across platforms in shaping educational practice and governance in HE. This research aims at investigating the unfolding of interconnectivity across digital entities in HE, and its effects. Two interconnective software used in an Italian university are examined through interviews, digital ethnography, and documentary analysis. The research highlights a close and threefold relationship between interoperability and standardisation processes in HE. In particular, interconnective textures may embed standards, exert standardising effects (on both local educational practice and the national HE governance), and become standards themselves. An alternative vision of interoperability in HE is finally articulated that focuses on collaboration and plasticity rather than control and closure.

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1. Introduction

The global higher education (HE) landscape has been changing in the last decades. Longstanding academic research has highlighted the ongoing process of convergence of HE systems towards the Anglo-Saxon mode of governance and cultural frame (Neave 1998; Normand 2016).

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According to this paradigm, (higher) education is expected to foster economic development and growth. The State is supposed to play as a mere evaluator of academic results and guarantor of compliance with (market) rules, whilst universities are required to compete in the provision of services so as to deliver "high-quality" – that is, efficient, flexible and cost-effective – education. Notwithstanding local re-articulations and historical legacies, national HE systems are now converging towards this mode of governance (Gornitzka and Maasen 2000).

As evidenced by scholars, digitalisation processes play a significant role in shaping HE policy and practice in HE (Selwyn 2014; Decuypere and Landri 2021; Williamson 2021). Partly as a result of the acceleration brought about by the COVID-19 pandemic (Cone et al. 2021), market actors and edtech "power networks" (Williamson 2019), as well as "fast" trans-scalar policies and discourses (Peck and Theodore 2015) on digital technologies, have a crucial impact in steering modes of governance in HE systems. These transnational standardisation actors foster the "soft" convergence of local and national HE practice and policy towards a neoliberal agenda in education that sustains the interplay between education and economy (Landri 2018). Educational quasi-markets and spaces of commensuration thus emerge in global digitalised HE (Fig. 1) that embed and perform the cultural and economic logic of the new public management model. Indeed, digital technologies are deeply entangled with sociocultural (Star 1999; Kitchin 2014; Decuypere 2019; Poell et al. 2019) and sociopolitical (Gillespie 2010; Decuypere 2016; van Dijck et al. 2018; Decuypere and Landri 2021) processes, in that they have far-reaching effects on (higher) education by exerting standardising effects on subjectivities, practices, policies, spaces, times, and cultures (Selwyn 2014; Normand 2016; Landri 2018; Brøgger 2018).

Figure 1. "2020 higher education technology landscape".
Image source: Encoura 2020

The inner workings of these complex processes are often not easy to observe as they are frequently shrouded by layers of opacity (Star 1999). Extensive research has analysed specific educational technologies (online platforms, apps, hardware, robotics, artificial intelligence, algorithms, etc.) to unravel hidden cultures and values inscribed therein and their social consequences with particular attention to design, usage, and interfaces. However, recent scholarship has highlighted the cruciality of going "beyond" the fixed boundaries of digital systems (Decuypere 2021) as "in-between" spaces provide valuable vantage points for observing the unfolding and consequences of digital practices. Far from being mere "silos", digital entities thus appear as complex and unstable assemblages that continuously interconnect thereby interweaving relational textures that link together closer and farther entities and produce multiple effects. An ever-changing and entangled space can thus be observed that is knotted together across this interconnectedness.

In the IT and engineering domains, these interconnective processes are referred to as "interoperability". While software interoperability is everywhere today (healthcare, military, home automation, Geographical Information Systems, etc.), it is now finding particular expansion in HE, where it is often framed in a neomanagerial narrative that calls for "con-

nected campuses", "smart universities", learning analytics, "AI for learning", etc. (Williamson 2018). Interoperability would thus enable to "augment" the efficacy of governance processes and learning experiences in HE institutions (HEis) by seamlessly integrating their data sources and applications. Benefits are announced for students (personalisation of the "student journey", ongoing "optimisation" of their experience, etc.), professors (360-degree view of the "student journey", reduced administrative burden), and managers (support for decision-making through visualisations, cost reduction, improved efficiency). As an example, these are some testimonies from a "success story" by Informatica, a US edtech specialising in interoperability for HEis:

> Imagine an environment where data moves seamlessly and is available to various systems at near real time speeds (…). Now imagine that data is automatically classified, cleansed, and secured while all this happens (…). (Enterprise Architect for ACC [Austin Community College]; Informatica 2020, 2).

> [interoperability] will provide us with a single source of truth for our student data – helping us ensure that (…) a student in one system is the same student in another system. (AVP Solutions Development & BI at ACC; ivi, 3).

> Data management and data integration are a "constant" in the life of any data-driven organization. ACC requires continuous evaluation for effectiveness and cost considerations. (Vice President of IT and CIO at ACC; ivi, 1).

The concept of interoperability is not new. It dates back to the late 1800s at least, with the first patents containing the term. However, its full-fledged emergence was in the military and IT literature from the 1970s onwards. In particular, in the 1990s, the vision of interoperability landed in the IT communities that were pioneering connective networks across information systems. It thus became a crucial element in imagining "worldwide digital system architecture" (Cannata 1991) such as ISDN and LAN. Interoperability then burst into everyday lives spanning e-government, healthcare, Geographical Information System, security, public safety, Internet of Things, military devices, and education software. Hence, the idea of interoperability had to be translated into policy-making at transnational, international, and local levels. The European Union launched the Interoperability Solutions for European Public Administrations programme which aimed at supporting the development of interoperable digital solutions in public services. A European Interoperability Framework was also launched aiming at promoting the development of a single digital market in Europe. With regards to education in

more recent times, the Rome Ministerial Communiqué 2020 by the European Higher Education Area has called for "new solutions to enhance the interoperability of digital systems and the exchange of student and institutional data" (2020, 6).

It thus seems fair to assert that interoperability has now become an "idea whose time has come" (Czarniawska and Joerges 1995) in many fields of social life, and on a global scale. Complex relational arrangements are now possible that unlock new challenges and opportunities in digitalised HE with the potential to reconfigure local and global educational governance. Despite the relevance of these issues, still scant research has been produced regarding the specific role of interconnectivity processes in HE governance and practice. What does interoperability do in/to HE? How can it affect the social life of HE and its practitioners?

This research aims at addressing these questions by exploring how interconnectivity across digital entities unfolds, and what effects it might produce in HE practice and processes. In particular, two interconnective software used in an Italian HEi (from now on, "Athenaeum"[1]) shall be taken into consideration.

In the first section of the paper, a brief history of HE in Italy will be drawn in order to provide a background for the empirical exploration. Thereafter, the theoretical framework of this work will be discussed. In the third section of the essay, I will present the methodological engagements of this work. In the fourth section, two interconnective software shall be unpacked in order to empirically examine the unfolding of interoperability and its effects. The empirical findings will be then discussed. Final remarks will be drawn in the last section of the paper.

2. Governing Higher Education in Italy: In-between Bureaucracy and Entrepreneurship

Continuity and change in the modes of governance in HE systems have been thoroughly studied by Higher Education Studies scholars striving to better understand the changing relationship between the State, the market, and further stakeholders in universities and society. These studies allow analysing the shifting national and global patterns in the governance of HE systems over time, as well as long-standing frictions between public and private players.

Scholarship has frequently referred to the Italian HE system as a particular case of the "continental" (Clark 1977) mode of governance of HE. Accordingly, the historical peculiarity of the Italian HE system has been found in the "bureau-professional compromise" whence it originated (Clarke and Newman 1997). On the one hand, the powerful state bureaucracy has been zealously designing procedures and *ex ante* evaluation instruments following a centralising and "control-and-command" logic

(Dobbins 2017) constraining the work of the public administration. On the other hand, actual decision-making in universities has long been happening through informal bargaining between academic interest groups (Moscati et al. 2015).

Systemic reforms developed in the 1990s aimed at limiting the power of academic oligarchies by shifting the balance of the system towards a "steering-at-a-distance" mode of governance of the State over academic activities. In particular, university autonomy was introduced with regards to governance, finance, and teaching processes, along with a Ministry for University and Scientific and Technological Research and some early quality assurance tools. However, aiming at preserving the traditional life of the system, academic guilds "outsmarted" (Dobbins and Knill 2017) the reform via local circumventions and re-articulations. The neomanagerial narrative could thus penetrate Italian universities only on a purely ideological rather than pragmatic and cultural level.

In the 2000s, Italian universities exploited the (regulated) deregulation phase in HE policy-making to multiply their activities. An anarchic situation thus emerged that the State attempted to buffer through the introduction of new regulations. This spiral of centralisation-decentralisation-recentralisation did not really bring any effective change in the governance of the system (Dobbins 2017).

Further reformist efforts were put forward in the 2010s. In particular, Decree-Law 112/2008 and Law 240/2010 introduced new grammars, repertoires, and financial levers that were more overtly inspired by the neomanagerial paradigm and the "steering-at-a-distance" model (Lumino et al. 2017). Narratives (efficiency, accountability, quality assurance) and tools (performance indicators, economic rewards and sanctions, *ex post* evaluation devices, cost-cutting) were imported from the managerial world into HE. Again, these policies did not have all the expected cultural and organisational success (Capano et al. 2016)

Contradictory patterns can thus be singled out in the governance of contemporary HE in Italy (Lumino et al. 2017) which has been aptly summarised by Giliberto Capano as "steering at a distance with strong bureaucratic oversight" (2018, 689). Across this hybrid arrangement, apparently contrasting aspects coexist which bring together legacies and new trends in Italian and global HE. On the one hand, strong bureaucratic-procedural aspects remain in the State's detailed regulation of the activities of institutions and professionals. On the other hand, instances of convergence towards the dominant Anglo-Saxon entrepreneurial model are emerging despite local resistance to change.

3. Theoretical Toolkit: Classifications, Standards, Infrastructure, and Interoperability

As discussed in the introduction, digitalisation processes in HE play a role in shaping HE practice and governance at the local and global levels. Several theoretical frameworks are available in social science literature for the analysis of the workings of digital technologies. Among these, the STS toolkit provides a valuable repertoire for exploring their relationality and performativity.

3.1 Classification Systems

The most convenient departure for this discussion might concern classification as the concept is intended within the ecological approach of STS. Classification systems are spatial, temporal, or spatio-temporal segmentations of the world. Specifically, they have been defined as "a set of boxes (metaphorical or literal) into which things can be put to then do some kind of work – bureaucratic or knowledge production" (Bowker and Star 1999, 10).

Classification systems are "complete" in principle in that their aim is to achieve thorough coverage of the world they describe – and, in fact, to overlap with it. Moral and political orders are thereby established and enforced as every object can (must) be placed in a predetermined box. When confronted with objects aberrant to the provided definitions, classification systems attempt to "make categories fit the circumstances" (ivi) according to principles of convergence. Indeed, this is about creating boundaries between what is "right" and "wrong" about the way things are organised, thereby shaping social life (Star et al. 2003). Despite their apparent stability, classification processes can always be subject to negotiation and contestation through tacit or explicit categorical work.

3.2 Standards and Standardisation

Classification systems are closely related to standards, in that standards often contribute to classifying the world (Bowker and Star 1999). Standards are often studied as agreed-upon rules to achieve "coordination and control of activities at a distance (…) by which to order and perform realities" (Landri 2018, 8). They are both inscribed in the fabric of social life, and reshape it in heterogeneous ways as they codify, incorporate and prescribe ethics and values (Bowker and Star 1999).

STS scholarship has famously described a number of dimensions characterising standards. In particular: a standard can be considered as any set of agreed rules for the production of (textual or material) objects; it spans more than one community of practice; it is used to make things work together in heterogeneous spaces, times and metrics; legal bodies

often enforce standards; the "best" standard will not necessarily prevail; standards have strong inertia and may be difficult to change (Bowker and Star 1999). Recent literature distinguishes between a realist, top-down idea in which standardisation is seen as a "complete" process that aims at constructing uniformity in space and time, and a performative, post-realist vision that focuses on how standards contribute to the creation of the world and the very alteration of what they govern (Brøgger 2018; Landri 2018; Staunæs et al. 2018).

Standardisation processes have been extensively researched in the case of education. Recent studies have explored how standards can exercise "soft" governance power in that they can establish uniformities in educational practices, processes, policies, spaces, times, and cultures (Landri 2018; Brøgger 2018). Particular – standardised – points of view on what education should be and do might be valorised and taken for granted as the legitimate and proper ones, while the others are made invisible and relegated to marginality. With differences being erased, iniquities might be reproduced in local and global educational practice and politics.

3.3 Infrastructure and Infrastructuring

As argued by Brian Larkin, infrastructure – such as databases or the internet of things – can be intended as "matter that enable the movement of other matter" (2013, 329). Infrastructures, which might become standardised (Bowker and Star 1999), can be considered as complex imbricated sociotechnical assemblages (Piattoeva and Saari 2020):

> modular, multi-layered (…) [they] consist of numerous systems, each with unique origins and goals, which are made to interoperate by means of standards, socket layers, social practices, norms, and individual behaviors that smooth out the connections among them (Edwards et al. 2013, 5).

STS scholars have identified a few distinctive dimensions of infrastructures (Star and Ruhleder 1996). They: emerge in relation to situated practices and cannot be understood "as a thing stripped of use" (ivi, 113); are embedded within other sociomaterial arrangements; are imbricated in the conventions and learning practices of communities of practitioners; are inherently invisible, except in the case of breakdowns; are interconnected. Infrastructures are also intrinsically fluid and non-linear in their spaces, timescales, and affordances. The concept of "infrastructuring" (Mongili and Pellegrino 2014) has been recently deployed to examine the constant emergence of infrastructure and its "accreting" onto installed bases (Pellegrino 2014; Karasti and Blomberg 2018; van de Oudeweetering and Decuypere 2021).

In the field of education, infrastructures are expanding on at least four fronts (Sellar 2015): the political scales in which they are becoming em-

bedded, the scope of the data that they contribute to generating, the explanatory power of the analyses that they afford, and the role of algorithms and datafication. Yet, few scholars so far have explored the processes and actors involved in the design, usage, and maintenance of educational infrastructures, as well as the relational work they afford in digital education (Sellar 2015; Williamson 2018; Aragona and Felaco 2019; Decuypere 2021; Kerssens and van Dijck 2021).

3.4 Interoperability

Being both things and the relationship between things, infrastructures are inherently relational. Whilst appearing as finite and accomplished, they continuously emerge through ubiquitous and interconnected processes (Pellegrino 2014; Sellar 2015). IT and engineering professionals often describe these processes as "interoperability", that is, "a measure of the degree to which different systems (...) are able to work together to achieve a common goal" (Ide and Pustejovsky 2010, 2) using standard technologies such as formats, procedures[2], and protocols.

STS scholars first attempted to research interoperability in the social sciences. Susan Leigh Star and Geoffrey Bowker picked up the notion of interoperability from computer science and worked it through with the concept of "convergence", that is, "the double process by which information artifacts and social worlds are fitted to each other and come together" (Star et al. 2003, 2; see also Mongili 2020). The Comparative Interoperability Project used qualitative research methods to comparatively study "interoperability strategies" in infrastructure (Baker et al. 2005, 65). David Ribes in particular has researched interoperability (2017; Ribes and Polk 2015) as "an umbrella term for the constellation of concepts, approaches, techniques and technologies that seek to make heterogeneous data work with each other" (ivi, 1515). Interoperability has also been addressed in the Computer Supported Cooperative Work literature with regard to healthcare (Ellingsen and Monteiro 2006), design (Mongili 2014), organisation (Sharma and Sawyer 2016), and welfare (Cozza 2018). It has also been discussed in data studies as a relevant episode in the journey of data that might change stories and generate social consequences (Borgman 2016; Leonelli and Tempini 2020).

With respect to education research, interoperability processes have so far received little scholarly attention. Some significant contributions have been made from STS and platform studies perspectives that emphasise the effects of interoperability processes on data production, practices, and organising activity in densely technologised educational environments (Ratner and Gad 2019; Hartong et al. 2021; van de Oudeweetering and Decuypere 2021).

4. Methodological Engagements

As mentioned, this research aims at exploring the unfolding of interoperability in an Italian HEi and its effects across such ecology. In order to explore this issue, and in the awareness that "method is not, and could never be, innocent or purely technical […] does not 'report' on something that is already there" (Law 2004, 143), a series of necessarily categorical acts have been performed with regard to research methods.

The first choice concerned the methodological sensitivity, namely, an ecological approach. Ecological perspectives in social and human sciences are concerned with connection over separation, inclusion over difference, and continuity over isolation (Bateson 1972). Holistic alternatives are thereby envisioned that challenge boundaries and divides in social theory and everyday life. Rather than extra-social space for "long-distance" relations between actors, environment is considered as a social practice that can hold together subjectual and objectual lives and multiple realities: "there is no distinction between individual and environment. There are no natural, pre-given boundaries. Instead there is blurring. Everything is connected and contained within everything else. There are, indeed, no limits" (Law 2004, 9). In particular, an ecological perspective inspired by the STS and interactionist approach initiated by Susan Leigh Star and colleagues has been deployed in this research. Rather than on the finalistic action or primacy of individual actors, events, or inventors (Star and Griesemer 1989), relations have been understood as instances of interdependence, cooperation, and boundary work (Star 1995; Pellegrino 2014). A comprehensive and reticular examination has thus been carried out in which all entities in the ecology have been simultaneously interrogated, and any attempt to fix, stabilise or demarcate limits in platforms has been tentatively eschewed (Decuypere 2021).

A second choice concerned the empirical field for the observation, i.e., the digital ecology of a large Italian HEi ("Athenaeum"). Based on the selected methodological sensitivity and relational understanding, I proceeded by examining the connection between processes of interoperability, and educational practice and processes in Athenaeum. Specifically, I selected two case studies – i.e., two interconnective platforms at Athenaeum – for observing the entanglement between nonhuman (online platforms) and human (university governance, professors, technicians) actors in a common interconnective arena. The relational space emerging from the interconnectivity across these entities has thus been observed as a sociotechnical field of action. In particular, I looked at how the interconnective texture was designed and maintained, who and what it was holding together, how it materialised to users, who was using it and how, and what effects such interconnectivity was exerting on educational processes in the digital ecology of Athenaeum – and beyond.

A third methodological choice regarded the theoretical tools to be deployed for the investigation. As mentioned, an ecological sensitivity was mobilised to simultaneously observe multiplicity and interdependence in the empirical field. In addition, insights from STS studies were deployed to observe more closely the movement and transformations of data across infrastructure (Star 1999). These perspectives were chosen since they can provide an adequate vantage point to grasp and bring to the fore an elusive and relational object of study such as interoperability processes.

A final methodological choice concerned the research methods and techniques. Since I could not actually "see" the processes of interoperability, I have trailed and collected all the "clues" that these processes left behind as they happened: "[u]nearthing the narratives behind boring aspects of infrastructure (…) reveal (…) how knowledge is constrained, built and preserved" (Star 2002, 122). I looked for any kind of "witness" (archival documents, programming codes, governance narratives, websites and platforms, accounts from technicians and teachers, student diaries) that would hold evidence of interoperability processes. I thence conducted 32 interviews, digital ethnography, and documental analysis. In particular, the interviews allowed me to explore the design (9 IT specialists), usage (15 professors), and governance (6 members of the Athenaeum governance staff) of interconnectivity as it unfolds across and beyond the digital ecology of Athenaeum. More generally, through the interviews[3] I could investigate the construction, practice, and effects of interconnectivity at Athenaeum. A digital ethnography was also carried out in order to "watch what happens, listen to what is said, and ask questions" (Pink et al. 2016) in the digitally entangled environment of Athenaeum. Specifically, and in conjunction with the interviews, I conducted a thorough observation of Athenaeum's interconnective software interfaces and the user journeys they afford in order to inspect whether and how interconnective processes are materialised in their web pages, and to what effects. Furthermore, I analysed offline (Athenaeum's historical archive) and online sources (Athenaeum's and interconnective software producers' websites) to obtain first-hand information on the functioning of interoperability processes in the case studies and, more generally, in Athenaeum's digital ecology. Notably, I collected internal technical material on digital platforms at Athenaeum, policy briefs on digitalisation in Athenaeum, promotional handouts by platform developers communicating software features. Through the triangulative use of these techniques, I attempted to construct a richer and thicker picture of the research results. In particular, the data collected through these three techniques were analysed considering the overall objective of the research and allowing the specific perspectives opened up by the different types of data to inform each other.

5. Interoperability and the Standardisation of Higher Education: Trailing Performative Interconnections in the Digital Ecology of Athenaeum

As mentioned, two interconnective software have been observed in Athenaeum in order to explore the interweaving of interoperability and its effects. I will now describe the analysis carried out.

5.1 MOPG: the Digital Bureaucratic Governance of Academic Teaching

The HE evaluation system in Italy requires each HEi to produce extensive data on teaching activities. This information is periodically elaborated by the central HE governance (ANVUR[4] and MUR[5]) which deploys set parameters to determine whether such HEi is fit to operate, and if so, issues a formal authorisation.

MOPG is the Athenaeum platform which transmits this data from the local HEi to ANVUR and MUR via interoperability[6]. This ensures Athenaeum's compliance with a complex set of (supra)national quality assurance standards:

> Every year, the university must communicate its educational offer to MUR. The university staff must upload on MOPG some 'structural contents' that must comply with a set of constraints laid down by the MUR. (IT Specialist, G)

Accordingly, such information is requested by MOPG from professors (Fig. 2). More specifically, professors must periodically enter on MOPG data on the courses and degree courses for whose design they are in charge. If this does not happen, teaching activities cannot take place. Notably, the demand for interconnection between HEi and the systemic governance of HE establishes it as an obligatory passage point in Athenaeum's professional life and organisational practice. In other words, MOPG is becoming a standard in Athenaeum. The potency of its mediating position in this interconnective texture is very much perceived by practitioners, and it is not without consequences.

Figure 2. The frontend interface of MOPG's accountability reporting forms for professors. Image source: screenshot by the author. Last access: May 2022.

Indeed, MOPG is often portrayed by professors as a powerful actor (a "*dominus*") that can effectively dictate and constrain teaching practices and processes. Its interface seemingly exerts powerful effects on the governance of teaching at Athenaeum. According to many professors, it is only possible to do with MOPG what MOPG itself allows to do:

> When you want to experiment with innovations in the educational processes, you are forced to take into account not only the MUR frameworks, but also the actual platform, which constrains what you can and cannot do (…) MOPG is like the *dominus* that governs the architecture of the educational offer, and limits possibilities for innovation. (Professor, M)

The interface of MOPG is a rigid and fixed space that constrains the design of courses and curricula based on what categories are visible and usable. As a result, professors need to "fit circumstances to categories", as educational imaginaries rarely match with what is allowed by MOPG's interface. Users' programmes are thereby circumscribed by the platform's affordance, and the agency for educational processes is redistributed (Akrich and Latour 1992). What counts – and what does not – in academic teaching and evaluation is thus determined by the platform, while everything else is pushed into invisibility (Bowker and Star 1999):

> Since MOPG is rigid and structured in a specific way, you end up adapting procedures to the IT platform, rather than *vice versa*. Whatever it allows you to do, that will become the norm – just because it is not possible to do otherwise. (Professor, L)

I have the feeling that in the development and customisation of digital platforms, professors are not consulted (…) Someone else makes the rules. (Governance staff, H)

Thus, MOPG-mediated interoperability seemingly constrains local educational practice through its interface, thereby potentially disciplining or hindering innovation in teaching design.

However, the effects of interconnectivity elude the local sphere of Athenaeum, as MOPG's interoperability apparently embeds and reproduces a specific cultural frame that pertains to the very governance of HE. As emphasised by professors, the information requested by MOPG often seems detached – in quality and quantity – from what is expectedly helpful for assessing professors and universities:

They ask for an infinite amount of information. The most mysterious thing is the reason why they ask for certain absurd things. (...) I wonder what precisely they do with them. (Professor, I)

MOPG is an administrative nightmare. (...) You have to waste a lot of time. I hate using it. I only use it because I have to. (Professor, H)

The *rationale* thus seems to be the demand for information *per se*, as if it possessed an inherent value rather than being a means to an end. Thus emerges – that is, through the impersonal and ritualistic application of procedures and norms – the bureaucratic legacy that still survives in the hybrid set-up of the Italian HE governance mode.

MOPG therefore appears as a powerful governance tool in Athenaeum that interconnects HEi with the national HE system. Positioning itself as an obligatory passage point, and affording an ineluctably rigid interface, this interconnective standard platform circumscribes the field of possibilities for local educational design in Athenaeum. Its interconnectivity also has effects on the broader governance level, in that it reproduces bureaucratic cultures in Italian HE that risk silencing the points of view of the academic actors striving to co-construct and innovate educational practice. (Bowker and Star 1999)

5.2 EYE: the Digital Entrepreneurial Governance of Academic Research

In order to participate in quantitative and evaluative title-based competitions and selections, Italian researchers are required to provide data on their scientific production to ANVUR and MUR via their HEi's platform[7]. In Athenaeum, the platform deployed for this purpose is EYE, which is an institutional repository on which researchers upload data on their scientific production.

On the local level, EYE is used by Athenaeum researchers to inform ANVUR and MUR about their scientific production. This data is transmitted via interoperability from the scale of the institution to the systemic scale for accountability and evaluation purposes. The research output uploaded by the researchers is also displayed on publicly accessible web pages that provide full-text search functions within the institution's database.

Most notably, an interconnection unfolds in this "public space" between the local scale of Athenaeum and the arena of global HE. The metadata of any research output that is uploaded by Athenaeum's staff into EYE is mechanically transmitted to bibliometric databases such as PubMed Central, Scopus, and Web of Science which return data on its performance metrics. This data is displayed as citation counts and graph-like visualisations on the EYE interface on its public web pages (Fig. 3). HEis using EYE are thus constantly interconnected with the global sphere of education and academic competition.
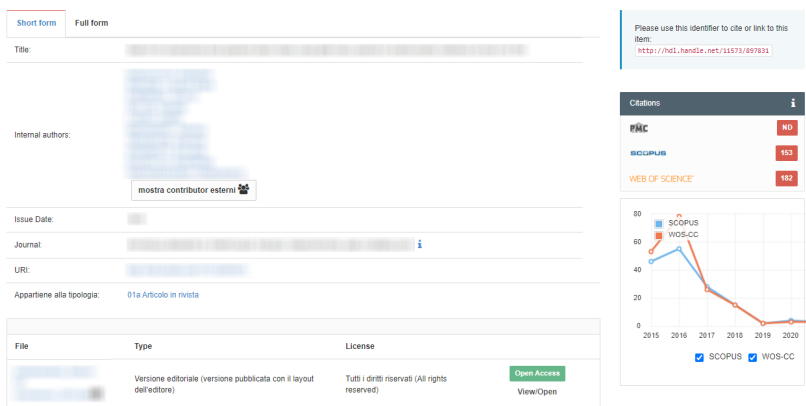
Figure 3. The frontend interface of an EYE public page: EYE and global citation databases are interconnecting. Image source: screenshot by the author. Last access: May 2022

A particular affordance is thereby suggested to Athenaeum researchers through EYE, i.e., the self-monitoring of academic performance (Burrows 2012; Lupton et al. 2017). The multi-scalar interoperability between the local institution and these powerful actors in global education constructs a visualisation device that opens a space of comparison and commensuration which might configure academic subjectivities (Espeland and Stevens 1998). Evidence-based interoperable indicators may lure Athenaeum's researchers into measuring the "quality" of their scientific publication according to quantitative standard metrics (Espeland and Stevens 2008). What "works" and what does not can thus be determined

through commensurative quantification processes (Decuypere and Landri 2021):

> This is also a "control" mechanism. Every morning I *must* check the "status" of my publications. That is, what that graph "is doing" – whether someone has cited me, or if I am visible on Scopus... (Professor, U; italics for emphasis)

Alongside its effects on the local subjectivities of Athenaeum researchers, EYE's interconnectivity encapsulates values that entail the broader field of Italian HE governance. Whilst the academic engines of anxiety are fed (Espeland and Sauder 2016), neomanagerial discourses – calculability, efficiency, excellence, etc. – are reproduced through metrics and visualisations. "Performative" scholarship and the pursuit of immediate research impact is fostered through quantitative measurement at the expense of fundamental or curiosity-driven research. New uncertainties insinuate in academic subjectivities:

> We are forced to respect what EYE wants, or else we do not exist. If we don't upload our research output to EYE, EYE does not deliver it to ANVUR, and we end up being invisible. (Professor, H)

Across this constant interconnection between local institutions and the global sphere of competition in HE, standardising processes are enacted that shape academic research and the production of knowledge. Specific and "legitimate" ways of knowing are tacitly privileged, while others are made invisible. Entrepreneurial logics are reproduced in HE as the space of quantitative research evaluation becomes a neomanagerial field for institutions and professionals that are expected to strive for excellence. The world and its constitutive relationships are constructed simultaneously with the tools for its measuring (Desrosières 1998).

6. Interoperability, Standardisation, and the Making of Higher Education through Interconnections

This paper aimed at contributing to literature by investigating the unfolding of interoperability and its effects across the digital ecology of an Italian HEi. To this end, two empirical cases of interconnective platforms have been interrogated through an ecological sensitivity and a repertoire of qualitative research techniques. After a brief overview of the empirical exploration empirical cases, I shall discuss the main points of interest that emerged in the research.

The first platform examined, called MOPG, is used in Athenaeum for the management of administrative activities related to teaching. MOPG

establishes interoperability processes in order to communicate teaching-related information from Athenaeum to ANVUR and MUR. It thus positions as an obligatory passage point for Athenaeum's professors who must however adapt their teaching design instances to the affordances of MOPG's rigid interface. Local educational practice is thus circumscribed by the constraints inscribed in the platform. However, the standardisation effects exerted by the interconnectivity processes mediated by MOPG elude the level of local practice in that they entail the governance of Italian HE as well. Indeed, MOPG seemingly embeds and performs the bureaucratic logic that constitutes one of the poles of the hybrid arrangement of the governance of Italian HE. The demand for data for its own sake is favoured over the objective of obtaining relevant information.

The second interconnective platform analysed, called EYE, is the repository into which Athenaeum researchers upload their research outputs. In this case, interoperability processes are aimed at the production of a complex interconnective texture between local actors (academic researchers) and big players in the bibliometric area of global education. EYE's multiscalar interconnectivity activates a self-monitoring comparative device for researchers' performance that draws on specific values to shape their understandings of what should be researched, and how. While interoperability processes have an effect on the local field of research in Athenaeum, they also affect the broader arena of HE governance in Italy. The engineering of a commensurable and comparable space through multiscalar interoperability reproduces the neomanagerial agenda that fosters efficiency, surveillance, and competition, that is, the pole towards which the governance of Italian HE is currently converging.

An intimate relationship between interoperability and standardisation processes in HE can thence be distinguished. In particular, the empirical research carried out allows to single out three ways in which digital interconnectivity can relate to standardisation processes in HE. First, *interconnective textures can embed standards*. They in fact encapsulate specific values and ethics that result from exogenous standardising forces. In the case of MOPG, (supra)national criteria and standards are inscribed in the design of interconnectivity which then materialise in its interface by means of spaces (filled/fixed), categories (present/absent), criteria (specified/glossed), choices (fixed/open). In the case of EYE, narratives are imported from the managerial world to the field of HE concerning visibility and comparability as basic foundations for academic life. Secondly, *interconnectivity can exert standardising effects.* The empirical cases have shown this kind of relationship on a twofold level. On the one hand, interoperability processes produce standardisation effects on the local Athenaeum practice, determining what is possible for teaching design (MOPG) or selecting what is proper for academic research (EYE). On the other hand, interconnectivity exert standardisation effects that entail the governance level of Italian HE by conveying bureaucratic (in the case

of MOPG) or neomanagerial (in the case of EYE) logics. Finally, *interconnective textures may become standards themselves.* MOPG has indeed become a stable and obligatory passage point both for compliance interconnectivity in Athenaeum, and for everyday academic professional life of professors. Likewise, EYE represents a crucial and irreplaceable tool for many academics who use it for everyday self-monitoring of their academic performance. Realities are thus uniformed through these standardised interconnective textures according to agreed-upon-rules that are supposed to articulate work across spaces, times, and metrics.

Being based on classifications and standards, this threefold relationship between interoperability and standardisation in HE is not neutral (Bowker and Star 1999). It entails the power to determine who is "in" and "out" of relational arrangements (i.e., which entities to include or exclude), and what status or knowledges are required to "stay within" relations (i.e., to negotiate the criteria for inclusion; Gorur et al. 2019). The link between interoperability and the standardisation of forms of (higher) education thus seems generative of social consequences. A transcalar, interconnected and standardised governance space emerges in HE in which research, governance, and administration, as well as (nonhuman and human) actors and discourses, are entwined and entangled. In this arena, visibility and invisibility, inclusion and exclusion, and all sorts of boundaries are continuously at stake (Star 1995). Hence, the challenge now concerns what academia, academics, and HE overall should be, do, and – most of all – become.

7. Final Remarks

A complex relationship between interoperability and standardisation processes in HE thus emerges from the empirical research carried out that may manifest as the encapsulation of standards, the enactment of standards, or the very standardisation of interconnectivity. Either way, the processes of standardisation appear inherent to interconnectivity in HE.

The texture of interoperability that ties Italian HE together ought thus not to be understood as a purely technical matter of data transmission across information systems. Beyond the imagery of digital entities chatting with each other, it might be worth considering the role of standardisation processes that exert influence on how these entities talk, what they say, and whether these conversations might risk hindering the potential for innovation and change in HE, i.e., whether dominant points of view may be advantaged to the detriment of residual and marginal forms of subjectivity and knowledge (Bowker and Star 1999).

By all means, the effects of these processes are – as always – situated and contingent. As reminded by STS scholarship, everything might have

been otherwise (Star 1990) – and might *still* be otherwise (Gorur et al., 2019). The relationship between interoperability and standardisation constructs a contested field which is the object of ongoing negotiation, local adaptation, (re)adjustment, and rejection. As shown with the empirical cases, academic actors do practice non-compliant and divergent conduct in order to express alternative visions and resist the ethics and values that are inscribed and performed throughout these processes. Indeed, all standards are bound to transform over time along with the impermanence of social life.

A space for reflection can thus be set in which to consider interoperability in HE as a tool for collaboration rather than bureaucratic or neomanagerial control. Interoperability can in fact prompt renewed engagement with connectedness as a key to understanding and cohabiting a complex, emergent, and troubled world. In this sense, it might be worthwhile to move the perspective from control to cooperation, and from closure to plasticity. That is, to focus on the power of boundary objects rather than standardisation as a means of achieving necessary alignment and articulation across the multiple worlds of technoscience (Star and Griesemer 1989). The challenge, then, is to envision practices and tools that, while maintaining their own specific identity, could be elastic enough to be engaging for diverse communities of practice, thereby becoming a means of collaboration and translation across heterogeneous social worlds in HE. This might counterbalance the controlling effects that often arise with the stabilisation of standards and the closure of their flexibility (Star and Bowker 1999).

Some practices are already underway that pursue such a vision of interconnectivity in HE. For example, open-access international Current Research Information Systems such as OpenAire and Zenodo have been launched for sharing research across disciplinary and national boundaries; alternative bibliometric forms (e.g., Snowball Metrics) are used in international universities that consider the social impact and uncited research output rather than just the citation count on peer-reviewed journals; an Higher Education Interoperable Data Initiative (HEIDI) is being developed that would interlink European HE datasets and publish them in open-access.

Other avenues to unlock the potential of interoperability processes towards participation could be explored through the analysis and constructive critique of existing processes in local and global HEIs. Ultimately, this is about practising interoperability as a medium for knowing and doing things together in organization – that is, as connectedness-in-action (Gherardi 2005) – rather than a device for distributed surveillance.

Notes

[1] Pseudonymisation has been applied on the university, software, and research partners names in order to mitigate the possibility that contextual information provided could lead to "deductive disclosure" of their identities (Kaiser 2009).

[2] In particular, APIs (Application Programming Interfaces) are used by developers as packages of procedures that software make available to outside programmes to draw on some of its functionality.

[3] The difference between the number of interviews carried out and the total number of consultants interviewed is due to the fact that two technical consultants have been interviewed for two rounds, and therefore counted as two separate interviews. As a side note, five consultants have been interviewed in a double guise, i.e., both as professors and members of the Athenaeum governance.

[4] ANVUR is the Italian national agency for university and research evaluation.

[5] MUR is the Italian Ministry of University and Research.

[6] Italian regulations stipulate that this information must be transmitted from HEIs to central infrastructure via interoperable processes and shared technical standards (Digital Administration Code, Art. 12(2)).

[7] Alternatively, it is possible for researchers to use the LoginMIUR platform by MUR. LoginMIUR is also accessible to independent researchers.

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Data Circulation in Health Landscapes

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Abstract: The crossing boundaries intends to open a dialogue between Science and Technology Studies, Social studies of Health and the emerging Data Journalism perspective. It explores major issues at stake in contemporary practices of producing and sharing data, with a focus on the COVID-19 pandemic.

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Pandemic Data Circulation

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Introduction

We have been two years in the COVID-19 (C19) pandemic, and many interesting patterns have emerged that are worth discussing. I can only attempt to touch on a few of them, which are related to the practices and flows of health data. It was interesting to see, as the pandemic ensued, how many different kinds of data were mobilised. And many different social actors got involved in the use of data, for many different purposes.

Data were put in circulation in ways and speed that were unforeseen, from both public and private sector companies. But data circulate well in some directions, and less so in others. Overwhelmed perusing a constantly moving panoply of numbers, charts and assessments on the state of the pandemic, it is easy to miss out that some data are not flowing well at all, and that others should perhaps stay where they are.

UK: "State of Play"

The UK has been widely regarded as one country where the state has been most willing to play with various sorts of data experimentation. A report by the Alan Turing Institute on data science and artificial intelligence in the "age" of COVID-19 (von Borzyskowski et al. 2021) highlights how, in many ways, the pandemic was an exceptionally propitious opportunity for all sorts of innovation and experimentation with data to occur. As it started reacting to the C19 outbreak, on 17th March 2020 the Government mandated healthcare data custodians at NHS (National Health Service) Digital to support access and processing of health data by authorised organisations for purposes of pandemic response (Secretary of State for Health and Social Care 2020). The relaxation of regulatory standards, with a mandate for various public agencies to put the data in motion, was the first "booster" for the circulation of data. But it was not only national healthcare system data that were quickly mobilised. Private companies including the likes of Silicon Valley giants Google and Apple also offered select access to proprietary data, albeit to a limited extent. This created the space for various teams and organisations to intervene and offer their services as to how such an unprecedented and all-encompassing mobilisation could be achieved. Datasets that could matter for the coordination of response were myriad, as were the indicators to closely watch to monitor how things unfold. Government decision makers procured from private companies a set of analytics computational infrastructures to manage the former, and analytics dashboards for watching the latter. One of the most important contracts, worth more than 12.5 million GBP (Gov. UK 2020), was awarded to Palantir – a secretive Silicon Valley company familiar to controversies thanks to its propensity sourcing contracts from military, intelligence and border control agencies involved in politically questionable missions. Consultancies McKinsey, Deloitte and Faculty AI also contributed. On top of Palantir's computational infrastructure NHS Digital could then launch a "COVID-19 Data Store", a repository of datasets available to agencies involved in the pandemic response: *"NHS COVID-19 Data Store brings together and protects accurate, real-time information to inform strategic and operational decisions in response to the current pandemic in one place."* (NHS England 2022a) The datasets included in the Data Store are rather disparate and come in many different formats, as a collection which could be potentially accessed by many different users for many different purposes would be (NHS England 2022b). There are data such as raw NHS medical helpline call data; NHS staff absence reports; mobility data from Google and Apple; Enterprise Resource Planning data for healthcare system management; patient demographics; counts of online and video consultations; personal protective equipment stocks and purchases; and even self-report symptom data collected by volunteers for the COVID-19 Symptom Study using a citizen science app called "ZOE". These data are

not limited to tables of numerical and/or structured text values. They are also lists, lookup tables, summaries of historical data, and records that "describe".

Thanks to several dashboards and analytics features which draw disparate data sources together in "actionable" summaries of visualisations, charts and numbers, decision makers in government should be equipped with the best real time intelligence to take complex decisions: *"These dashboards are designed to help senior national and regional officials to make policy and strategic decisions in response to COVID-19"* (NHS England 2022a). Perusing Palantir's contract we learn that the system comprises of three main interfaces: the Strategic Decision Makers Dashboard; Recovery of Critical Services; and Early Warning System. We also learn that these technologies might have a scope and longevity that reach farer than the pandemic alone: they should help to *"coordinate national response to COVID-19 and EU Exit"* and provisions are made to allow the Government to transition this system from the pandemic use to *"general business-as-usual monitoring"* (if Palantir's software-as-a-service contract is renewed past expiry). The Early Warning System interface seems the most ambitious, sporting an *"Explainability and Trust Overview"* feature displaying forecasts generated by the models of a private third party (the consultancy Faculty AI, founded by a physicist) using NHS data, 111 medical helpline data, and Google and Apple mobility data among others. And so, the time when governing comes to resemble a session of Sim City (or Chile's Cyber-Syn room of cybernetic government, discussed by Medina 2015) might be finally here. Those who sit at the fence of government action and have limited information to go by might have many questions about this "system of systems". One may wonder, for instance, who is interested in knowing counts of tele-care consultations? How many of the people calling a medical helpline or logging their symptoms through the ZOE app would imagine that their data could show up on a government dashboard, and what would they think if they knew? Are self-report data from the ZOE COVID Symptom Study app displayed on any dashboard, and who looks at it?

Those around the Data Store are not the only movements of health data between public and private sector that are currently noteworthy in the UK. The General Practice Data for Planning and Research (n.b. GPDPR – not GDPR) is a policy unveiled in the Spring of 2021 that, resurrecting the ambitions of defunct "*care.data* framework" (Vezyridis and Timmons 2017), mandates NHS Digital to create a centralised repository of general practitioner healthcare data, the access to which should be sold to private sector companies on a cost-recovery basis. It is the latest of a series of attempts to enable the permanent circulation of national healthcare system data in the UK private sector and boost its valorisation. As researchers at the Ada Lovelace Institute observe (Machirori and Patel 2021), the scheme was introduced with notable disregard for public engagement through a "method" that could be described as "decide, announce and defend": if

the policy is rammed through fast enough, it might survive the public back-
lash and the government would get its way. Once again, public backlash
might prove sticky enough. The introduction of the plan has been delayed
and there has been a sizeable opt-out, as noted by Cori Crider, director of
Foxglove Legal, in a recent expert consultation by the Ada Lovelace Insti-
tute (2021). Regardless the exact timings, the repeated attempts of consec-
utive UK governments to enable private sector use of patient records
demonstrate a long-term determination, which predates and will outlast
the pandemic, to get health data to circulate more widely and loosely and
for many more purposes than the performance of health care; and for the
government to allow private data platform developers to embed themselves
in the infrastructure of the state and its governance activity. As also high-
lighted by the Ada Lovelace Institute, the UK Government fancies the op-
portunity to turn the relaxation of data circulation regulations introduced
during the pandemic into a standard for the future regulatory regime, so as
to favour faster and broader circulation. The same kind of pattern has been
observed in yet another front of government development of pandemic
technology infrastructure, that of contact-tracing apps. As Rob Kitchin has
noted (Kitchin 2020), in order to develop contact-tracing apps many coun-
tries desperate to curb the spread of C19 resorted to working with organi-
sations that have been at the centre of scandals or polemics in "normal"
time because they develop controversial techniques, technologies or ser-
vices of population surveillance. Contact-tracing collaborations includes
organisations such as NSO Group, who sells weapons-grade spyware to
illiberal and autocratic governments accused of repressing dissidents and
opponents, and has worked with Israel on their app. More notoriously,
tech giants and mobile monopolists Google and Apple, who rushed to offer
a common Bluetooth-based stack for automating contact tracing in An-
droid and iOS phones, used their privileged position of mobile gatekeepers
to make an impactful contribution (not without privacy implications – see
Kitchin 2020).

Translating Private Technology to Public Infrastructure

In respect to organisational operations and decisions, data seem to cir-
culate well indeed. Many more private organisations have been taking part
in the C19 data craze, often with much display aimed at "covid-washing"
their reputation (Kitchin 2020), keen to be seen as generous tech wizards
rather than greedy data harvesters. After all, one might say, there is a point
in letting these companies collecting so much data about the public, if they
respond to the call when their help is needed. But are in particular those
organisations, who outside of "pandemic time" have been at the centre of
many ethical controversies over the ways in which they generate and use
data, that have rushed to the forefront of more and less consequential

efforts to help. It reveals a key assumption as to the ways in which technological, organisational and methodological frameworks originally developed for watching and manipulating consumer behaviour through digital technology have been seen as *translatable* to the context of social distancing restrictions and other emergency rules. The double-edgedness of these initiatives is easy to surmise. For instance, data broker Experian, who sells individual data at population scale after collecting them through a vast network of business relationships and repackaging them in the form of value-added marketing demographics, studied the distribution of C19's socio-economic impacts. Besides the potential to help public health response, one should remember the knowledge thus generated is likely to have value for marketing demographics too; and so, the first beneficiary of this effort might well be Experian itself. At least in a rhetorical sense, these frameworks have proved translatable: research into individual attitudes towards contact-tracing apps (Lucivero et al. 2021) shows that many believe the impact of intensive data collection and cross-dataset linking is negligible since the lives of ordinary individuals are already intensively surveilled, and for much less of a reason.

With so much "help" on offer, the pandemic has certainly reaffirmed the central role of private technology in the coordination of society's reaction to emerging events. But should it? A piece on the Harvard Business Review (Balsari et al. 2020) suggests otherwise. A *"tidal wave of data"* is sloshing around all corners, but not much of it might be *"any good"*. Many datasets made available are incomplete in ways that are not-randomly distributed across society, but rather, reflect socio-economic inequalities. If the disadvantaged are less well represented in datasets used to coordinate pandemic response, expect the inequality to be drawn on. And so, the authors suggest, while many tech organisations are busy offering up datasets and expertise on linkage, hosting and analytics, there is not enough engagement with subject matter experts. Many models are produced with expertise that is translated from being involved in the solution of problems other than the medical, but rather, rooted in mathematics, physics, or operations management expertise, among others; other innovations, such as automated contact-tracing, are live experiments. What a contrast with the exhortations of data analytics and visualisations leader Tableau, who encourages users to start *"your own analysis"* (Tableau 2022). Cloud-computing giant, Amazon Web Services, offers a suite of data and computational infrastructure resources to help and *"provide these experts with the data and tools needed to better understand, track, plan for, and eventually contain and neutralize the virus that causes COVID-19"* (Amazon Web Services 2020).

Experts can *"use AWS or third-party tools to perform trend analysis, do keyword search, perform question/answer analysis, build and run machine learning models, or run custom analyses to meet their specific needs."*

The Challenges that Remain

While some data might have been circulated in and out, and across, government quite well, other data were not circulating equally well. As the Alan Turing Institute's report observes (von Borzyskowski et al. 2021), a number of challenges were experienced by the community of data science and artificial intelligence researchers striving to make an impact through the production of new knowledge about C19. Certain kinds of data can be difficult to access because of governance issues – the Ada Lovelace Institute points out that current governance processes were often too slow and required too much of too few data custodians (Ada Lovelace Institute 2021); but also because they are more difficult to generate than others. Data on some pandemic response measures and their impacts, such as non-pharmaceutical interventions (e.g., social distancing and face masks), were not sufficiently available. Local council and administration decision makers complained not enough data were made available to them. Uneven quality and representation in population datasets further raised concerns of inequality in the response to the pandemic. Unequal vulnerability to pandemic response measures would also lead to mistrust and uneven participation and compliance in various undertakings, such as active installs of contact-tracing apps, or symptom self-reporting in citizen science studies such as ZOE COVID Symptom Study. While datasets were over-produced in a scramble to help, attention slipped over quality and methodological issues such as sampling (von Borzyskowski et al. 2021). While new problems are often resolved more quickly the more open and participative is the search for a solution, there is a way in which the eventually ensuing chaos brings about new problems in the meantime. The ubiquitous discussion of statistics and data in all kinds of public reporting further amplified concerns over interpretation and communication. Last but not least, Alan Turing Institute researchers complain about their relationship with government decision makers. They found it difficult to understand if the expert knowledge that they were generating through many studies was getting any attention by policy makers. Researchers who are well connected could have government's ear and access data that others could not. As we have seen, government decision-makers were providing themselves with cutting-edge analytics technology from private firms the likes of Palantir. It is as if they wanted to lock themselves up in the button room with the latest tech gear,

leaving other experts outside who kept insisting they could help. The appeal of translating all-powerful consumer surveillance infrastructure might have been more powerful than working with experts the old way.

From Normal to Pandemic Time, and Back

From this quick sketch, it should be possible to get a feel for a complex and protracted situation involving many kinds of initiatives, data practices, actions, claims, and contexts of use. Talk about data can be at different levels (Rosenberg 2013; Leonelli 2016; Tempini 2020): as digital object stored on computer systems, as epistemic product of an empirical scientific investigation or of activist projects, and as a rhetorical device that can be waved around (as in the press conferences that saw Boris Johnson so frequently argue that the UK government "just" followed the data). This makes the analysis of data practices and movements complex. Some of the stakes of data practices and movements from "pandemic time" will be played out in the future, and in such a cacophony of data practices and claims it is easy to lose sight of a few big trends that have been driving all things data. But there is perhaps enough to see that the circulation of data during the pandemic was uneven and dependent on many factors including the organisational and technological infrastructures datasets are managed with; and to suspect that the pandemic crisis, like many other crises, won't be let go to waste, and instead, will allow private infrastructure to be wedged further underneath society and its spaces. In times of emergency a general mobilisation of all sectors and actors might feel like the only intelligent thing to do, and so many private sector organisations all scrambled to see what they could offer to government and research community. But in all things infrastructural, there is a strong sense in which the past will become the present, and the present will become the future; because infrastructures are built over long time and sit on top of even longer-evolving methodological and cultural frames, path dependencies are deemed and continued through the material shaping of systems and practices (Star and Ruhleder 1996; Hanseth, Monteiro, and Hatling 1996; Hanseth 1996; Bowker and Star 1999).

Time was of the essence, and the rapidity with which private data-intensive businesses deployed a panoply of initiatives to share and analyse data of all kinds bears witness to the strategic dynamism and translatability of data platforms. Response to the pandemic was characterised by lack of time, and those who control data infrastructures were in a good position to enter the frame of pandemic response efforts and reap financial and

reputational benefits. Infrastructure evolution in "normal" time has often been seen as challenged by "infrastructural inertia" (Star and Ruhleder 1996; Bowker and Star 1999), that is the way in which infrastructures swamp change and make material legacy. In "pandemic time", instead, it seems as if infrastructures were key to enable movement and change. All time had been suddenly sucked out. Being able to re-deploy and re-purpose data infrastructures and methods was a chief way to buy time. This might not need to be a contradiction. Infrastructural inertia is likely to be observed as an infrastructural reaction when the change that is being carried out is proactive or transformative – a move away from the current ways of doing. The change and re-organisation that the pandemic time required was essentially *reactive*: when surprised and unprepared to unexpected developments, the current ways of doing might be the only available to effect change. Infrastructures and methods that are re-deployable, transferable and extendable are quickly whisked into new positions.

One could wonder why should we be concerned about all this? That is because once time is "normal" again, infrastructural inertia can kick in again. Dislodging private technology infrastructure, and the practices associated with it, that was deeply embedded in the government machinery back in pandemic time will become ever more difficult. As Sharon points out (Sharon 2020), running pandemic response with the technology provided by private corporations will *"increase our dependency on them for the provision of (public) services, and they make themselves necessary passage points for the adequate functioning of these sectors"* in the future. Continued reliance on any infrastructure makes it invisible and undermines the imagination of technological-organisational-political alignments that respond to different values, priorities and logics. Complex and consequential infrastructures, and their developmental inertia, help to ensure the past, from before the pandemic, is carried over to what comes after. They make some of the linkages that thread together the before-during-after of pandemic times.

Update 9th June 2022
This morning the Financial Times is breaking with reporting suggesting the Government is planning to award a giant contract for the provision of a data analytics "operating system for the NHS" and Palantir is devoting enormous resources to win the contract. Privacy activists who have exposed Palantir's penetration in state infrastructure since 2021 point out the same kinds of concerns I have been repeating here. It turns out worrying developments might be moving even faster than we might have worried.

"*Palantir gears up to expand its reach into UK's NHS*", 2022. *Financial Times*. https://on.ft.com/3xaqnsw

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Polysocial Risk Scores and Behavior-Based Health Insurance: Promises and Perils

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Cotton Balls, Zinc Supplements and Predictive Analytics

Once upon a time, a long time ago, around 2010, an irate father walked into a Target store on the outskirts of Minneapolis. He asked to speak with the manager, and upon their arrival, he waved coupons and vouchers in their face:

"My daughter got this in the mail!" he said. "She's still in high school, and you're sending her coupons for baby clothes and cribs? Are you trying to encourage her to get pregnant?"[1]

The manager apologized profusely and stammered that he had no idea how this could have happened.

A few days later, the same manager called the father to apologize again, but something happened:

> On the phone, though, the father was somewhat abashed. "I had a talk with my daughter," he said. "It turns out there's been some activities in my house I haven't been completely aware of. She's due in August. I owe you an apology." (ibid.)

What led to this bewildering encounter was a new office in that retail location, where a mysterious new practice had been implemented: *Predictive Analytics*. A sudden change in the young woman's shopping patterns had been noticed, signaled through her loyalty card, sparking an unanticipated chain reaction. Back in 2010, retailers had just started to collect intimate details about consumption habits. They had noted that:

> Women on the baby registry were buying larger quantities of unscented lotion around the beginning of their second trimester. Another analyst noted that sometime in the first 20 weeks, pregnant women loaded up on supplements like calcium, magnesium and zinc. Many shoppers purchase soap and cotton balls, but when someone suddenly starts buying lots of scent-free soap and extra-big bags of cotton balls, in addition to hand sanitizers and washcloths, it signals they could be getting close to their delivery date.[2]

Because of this shift in purchasing habits, the young woman's pregnancy had been made apparent in her data-double, even before her social identity.

This incident occurred over ten years ago, while paper mail was still the main form of promotion. In the meantime, self-tracking has exploded, generating enormous amounts of data, especially physiological and behavioral data. In addition, sophisticated algorithms can monitor the time we spend on a site, the physical places we visit, and the likes we place. By monitoring our credit cards, it is possible to know what we eat and how many calories we ingest. Especially in the context of COVID-19, unseen sensors can recognize who is running a temperature in a train station. In the field of health, therefore, there is not only big data but thick data: data that can tell us about our health from a clinical, physical and social point of view.

In this datafication of health, perhaps the two most disruptive and cutting-edge developments are "Polysocial Risk Scores" and "Behavior-Based Health Insurance". These two areas, in some ways, overlap since the risk score is the basis of health insurance, of which Behavior-Based is the most advanced kind. Surrounding both are big players with keen interests and high expectations. Both Polysocial Risk Scores and Behavior-Based Health Insurance share close attention to social aspects of health, and both are

driven by the need to predict possible (individual) futures on the basis, of course, of quantification (e.g., datafication). Surrounding these developments, beyond innovative possibilities, are clear doubts and concerns about their implications and consequences in terms of social justice.

The Polysocial Risk Score

In order to understand what Polysocial Risk Scores consist of, it is helpful to underline the main features of the Polygenic Risk Score, which in some ways acts as its prototype.

The Polygenic Risk Score estimates the risk that a person has of developing a disease from his or her genes. More precisely, the Polygenic Risk Score represents the total number of genetic variants that an individual has to assess their heritable risk of developing a particular disease since multiple genetic mutations and their interactions cause most diseases.

At first glance, Polysocial Risk Scores can be seen as the sociological version of the Polygenic Risk Scores, with the idea of the Polysocial Risk Score being developed in the context of the social theory of social determinants of health.

Social determinants of health are the factors that affect a person's health, namely education, income, type of work, type of housing, neighborhood, social cohesion, and others. These determinants affect health through lifestyles, health literacy, and access to care. Epidemiologists and health sociologists have repeatedly confirmed the influence of social context and social determinants on physiology. The determinants of health are strongly intertwined, e.g., how income influences health and how it, in turn, is affected by education; how the weight of income and how the weight of education affects a person's health, and how much, in turn, the weight of education on the possibility of acquiring higher income.

Therefore, the challenge is to weigh and estimate the conditioning of social determinants and their interactions with individual health. However, to date:

> Most efforts to precisely quantify the influence of individual social determinants of health have failed, largely because the causal pathways are numerous, interconnected, and complex. (Figueroa et al. 2020, 1553).

The enormous amount of data that can now be acquired on people's health could mark a turning point for developing precise estimates of individual risk of becoming ill. Notwithstanding, one would have to arrive at a Polysocial Risk Score for each disease or health outcome, even in this case. One person would then have several Polysocial Risk Scores. Nevertheless, compared to the Polygenic Risk Score, there is a considerably more turbulent level of complexity:

> One key difference is that unlike polygenic risk scores, which are not dy-
> namic because the scores are based on an individual's genes, polysocial risk
> scores may change if an individual's social circumstances change. (ibid.)

Where the Polygenic Risk Score is static, the Polysocial Risk Score is
(would be) dynamic. Moreover, the same social determinants have differ-
ent weights in different social contexts. Indeed, and methodologically it is
even worse with some social determinants being part of the context itself
(e.g., social capital and social cohesion).

As Figueroa and collogues (2020) illustrate, it is necessary to constantly
collect, aggregate, and mobilize data from different domains regarding
people's quality of life and sociodemographic data Polysocial Risk Scores
need to be periodically updated. Above all, it is necessary to relate these
"external" data to people's state of health, to their "internal" health data,
and to their physiology.

Moreover, as scores are elaborated and processed by algorithms, in
some cases, health data may result in biases and, in worst cases, social dis-
crimination. As summarized by Leslie et al.:

> AI systems can introduce or reflect bias and discrimination in three ways:
> in patterns of health discrimination that become entrenched in datasets, in
> data representativeness, and in human choices made during the design, de-
> velopment, and deployment of these systems (2021, 1).

Thus was the case of genetic data, as in the U.S, most genome-wide
association study-based polygenic risk scores have been based on popula-
tions of European descent, neglecting the health of other ethnic minorities.

Pricing Risk: Behavior-Based Health Insurance

Creating the Polysocial Risk Score would be something between mira-
cle and mirage, yet this does not mean that attempts have not been made.
On the contrary, the health analytics industry is a rapidly developing sector
in the digital firms of Silicon Valley and the biotech industry of the Boston
Area, with the American health insurance agencies leading the charge to-
wards the construction of health risk scores, with the latter being interested
in knowing the health status of their members. Moreover, actors that has
most influenced this orientation of health insurance, at least according to
some scholars, has been a legal provision contained in the Affordable Care
Act (ACA), approved in 2010. As Liz McFall points out:

> The ACA alternative introduced a "behavioural" approach (…) including
> new responsibilities to pay a "fair share" of the costs of the entire pool and
> be "as healthy as you can." The responsibility to be healthy is promoted by
> the provision of access to preventative care and treatments for chronic,

preventable disease. (...) This emphasis on behavioral responsibility is a great fit with data-driven healthcare innovations including wearable self-tracking devices and apps. (Mc Fall 2019, 60).

This provision has operated in "association" with other factors, primarily technology. As McFall (2019) and Schüll (2016) point out, digital technology and the ACA have been presented as a "dynamic duo" working together, and

compelling insurers, health care providers and consumers to cut costs (...) shifting the management of chronic conditions like diabetes and heart disease away from hospitals and doctors and into the hands of patients themselves (Schüll 2016, 318).

If over a decade ago the office of a chain store was able to learn of a customer's pregnancy through her purchases of hygiene products, what can health insurers know about us today? What could insurance "providers" learn when they are given access to sociodemographic data, clinical data, genetic predisposition, and, more importantly, lifestyle data (not simply "lifestyle data" as in whether individuals are smokers or vegetarians, but all digital activities and data-doubles)? Moreover, some digital platforms have already identified rich sets of data points for proxies of social determinants of health:

individual purchasing behavior, consumer engagement with advertising, insurance claims, sentiment, and expression in online forums, credit histories, and online social networks (Rowe 2021, 4).

This data, in turn, is coupled with the mundane data generated by personal FitBits, generously gifted by health insurance agencies (Maturo and Moretti, 2018).

Before the spread of digital social networks, Christakis and Fowler (2010) wrote that social friend networks greatly influence personal decisions. Christakis and Fowler showed through animated sociograms based on accurate longitudinal research how certain behaviors may be "contagious". Not only does a person have a high probability of gaining weight if their friend does, but also if their friend's friend does, this can be further applied to divorce and smoking cessation. Today these analyses are immensely easier given the ease with which big data can be collected and processed. The predictive potential delivered to insurance agencies is enormous, leading to correlation taking the place of causation, with the latter becoming an obsolete 20th-century category (Anderson 2008).

Raschel Rowe (2021) has done thorough research on the platform "Opioid360", a platform that combines browser histories, credit, insurance, social media, and traditional survey data to sell the service of risk

calculation in population health. Created as a tool that would support over-worked clinicians to see invisible signs of potential addiction in their patients, Opioid360 paved the way for broader applications to prevent chronic diseases. Most importantly:

> By extending digital phenotyping imaginaries, Opioid360's presentation appealed to the notion that comprehensive personal data can offer behavioral science the precision that genomics has offered to identify rare diseases (Rowe, 2021, 4).

In their analysis of Vitality health insurance, McFall et al. (2020) make clear that:

> Behaviour is Vitality's core brand value and its policies provide incentives to customers to meet behavioral targets, share their data with the company and share their progress on social media (McFall et al. 2020, 7).

The big switch that many health insurers have made is to link insurance premiums and access to specific policies to the constant digital monitoring of physical activity (InsurTech). In theory, through self-tracking, the premium costs could fluctuate every day, in connection with our physical states, instead of once a year. The extension of insurance surveillance to other aspects of our lives through the datafication of health raises big questions about social justice.

The encouragement of certain behaviors opens an extended reflection on the empowerment of the individual. In social studies of health, it is well known how social context affects a person's health and that certain social factors such as income make adherence to healthy lifestyles relatively easy for some people, while for others practically impossible.

When I arrive at around 8 o'clock outside my department, I often meet one of the ladies who clean the offices – being female, visibly overweight, doing an extremely physical job (maybe she has a disease or seeks satisfaction in food?). She gets up at 4.45 a.m. to start work before 6 a.m. When she greets me at 8 a.m., she lights a cigarette with her South Italian accent before getting into the car. She inhales in big puffs as if it were a prize, a seal, or as we say today in the field of gamification, an award for the work done. However, it is not her avatar who is smoking, unfortunately. Her face is tired, and she is in a hurry – maybe she will light another one soon: she has to go to the other side of the town to do some more cleaning, and there is a lot of traffic by then. Just before entering the department, out of the corner of my eye, I see a colleague of mine jogging through the beautiful palm trees on our campus.

Algorithmic Forecasting and Insurance Customization

According to Barry and Carpentier (2020), insurance can be defined as

the transformation of unknown individual uncertainty, or chance, into a measurable aggregate risk. Technically, it consists of pooling uncertainty and applying the law of large numbers (Barry and Carpentier 2020, 3).

In this way, the occurrence of catastrophic events for one person was remedied by adding small amounts set aside by all. Through statistical predictions, it is relatively easy to predict that a certain number of insured people will fall ill without knowing who exactly. At least until now, insurance has been based on the concept of socialized actuarialism. However, as early as 1996, O'Malley glimpsed the advance of privatized actuarialism, a more refined approach based on:

a technology of governance that removes the key concept of regulating individuals through collectivistic risk management and places the responsibility for risk management back on the individual (O'Malley 1996, 197).

Thus, whereas traditional insurance was based on prediction (i.e., aggregate predictions at the macro level), the new behavior-based insurance is based on forecasting (i.e., attention to the individual's future at the micro-level). This mode of insurance makes policyholders more responsible for their daily actions and health. However, many scholars question whether, technically, behavior-based insurance can still be considered insurance. Based on the distinction between individual fairness and social fairness, Cevolini and Esposito, effectively summarize how the ancient principle of solidarity can be undermined by new insurance policies:

Algorithmic prediction could radicalize the principle of segmentation, culminating in the extreme case of "segments of one." This would almost automatically mean the end of the risk-pooling on which the principle of risk-sharing is based (Cevolini and Esposito 2020, 4).

The end of risk-pooling carries significant implications as to whether Polysocial Risk Scores have the potential to become a central tool in healthcare. In this regard, a crucial issue here concerns what would happen if Polysocial Risk Scores are calculated and accredited by institutions.

Considering that constructed indicators tend to become objective entities, Polysocial Risk Scores can be employed in different contexts and by different actors; from public health departments, government officials,

technology companies, investors, and private insurance companies (Ne-resini 2015). In a world that is increasingly computerized, quantified, and managed by algorithms, health scores could be mobilized for a variety of purposes. Some of these uses could be noble and others less so:

> Health risk scores are not only useful for immediate patient classification or public health program planning, they are also useful to investors seeking to leverage or hedge their risk exposure. (Rowe 2021, 9).

Although indirectly, a strong impetus for developing health scores has undoubtedly come from COVID-19 pandemic. The pandemic has bolstered the trend of health quantification through the robust joint growth of medicalisation and digitalisation. Most importantly, COVID-19 pandemic has spurred surveillance. To put a long story short: *9/11 increased police surveillance, big data stimulated capitalist surveillance, and COVID-19 hyperbolically accelerated molecular surveillance*. Molecular surveillance can be seen as the scrupulous and precise monitoring of our physiological motions and their instantaneous transformation into data. A panopticon of our internal states, or more precisely: the *endopticon* (Maturo 2015). However, this surveilling is not perpetrated by shadowy officials of mysterious agencies wearing thick-lensed glasses in smoke-filled rooms of some governmental molecular surveillance departments but by algorithms themselves. Programs that react to numbers that exceed certain thresholds, to parameters that measure, compare, and discriminate our physiological motions, collect our behavioral habits and read our molecules' silent but vivacious lives.

Yuval Noal Harari, the author of the successful *Homo Deus*, in an article published in the *Financial Times* on April 19, 2020 entitled *The world after the Coronavirus*, fears a dystopian scenario:

> Hitherto, when your finger touched the screen of your smartphone and clicked on a link, the government wanted to know what exactly your finger was clicking on. But with Coronavirus, the focus of interest shifts. Now the government wants to know the temperature of your finger and the blood-pressure under its skin. One of the problems we face in working out where we stand on surveillance is that none of us know exactly how we are being surveilled, and what the coming years might bring. Surveillance technology is developing at breakneck speed, and what seemed science-fiction 10 years ago is today old news.[3]

Harari's concerns reaffirm that health scores will soon be the subject of a Black Mirror episode. Behavior-Based Insurance and Polysocial Risk

Score have disturbing implications, starting with the de-politicization of health, which is no longer understood as a public and social issue but as a business and private concern. The challenge, however, is not to assume ipso facto Luddite or apocalyptic attitudes. It is necessary to find a catalyst that brings health back to the center of public discourse. In a society dominated by chronicity, the masses (of patients and caregivers) should become aware of their strength.

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A Data Journalism Perspective on Data Circulation

Elisabetta Tola, Formicablu

Introduction

No longer in its infancy, but not a grown-up either. That is the state of data journalism, as far as Italian media are concerned. With very few exceptions, the practice of using data to provide sound, accurate, transparent information is still very rarely explored at its full potential in our country. The reasons are many, and the recent experience of the COVID-19 pandemic has made them clearer. The list is long – lack of the appropriate mindset on the side of most journalists and even more of their editors and publishers, lack of resources and skills, lack of time and reliable sources. However, most of all, lack of data. Despite the data deluge we seem to have experienced, with maps and graphs popping up everywhere, the reality is that meaningful and valuable data are still very scarce. The negative impacts and implications of such a greedy approach remain to be assessed. But there are also lessons to be learned and used to improve the information and the future journalistic work.

Data and Health: How We Learnt to Tell Stories in a Different Way

The first data-driven investigations appeared in UK and US newspapers around 2009-2010. The Guardian Datablog, founded by journalist Simon Rogers, currently data editor at Google, was one of the earliest efforts to introduce data in daily journalistic practice routinely. *Anyone can do it* – argued Rogers in a popular piece he wrote at the time: *Data journalism is the new punk*[4]. The combination of data available in easy-to-use formats released by many public institutions with the ability to use a datasheet to compile basic statistical operations and a few tools to create graphs and maps were deemed by Rogers as the basic bricks that could build a new

approach to journalism. Nevertheless, even at that initial step, it was already clear to all, and well highlighted in Rogers's article, that:

> Maybe everyone can do it, but not everyone can do it well. Like so many other things, done well is a mix of art and science (see footnote n.4).

It was almost immediately apparent that data journalism could be particularly useful when applied to issues that, while being of high public interest, are particularly difficult to interpret and understand, such as health or environmental ones. "Not all data journalism has to bring down the government – it's often enough for it to shine a light in corners that are less understood, to help us see the world a little clearer." That is Rogers, again (see footnote n.4).

One of the first iconic data investigation in the health domain was the initiative *Dollars for Docs*, a long series of online articles and a rich database built in 2015 and maintained until 2019 by the US online magazine "ProPublica"[5]. According to the methodological scaffold in which the articles are framed, the story started in 2009 when seven drug companies were required by a court to release details of their payments to doctors and teaching hospitals in the US. The story grew big in time and lasted over 10 years until, in 2019, the magazine stopped updating the database. At that point, the database included information on payments made by over 2000 companies to more than 1 million doctors and 1200 teaching hospitals for a total of over 12 billion dollars of payments. The payments included diverse categories, such as promotional speaking, consulting, meals, travels and royalties. A tool was developed that allowed any reader to search for their doctor and check whether a company had somehow paid him or her, when, how often, for what and how much. *This may put your next prescription in a different light,* wrote the editor Stephen Engelberg in one of the first commentaries accompanying the launch of the *Dollars for Docs* investigation[6]. Furthermore, the investigation and the data enacted a collaborative approach where ProPublica started co-producing articles and in-depth analyses with other media, local and national, to make sure that the database could be exploited to its total capacity and highlight many stories of local interest to citizens living in different cities and states. In many cases, it spurred actual investigations on malpractice and wrongdoing, which would have been very difficult to undertake without those data.

Shortly after that, Wired Italy launched the *Dove ti curi* [Where do you go for your health care, n.d.r.] investigation, based on the first release of data by the Agenas, the Italian National Agency for Regional Health Systems. Agenas produces a periodic report on health care quality in all 1200 Italian public hospitals. These data were made available for the first time to journalists and professionals in the health sector in 2012. The following year, Wired Italy decided to publish the entire dataset in a searchable format and many articles explaining the meaning of those data. It was an

absolute novelty in the landscape of health journalism in our country. The investigation is, unfortunately, no longer available online. However, it remains a landmark in the way health data could and should be used in enabling people to make informed decisions on where to go to be assisted, which hospitals are better for one or the other type of treatment, and which are absolutely to avoid because their rate of mortality is a dangerous outlier. Thus, those data would be precious also to researchers and professionals in the health sector for assessing and comparing the performances of the different health centres. They can show how organisational choices can have a positive impact in terms of outcomes, and they can help re-modulate or eliminate the situations where the outcomes are adverse, reducing suffering and saving lives in the end.

Interlude: How Data Enter the Journalistic Practice and Become Stories

Far from being magic, data journalism is done following a very straightforward methodology:

> Data journalism begins in one of two ways: either you have a question that needs data or a dataset that needs questioning. Whichever it is, the compilation of data is what defines it as an act of data journalism. (Bradshaw 2011).

The first step is finding and compiling the data. One can do this by finding a ready-to-use spreadsheet online, but also by using advanced scraping techniques to get data from online pages and databases, by extracting numbers from .pdf or other formats into a table, or by pulling the data using an API or finally collecting them manually, either by observations, surveys, questions, investigations. Once the database is available, it needs to be cleaned, filtered, combined, and analysed. Even with a ready-to-go table, such as the ones that can be downloaded from any open data repositories, as the data warehouses of the National Institutes of Statistics or the international organizations (such as FAOSTAT, World Bank Open Data or OECD data), the numbers are not ready to be used to write a story. This is even more true if the data are raw, and the database has been built from scratch. In this latter case, there is the need to run some statistical test to make sure that the data are significant with respect to the initial hypothesis. When the dataset has been validated, there are more operations to go through. We need to be sure that there are no mistakes, duplications, misspellings, missing information and so on, and we can achieve this step by means of running tools that highlight those errors and allow corrections in order not to misinterpret the final result.

At this point, a journalist will look at a data set in a different way than a researcher: the questions that come to mind when using data to craft an investigation are motivated by the interest in finding an angle, an explanation, an interpretation for a story that will have an impact on people's view of a certain subject. Journalists look for outliers to see if there is a moment in time, or a situation compared to others, that could be explained by external factors. Or they look for trends comparing situations that might give rise to a wider view on a certain phenomenon. Therefore, it is particularly important to be very accurate in the cleaning step since outliers are often simply the results of errors, generated either during the data collection or the data entry into the database. Comparisons in time or across different geographical situations, for instance, can only be made if the data are consistent, if the same methodology has been used to collect them in the dataset.

Furthermore, data need to be put in context, with the appropriate metadata explaining the methodology and the significance behind the data collection and organisation. In the journalism domain it is possible to use data collected in different ways, if those are the only one available, but the extent and meaning of those discrepancies have to be made clear to the readers in order to be truly informative and not misleading.

For a journalist an interesting set of data can also be a dataset that is missing a key information: at that point, the question is why that piece of information is not available. Sometimes the story can be, as a matter of fact, in the missing data, since that absence is telling something about inefficiency, malpractice, opacity and much more. Finally, in order to tell a full story, the concerned database might need to be combined with other data, such as demographic ones, historical, environmental. By addressing specific questions through the database, the journalist might see if there are interesting correlations, i.e., identifying factors that might influence or affect a certain trend. For instance, *The hunger profiteers*, a recent investigation published by Lighthouse Reports, a European collaborative investigative journalistic effort, has focused on the dramatic increase in food prices in recent months[7]. The current narrative, both by media and by many key actors and public institutions is that this increase has a lot to do with the Russian invasion of Ukraine and its impact on grain production and trade. And yet, looking more closely to the food price index estimated by Food and Agriculture Organization of the United Nations and comparing that with the global production of cereals in the last few years and the global demand, it becomes obvious that the price skyrocketed well before the Russian invasion and it does not seem to be linked to production nor demand but rather to other external factors. Investigating further and getting hold of the documents published on the main cereal trade exchange markets, those in Paris and in Chicago, the reporters exposed the role of investment funds and of speculative maneuvers on the price of cereals. These speculation have, as a primary effect, that of generating food insecurity for

millions of people. Of course, more data are needed to consolidate this interpretation, but this investigation shows exactly what the power and role of data journalism is, that of connecting and exposing data and facts of public interest. These stories are then often better explained using charts and visualisations, but that is not always the case, and sometimes charts can also lie (see Cairo 2019). In conclusion, doing a story with data requires profound respect for the data and the way they are collected and analysed. This also may require an effort in spending some time asking the appropriate questions to the database once it has been created or obtained. On the contrary, inaccurately using the data can lead to a wrong story, or no story at all.

Covering an Emergency in a Data Void

Fast forward ten years, there has been a steady increase in the number of civic activists and data journalists that bring data into the information flow. In some cases, by collaborating with a local or national media. In others by doing their work independently online, on different platforms, and organised more or less informally. There are collaborative efforts, small communities of data journalists helping each other, training courses. Many people have learned how to manage a datasheet, perform the basic checks and operations, and convert the data into meaningful graphs, charts, and maps. In these over 10 years, we have gone from simple maps and graphs showing the data in an interactive way so that the readers could select the information they most needed or wanted to see, to very elaborate data visualizations that have become, in the worst cases, more focused on the aesthetic and decorative aspects than on the informative ones. Recent investigations see a return of simple graphs that prove to be easier to access and interpret. Data journalism units and teams have been organised in small and big media outlets in many countries, and this practice has now been integrated in the journalistic practice so that maps, charts, dashboards are produced on quite a regular basis. In Europe many collaborative networks have been working on data, such as the "European Data Journalism Network" that includes news outlets from many European countries, such as "Investigate Europe": a collective effort publishing investigations, often data-driven, in different languages. There have been massive global data investigations such as the well-know "Panama papers" published by the "International Consortium of Investigative Journalists", that have been awarded the Pulitzer Prize and have seen more than 400 journalists and investigators from over 80 countries cooperating together. But also, more regional efforts, such as for example that of "Grand theft Europe", coordinated by the "German outlet Correctiv", where 63 journalists from 30 countries worked to expose the largest tax fraud in Europe perpetrated by criminal organisations, or "Don't miss the train", coordinated by "Journalism ++" and the "EDJNet".

Contrary to most other countries, with few exceptions Italian media still do not have a data team embedded in the newsroom. While the main interest of data journalism is finding new stories, new angles, and new or better explanations in the data by analysing them thoroughly, most Italian media still use the data without questioning their quality. Data are turned into something decorative, a chart here and a map there to catch the eye. Even worst, data might be cherrypicked to support a theory, a thesis, or an argument. Of course, there are numerous exceptions and truly thorough investigations done mainly by freelancers, and published on Italian media outlets. "Infodata", the data journalism section of Il Sole 24 Ore, or Wired Italy, are among the few ones to do data-driven journalism on a regular basis.

At the beginning of the COVID-19 pandemic, things changed dramatically. Before then, any investigation by media usually used the data from months or even years before. Most public institutions were (and are) still very far from releasing the raw data as a flowing stream as soon as they collect them. Hiding behind the idea that non-experts cannot access the data because they would not know how to read them, institutions demand time to clean, polish and harmonise the data before making them available to the public. At the end of February 2020, after news broke about the first Italian COVID-19 case, it soon became evident to many people from different professional environments that fresh data were badly needed. We quickly moved into one restriction after another, without having a deep understanding of what was happening and without the numbers to support many decisions. In this respect, the only guiding North Star was the daily bulletin of the Italian Civil Protection Department, released every evening at 6 p.m., listing the number of total cases by province or region. We knew nothing about the testing scale, the availability of tests, the registration of new cases compared to the previous days, as well as the testing capability. We knew nothing of the hospital capacity, how many beds could be given to the patients suffering COVID-19. For days, and then weeks, the only thing that majority of media did was publish the bulletin as it was, a .pdf table, with no further information.

Journalists Filling the Void: Bottom-up Data Related Practice

The first ones trying to have more data were the journalists working at local media outlets in the most hit cities, Bergamo, Brescia, Varese, in the region of Lombardy. Tomaso Bassani, deputy editor-in-chief of "Varese News"; Isaia Invernizzi, at that time reporter at "Eco di Bergamo"; Cristina Da Rold, freelance data journalist at "InfoData – Il Sole 24 Ore" and her colleague Riccardo Saporiti, who is also writing for Wired Italy; the team at "Il Giornale di Brescia". These journalists, to mention a few of the most active ones, immediately started looking at those data posing the same questions discussed above: *What does this data mean?*; *How were they*

collected?; *What is left out of the databases that are being shaped to monitor the COVID-19 pandemic?*. More and more journalists and activists in the fields of open data and transparency have started asking public institutions for better data and detailed information, so as to be able to compare data coming from the different cities and regions. They also launched collective efforts to get the data from the local health agencies. Around them and together with them, different grassroots associations became vocal actors in reclaiming more data: the association "OnData", advocating for open data for over a decade; the independent "Gimbe Foundation", working on evidence-based medicine; the collective "DataNinja" group on Facebook, where many data journalists discuss daily the problems encountered in working with data. For all of them, the main point was the impossibility to inform their audiences and communities helpfully because the numbers offered in the daily bulletin were meaningless. Tomaso Bassani (deputy editor-in-chief of the newspaper Varese News), for instance, started building a longer-term series, creating his own database, collecting the data daily and showing the trend in the mid and long term instead of offering just the day-to-day numbers. On March 4th 2020, OnData opened a repository on GitHub to collect, in a machine-readable format, the data published by the Civil Protection in .pdf, so journalists and activists could at least build their tables and do some analysis. At the same time, journalists campaigned to ask the Ministry of Health and the Civil Protection for the release of all the data in an open format, machine-readable, with less aggregated data needed to perform local analysis. Finally, the Civil Protection adopted the same attitude and created a GitHub repository to publish their daily data in an open format and with an open license. Since then, thousands of people have used it, showing its potential for scrutinizing the COVID-19 pandemic.

In those early weeks, journalists were among the first ones to complain about the lack of data. Those working in smaller towns were asked many questions directly from their readers regarding the actual scale of the emergency. They put up an enormous endeavor to find out more data using the old method by calling public hospitals, the regional health agencies, and the local health agencies, thus shaping databases from scratch. Their stories highlight the complete absence of an institutional culture of transparency for what concern the release and use of data. Some local health agencies or governments understood the importance of disclosing the extent of the emergency, even if only to gain support from the population. But many preferred to remain silent, hiding behind the fact that they were dealing with an emergency and did not have the time and resources to work on the data. One of the major problems was that the Italian Regions are formally in charge of locally addressing and regulating relevant issue health system. And each region works differently. We have nineteen administrative regions and two autonomous provinces, meaning 19 regional health systems and 2 provincial ones. And not only the health systems are very diverse, but

the way data are collected differs, and the results are not always compara-
ble. Therefore, aggregating them in one table is meaningless, and it can
hardly lead to any conclusion.

Besides journalists, researchers became highly interested in the data
too. Given the scale of the COVID-19 pandemic, this was a unique oppor-
tunity to make in-depth data analyses at many different levels: perfor-
mances of the health system; comparisons, trends, correlations to under-
stand if the spread of the virus could also be worsened by other factors,
such as environmental ones, among many others. Even local administrators
and authorities can benefit greatly from the access to the data with the aim
to assess the evolving situation and the measures to be enforced. An exam-
ple can elucidate this point. The Italian schools remained closed for
months, even in areas where the cases remained very low during the first
and the second wave. The absence of data regarding the impact of the
COVID-19 pandemic within the teaching system is probably still one of
the less acceptable outcomes of the entire story. Studies published after the
first lockdown, such as the "OpenPolis"[8] series on educational poverty or
the report by "Save the children"[9] on the same topic, showed a consistent
increase in learning and educational inequalities worsened by the complete
unpreparedness of the Italian school system to use digital schooling appro-
priately and equitably. Beyond any wishful thinking, there is no doubt that
our defeat to protect the most vulnerable groups of the youngest genera-
tions and to offer them a viable opportunity to attending school could have
been mitigated if we had known better how the virus was spreading in
schools. Reality is that even the institutions that should be on the forefront
of data collection seem to lack either suitable methodologies and standards
or a set of procedures in place to make those data promptly available to
researchers as well as to the public, as it should be granted within an open
democracy. Particularly, in the case of health data and of school-related
data, each Italian region is responsible for the monitoring of the situation,
for the data collection and for the communication of those data both to the
central state authorities, such as the Ministry of Health or that of Educa-
tion, and to the citizens through the websites.

This fragmentation has been used to justify, for instance, the inexist-
ence of a complete database of all Italian public schools on the Ministry of
education website. Only in 2019, after more than seven years of public re-
quests, campaigns and investigations, those data have been finally made
available. Therefore, what happened during the COVID-19 pandemic is
not a surprise, but it is still unacceptable.

The Civil Protection daily bulletin failed to provide an accurate picture
about the real death toll of the pandemic. Indeed, many mayors of local
villages and towns, particularly in the most hit places (such as the province
of Bergamo), highlights the low reliability and the scarce heuristic power
of the official statistics on the progress of the pandemic.

With no fresh mortality data available from ISTAT – traditionally released only every three months – it was difficult to make comparisons with average mortality for specific geographic areas. That is why the local newspaper "L'Eco di Bergamo" launched its own investigation. Supported by a data science startup, the journalists designed a survey to collect the data from the local administrations, one by one. The results were distressing. In an online newspaper article published in L'Eco di Bergamo, the journalist Isaia Invernizzi argues:

> What the official figures don't say. They don't say that in March 2020 more than 5.400 people have died in Bergamo province, 4.500 of which due to Coronavirus. Six times more than the previous year. Of only 2.060 of them, the «official» certified deaths caused by COVID-19 in the local hospitals (data as at yesterday), we know everything: age, gender, pre-existing conditions. We do not know anything about the other 2.500. Many of them are old people, who died at home or in assisted residential homes. In spite of the unmistakable symptoms, as recorded by physicians and relatives, they were never tested for the disease. On their death certificate you can just read: interstitial pneumonia[10].

In this case, the data making the difference were the missing ones. Behind those data, Isaia Invernizzi and his colleagues found the most crucial story and managed to give back to those neglected dead people the right to be remembered.

Another missing piece of information, not evident at first, was the impact of COVID-19 on ordinary health care treatments. The journalist Riccardo Saporiti – supported by a scholarship granted by SISSA – Scuola Internazionale Superiore di Studi Avanzati and funded by the writer Paolo Giordano – worked for the whole year on an investigation called *Pazienti dimenticati* [Forgotten patients] (Saporiti 2021). His effort focused on the screenings, diagnostical exams, oncological treatments or other surgeries that have been cancelled or postponed due to the reorganisation of the hospitals during the COVID-19 pandemic. These postponements resulted from a political decision endorsed by the Ministry of Health in March 2020. According to Saporiti (2021):

> A decision, the judgment on which it is left to the reader, which has affected the national territory in a homogeneous way, in a context in which the pandemic has hit the country in a way that is anything but homogeneous.

Since data about the cancellation and/or rescheduling of ordinary care treatment were not publicly accessible, Saporiti had to send 200 Freedom of Information requests to Local Health Agencies and hospitals for obtaining the concerned data: 57 ignored the request; 21 rejected it; 122 sent the requested data, although not always in complete form. The request was

aimed to access to data relating to surgical interventions, outpatient visits and examinations and oncological services performed and postponed between March 1st and April 30th 2020.

In the words of Saporiti (2021), the numbers offer only:

> a photograph, albeit partial, as detailed as possible of the impact that the pandemic containment policies have had on patients not affected by Sars-CoV-2. The effects of these postponements are still all to be assessed.

The use of Freedom of Information requests and a thorough collection of available data published in scientific journals and on a range of different institutional websites were also the tools used by Davide Mancino for his one year-long investigation, called *The Big Wave* (available both in Italian and English[11]), on the health, economic and social impacts of the COVID-19 pandemic in Italy.

Elusive Data and the Campaign to Free Them

Difficulties relating to the collection and rapid release of data characterized both the first (25th February 2020 – 31st May 2020) and second (10th October 2020 – 31st December 2020) pandemic waves in Italy. During the second wave, a new system for managing the pandemic was put in place, where the different regions were assigned a colour, from yellow to red, depending on 21 parameters, the most important one being the occupation rate of hospital intensive care units. However, the whole set of 21 parameters remained very complicated to be understood by concerned people. There were weekly reports published by The Italian National Institute of Health (ISS) and the Ministry of Health, but

> if the idea was that of sharing the choices with the citizens, the result is a very complex document, comprehensible only to professionals, between numbers that do not find any explanation and algorithms that refer to previous publications (Da Rold 2020).

Citizens can no longer be expected to trust the government and institutions simply without understanding the evaluations that assign a color to each region corresponding to different levels of restrictions. According to Da Rold (2020):

> *Trust us* is no longer sufficient. Many months of sacrifices have passed, and now citizens and all those who work with data demand to know the data behind the decisions and the risk assessment.

November 2020 marked two critical steps on the data front. The first was an agreement signed between the "Accademia dei Lincei" [The Lincean Academy], whose President at the time was the Nobel Prize physicist Giorgio Parisi, with the National Institute of Nuclear Physics (INFN) and the ISS. The agreement implied that all data produced by the ISS would be given to the Accademia dei Lincei to be made available through a new platform. However, it was not clear which data were part of the bundle, and it took many other months just to see the data. Researchers from other institutions complained and criticised the decision, claiming that it would have been more fruitful to make the data available to the entire scientific community to multiply the research potential. There was also a growing interest in these data outside the scientific community. This movement finally brought to the launch of the campaign *Dati bene comune* [Data as Common Good], promoted by "ActionAid", "Ondata" and "Transparency International". The campaign was meant to foster a

> culture of open data among the Italian civil society and the public institutions and to ask the Italian government to publish open data on the management of the COVID-19 pandemic[12].

By the end of 2021, the campaign had collected more than 50.000 signatures and the support of over 275 organisations. Some results were obtained, i.e., the change of license on publications and data available on the websites of the ISS. Nevertheless, so much more needs to be done. The campaign, not limited to COVID-19, is currently asking for the data in compliance with the Recovery plan for Europe – NextGenerationEU and the application of the due economic measures.

Lessons Learned, Looking Ahead

In conclusion, the lessons to be learned are different and quite significant. In the absence of preparedness, data are the most vital tool to support decisions and try to assess risk. Data are the key ingredient to building a common ground of trust and dialogue among institutions operating at different levels and between institutions and citizens. They are the only way to promote accountability on all parts: to see if the political decisions are followed through and if the results are coherent with the premises. Furthermore, they serve the purpose of monitoring in real-time and adjusting when things go wrong. Dealing with a pandemic, as much as with an economic or an environmental crisis, requires the capacity to embrace uncertainty and complexity simultaneously. It requires a sincere and transparent attitude. The sense of frustration experienced by different stakeholders and concerned groups of people hit by the consequences of the pandemic could have found at least partial solace in the knowledge that the decisions

were taken upon precise solid data and not based on ineptitude or political calculation.

Finally, to answer those who think that data should only be handled by a restricted circle of experts and not by lay people, many experts work in different capacities and, when there is transparency, researchers, activists, journalists can indeed, independently or collaboratively, confirm or dispute calculations, interpretations and conclusions with better outcomes for the entire community. When transparent and available to all, data cannot easily be manipulated or misinterpreted or used to support wrong theories and false conclusions. A democratic and responsible society is a society where all have access to information the same way to make proper decisions, be responsible citizens, and be an active part of the joint effort to solve collective problems. Data *per se* are only one of the components of information, but in a society that is so intensely data-driven data become a very critical ingredient of a complete, transparent and honest information. Without data there is no transparency, and without transparency democracy is at risk.

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Science and Technology Museums Meet STS

Going Beyond the Galleries and Into the Practices

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Abstract: Science and technology museums and centres are usually conceived as settings for science communication. In the STS tradition of Public Communication of Science and Technology (PCST), galleries and exhibitions represent the museum side most exposed to research. However, these museums are complex organisations where artefacts are not only exhibited but also collected, stored, studied, and preserved because they make the technoscientific heritage of a place. In this Scenario, I review the literature in PCST/STS and Museum Studies to show how the PCST approach is insufficient to study science and technology museums because issues about the private side and heritage are not addressed. I argue for the need for STS to enter the private sides of science museums and study them as places of technoscientific knowledge production. The Scenario suggests an STS approach situated in sociomaterial ecologies to study museum practices which, as discussed by Museum Studies, are the sites where narratives about science and technology arise.

Keywords: science and technology museums; museum artefacts; heritage; sociomaterial ecologies; museum practices; narratives.

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1. Introduction

Science and technology museums and centres are usually conceived as places where to engage with hands-on science and technology or the history of great accomplishments in these fields. In Science and Technology

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Studies (STS), studies in Public Communication of Science and Technology (henceforth, PCST) have fully embraced this view and thoroughly studied their contributions to science communication. Nevertheless, galleries, exhibitions, and public events are only one of the many layers that make up the complex organisations that are science museums and centres.

In this Scenario, I review the literature in PCST and Museum Studies[1] to analyse key issues around object-based science and technology museums[2] and argue that the PCST approach is insufficient to study them as a whole. STS must mobilise other traditions to go beyond galleries and engage with the practices of S&T museum practitioners' daily work. The reflections in Museum Studies about science museums and how their practices and materiality affect narratives about science and technology are very similar to what STS ask about other organisations such as laboratories. Thus, an integrated approach can help answer critical questions about the practices, objects, and people that participate in the construction of the narratives about technoscience within and beyond exhibitions.

In the first section, I position science and technology museums in the debate of PCST to show that, despite the invaluable theoretical tools developed to understand how science and technology are publicly displayed in such museums, the field generally misses an understanding of the museum that goes beyond the gallery. Instead, Museum Studies attend to the private sides of museums. In the second and third sections, I address two recurrent topics in science museums literature – the role of museum practices and the role of objects in science museums – to show their value in understanding the construction of narratives about science and technology. Finally, by drawing from these insights, I propose an integrated approach based on conceiving the S&T museum as a sociomaterial ecology.

2. Science and Technology Museums and Science Communication

Studies in PCST tend to refer to science and technology museums and centres in relation to their publics, as they consider these places as one of the possible settings of science communication, where questions about the relationship between science, technology, and society unfold (Bucchi and Trench 2014, 1-14; Davies and Horst 2016, 4). According to Bernard Schiele (2014), S&T museums and centres have several public objectives that range from making the publics aware of the latest discoveries of science and displaying a history of inventors and discoveries to contributing to science education and helping the publics develop skills and competences. Thus, the role of science museums and centres in society is "to make science and technology present in the social imagination and in the public space" (Schiele 2014, 44).

These institutions, too, have been influenced by the changing paradigms of deficit, dialogue, and engagement in science communication. Since the second half of the 20th century, museums have shifted their attention towards visitors. This shift goes hand in hand with the loss of safe resources, forcing museums to opt for marketability and a logic of profit in their internal activities, such as choosing blockbuster exhibitions over the valorisation of collections (DesRoches 2015; Poulot 2008, 24-28). The birth of Visitor Studies – a discipline focussing on why visitors go to the museum and how they behave in the gallery (Gregory and Miller 2000, 210-214) – and the expansion of science centres are also part of this shift (Schiele 2014). However, according to curator Robert Bud (2017), science centres have challenged the legitimacy of object-based science museums in a time of defunding and shifting perspectives towards these institutions. In fact, at the beginning of the 1990s, the "New Museology" paradigm called museums to prove their social relevance and to redefine their very methods and objectives as institutions, shifting the theoretical reflection towards understanding that the meanings of objects and collections are not value-free but contextual (Macdonald 2011; Vergo 1989). Therefore, while science centres demonstrated their social and market value by presenting themselves as places where to showcase cutting-edge science and technology and educate the publics about it, science museums could not count on that asset, leading to a major sense of crisis among practitioners (Bennett 2005; Bud 2017).

Today, S&T museums and centres have strengthened their relationship with the publics by adapting to the new participatory and dialogic conceptions of science communication (Bandelli & Konijn 2015). Some approaches entail co-curation and conceiving these places as "sites of deliberative democracy" that embrace broader social goals than just science communication (Cameron and Deslandes 2011; Pedretti and Navas Iannini 2021). Simultaneously, PCST has investigated the many social issues surrounding science galleries – e.g., matters of access and inequality in science museums and centres, that generate different attitudes towards the institution depending on the visitors' gender, class, and race (Dawson 2014; 2019) and how such issues contribute to configuring science communication as a "white, Western paradigm" (Finlay et al. 2021). Ultimately, one of the key objectives of PCST is to understand how science communication in museums and centres works. Therefore, whether they are interpreted as "brokers of participation" (Bandelli and Konijn 2015), safe places where to engage with contentious topics (Cameron 2005), or exclusive white, middle-class venues (Dawson 2018), the centre of the reflection for science communication is the public space of the museum/centre and its relationship with visitors. This is understandable since these studies focus on unveiling the very issues of presenting science in public and have developed invaluable frameworks and concepts to do so.

Nevertheless, such focus misses at least two important points that would bring more depth and context to what emerges from the galleries.

The first point is a lack of attention to the museum beyond its public facade, both in its physical spaces and its people. A museum is a complex organisation, where galleries – its public side – are only one part of its components, communication and exhibition being only two of its many duties. Indeed, according to the current International Council of Museums definition, a museum "acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment" (ICOM 2007). Although this definition is currently under revision – due to the ongoing debate about the changing social role of museums (Brown and Mairesse 2018) – we can consider it an operative description of the actions that museums put in place. In the case of science and technology museums and centres, the situation is no different. As demonstrated by Sharon Macdonald (Macdonald 1998b; 2002) in her ethnography of the making of the *Food for Thought* gallery at the London Science Museum, the narratives encoded in an exhibition stem from complex negotiations that entail both the team involved in its making and the many constraints that the museum poses as an organisation and institution, such as sponsorship, managerial rearrangements, and practical decisions about what competences and professional figures ought to design an exhibition.

Macdonald's account is in line with what research in Museum Studies has been doing for at least thirty years, and that I will present in the next section: investigating from within the practice how museums construct knowledge and narratives about what they display. At the same time, STS have been studying the emergence and circulation of scientific knowledge and narratives in laboratories and industries, such as in the case of Laboratory Studies (Latour 1987), and in public arenas where technoscience is co-produced with society and politics and is part of an imaginary for the future (Jasanoff 2004; Jasanoff and Kim 2015), although they have not given enough attention to science museums and centres as institutions that construct imaginaries and knowledge about technoscience.

The second element that current science communication approaches miss applies primarily to object-based science and technology museums. Current studies discard aspects about heritage and artefacts, which are vital from a museological perspective because they represent the very reason why museums exist as institutions, as I will argue in the fourth section. Science communication contemplates objects, too, and many science educators and practitioners have asked how objects and their affordances – mostly interactive exhibits – invite experiences and learning (Davies and Horst 2016, 159-185). Yet, both its study and practice in the museum have not looked in depth at object-based galleries and at how presenting material objects as "texts" of a specific story generates certain narratives and understandings of the history of science and technology (Boon 2011).

3. From the Gallery to the Storeroom: The Practitioners' Point of View

Museum Studies have looked more reflexively at the role of museums as institutions and producers of knowledge, especially after movements like the "New Museology" at the end of the 1980s. The museum started to be conceptualised as a medium, with the same issues of authorship, framing, and encoding/decoding as television or newspapers (Gregory and Miller 2000, 196-219). However, as Eilean Hooper-Greenhill (2000, 12) remarks, "[i]n beginning to consider the museum as a communicator, we realise that we are just at the beginning of finding the answers", meaning that we should go beyond considering museums as institutions only devoted to communication and link the theoretical understanding of communication models to museum practice in general. For media scholar Roger Silverstone (2003), the museum-medium has three distinctive features: it holds objects and constructs precise biographies that are re-inscribed by the visitor into their personal experience; it constructs its texts according to different logics and ways of ordering and classifying both collections and exhibitions; it mediates content through time and space.

Answering the call by Ludmilla Jordanova (1989) for exploring how museums constructed the idea that objects tell a univocal story about abstract concepts (e.g. childhood), museum scholars have developed historical perspectives about museum practices related to knowledge. The seminal work by Hooper-Greenhill, *Museums and the Shaping of Knowledge* (1992), asks precisely what counts as knowledge and rationality in the museum. Following Michel Foucault's *The Order of Things*, the forms of reason and regimes of truth of the museum lie in the practices of collecting, ordering, and classifying objects. Thus, three different discourses about objects and knowledge unfold along with the three *épistèmes* – the Renaissance, the Classical Age, and Modernity – reflecting different circulations of power and different understandings of the truth (Hetherington 2013).

Drawing from Hooper-Greenhill, Macdonald (1998a) develops a historical perspective on science museums and their changing role. If, during the 16th and 17th centuries, collections were developed around ideas of observation, mathematisation, and natural order, in the 19th century, museums built their presence and collections upon the modern idea of displaying progress and the order and control of nature. Much of this demonstration of power came about with the World Fairs, which have influenced museums in many ways since the 19th century. Not only do many collections of modern science museums come from what was exhibited at these expositions; Fairs also granted public endorsement and funds to S&T museums, inserting them in their moral and political economy, due to the shared mission to disseminate science (Canadelli et al.

2019; Friedel 2019). Such mission is prioritised during the 20th century when science museums moved away from the institutional analogy with libraries and started looking for appealing narratives to make science attractive to the public (Macdonald 1998a, 11-12). These narratives of heroes, innovation, and progress create a mythology about both present and past science and technology. Representing myths and heroic figures is understood by curators both as problematic – because it serves precise interests by presenting a morally charged idea of science – and as a great source of science museums and centres survival, because the publics crave such stories (Jordanova 2014). Similarly, Gregory (2016) shows how presenting a rhetoric of progress associated with technology and innovation in science centres is problematic, especially if presented as a socially-oriented dialogue. Indeed, these tendencies reveal how science museums depend on a wide range of stakeholders, like scientists and science enthusiasts, whose opinion counts as much as that of curators.

These historical works highlight how certain discourses about knowledge, science, and technology have been intertwined with discourses about exhibitions and collections. Most of all, they bring forth the invaluable viewpoint of the curators and heritage experts working in museums. However, their effectiveness falls short when studying the present state of science museums and centres, and especially when it comes to processes and narratives within them that still have not been historicised.

This is not to say that scientific museology completely lacks sociological perspectives. Concerning science practitioners and enthusiasts, Soraya Boudia and Sébastien Soubiran (2013) explore the relationship between these interest groups and heritage in France and conclude that scientists have an ambiguous relationship to heritage and the history of science: on the one hand, heritage is a means for scientists to make themselves intelligible; on the other hand, they wish to talk more about present science and technology rather than the past. Even Macdonald's *The Politics of Display* (1998c) goes towards a more sociological approach. In line with the claims of *New Museology*, she asserts that both scientific facts and exhibitions are publicly presented as unequivocal and objective rather than as outcomes of specific processes:

> By analogy with the use of the term "black box" […] in the sociology of science […], we might suggest that exhibitions tend to be presented as "glass-cased" – that is, as objects there to be gazed upon, admired, and understood only in relation to themselves. (Macdonald 1998a, 2)

For example, in describing his experience with the controversial exhibitions *Science in American Life* and *The Crossroads: The End of World War II, The Atomic Bomb and the Origins of the Cold War*, Thomas Gieryn (1998) analyses the internal political negotiations and compromises that the directors and curators of the Smithsonian Institution, the pub-

lics, the press, and stakeholders went through, linking the debate to the broader context of the Science Wars and the question of which interest group between curators and veterans' organisations had authority over the history of the Hiroshima bombing.

STS traditions such as the Social Construction of Technology and Laboratory Studies have referred to black boxing as a common practice in science and technology. They understand the act of opening the black box as going into the private, inaccessible places where technoscience is constructed (e.g., laboratories, industries) to understand what happens from within the practices, and to grasp the tacit knowledge and assumptions that are discarded or deliberately concealed when presenting technoscience to the public (Latour 1987; MacKenzie and Wajcman 1999, 22). Instead, for Macdonald, opening the black box of exhibitions means asking questions of power, authorship, exclusion, political and economic interests in exhibitions, and the relationship between the values we attach to science and the representations we make by exhibiting it. In the black box metaphor, this is still looking at the surface of the box, i.e. the public presentation of science, technology, and their history and social value. The practices that happen inside the box besides exhibition-making – and that, even indirectly, allow galleries and public narratives to exist – remain understudied, despite their utmost importance to museum practitioners who have underlined how the private side of the museum is hardly ever an object of scholarly attention, both in museums of science (Alberti 2017) and of other disciplines (Brusius and Singh 2018, 2; Domínguez Rubio 2020, 15).

What is worth asking now is what are the practices and private places of science museums and centres that would benefit from an STS analysis beyond PCST, and what is their impact on public narratives about science and technology in the museum. Curator Sam Alberti (2017) identifies three practices besides exhibiting and engaging the public in the science museum: to collect, to store, and to study. Criteria of collecting vary and are not always logical or scientific; they do not always respond to the mission of illuminating a particular historical period or aspect of science and technology. For instance, scientific instruments have been collected with many different scopes in mind; some are kept for aesthetics and spectacle, others are performatively collected as expressions of power or pride (Alberti 2019). Collections are ultimately made by individuals who may have personal motivations to collect certain items, while institutional reasons may involve national identity and public good (DeVorkin 2006). These values and motivations impact how an object will be classified and catalogued in the museum or presented to the public. Strong emphasis is also put on contemporary collecting and how it makes collections dynamic, more relatable to contemporary science and technology, and open to participatory approaches, while also posing practical issues (Alberti et al. 2018; Boyle et al. 2017, vi-ix): How to collect enormous research equip-

ment such as colliders or immaterial objects such as software? How to make the uncertainty of science-in-the-making intelligible through artefacts? What stories will come out?

The acts of collecting and studying objects are united by the venue where they happen: storerooms. Although such places have become a metaphor for the confiscation of artefacts from the public domain (Poulot 2008, 24-28), they deserve an STS study for two reasons. First, museum practitioners view storerooms in quite the opposite way, as places for conservation and research. Secondly, they are the place where many objects spend their whole museum life, another aspect that practically impacts and reflects the narratives circulating in the museum. Storerooms hold objects that are not displayed for many reasons: they could be too fragile, too big, too small, morally sensitive, controversial, collected randomly, or unknown. People who have access to these spaces develop unique relationships with objects. Object-love, the affection and emotions that keepers attach to objects, shape storerooms as affective places and influences the work ethically and practically in conservation (Geoghegan and Hess 2015). Storerooms are also liminal spaces for scholars and museum practitioners who are granted access (Brusius and Singh 2018, 1-33), and the same scholars and curators who access storage are the ones who construct narratives about science and technology for displays and dissemination. Many questions arise: how is meaning maintained in storerooms? Who and what concurs to the production of meaning? How does object-love or other emotions affect the stories taken out of stores and into the gallery? Answers to these questions lie in the practices happening in storerooms, from everyday curation and conservation to allowing donors into the storage and establishing a relationship with them centred on the object they are donating and what the museum will make of it.

In conclusion, museology has been able to develop critical perspectives on science museums, by being careful to represent their many layers and by inserting them and their contentious role in the context of society. As the exhibition is only the tip of the iceberg-museum, I suggest that the relationship between science, technology, and society in the museum starts way before the exhibition, which is the cementing of a specific narrative through the display. However, although the many historical perspectives on science museums have illuminated the evolution of ideas about the S&T museum, its practices, and professions, we could look more attentively at the present through an STS lens based on Laboratory Studies or, as I argue below, sociomaterial ecologies. In fact, science museums are yet another organisation where narratives and knowledge about technoscience are constructed. Practices such as collection, donation, study, and conservation, happening in collection sites, storerooms, and research areas, are well known by practitioners in the intimacy of their institutions, and they ultimately impact the stories that are told through the collections and the very image of technoscience kept in science muse-

ums. Relevant questions for STS would be: how do narratives form in the study, conservation, and curation of a collection of objects? How do object classifications contribute to creating a specific narrative of science and technology? Engaging with such questions would show S&T museums in their process of producing results and stories about science and technology. As I will argue in the discussion, STS have their traditions of understanding ecologies of practices, people, and objects, especially in organisations, which would give unity to the understanding of the museum-institution, where all the practices are intertwined together, whether they refer to exhibition-making or curation and research.

4. The Role of Objects in Science Museums

As Sandra Dudley puts it, "Museums are about things" (2012a, 1), meaning that the very reason why museums are distinct institutions from libraries and archives is that they hold, preserve, and exhibit collections of objects. Thus, including objects and materiality in an STS study of science museums is necessary because they are the centre of museological practices. Indeed, one could argue that STS have developed invaluable theoretical lenses to integrate materiality and ask why we need to integrate Museums Studies approaches with already consolidated material theories in STS. Museum Studies attend to a particular kind of materiality: material culture. And as I argue in this section, being sensitive to this concept allows us to look at materiality from within the practice.

Material Culture Studies permeate museology, increasingly demystifying the misconception that objects in the museum are dead. For practitioners and scholars, objects have value beyond the stories they can bring due to their physical and sensible properties, which are fundamental to their nature and the possibility of engaging with them (Dudley 2010, 1-17). Reviewing the dense debate around materiality in this field goes out of the scope of this paper. Yet, it is worth noting that "material culture" does not refer to a univocal definition or approach. Prown (1996) describes two kinds of practitioners approaching it: one, the "farmer", is more interested in material and tangible aspects of the artefact – e.g., its shape, colour, size, material, chemical composition, structure – while the other one, the "cowman", is more interested in the social and cultural context that can be derived from the artefact and its material form. The two approaches, either emphasising more the *material* or the *culture* of an artefact, span across the whole literature (Dudley 2012a, 5; 2012b, 4), and they also pertain to science museums.

Out of the many approaches to material culture, science museum practitioners generally refer to the biographical approach to objects discussed by Sam Alberti in his seminal paper *Objects and the Museum* (2005). Drawing from *The Cultural Biography of Things* by Igor Kopytoff,

he argues that science artefacts should be studied as sources of their two lives: the one in their context of use and the one in the museum, which is no less important. Through the movements of artefacts from their context to the acquisition, from the storeroom to the display and across collections and classifications, we can follow both the object in its changing meaning and status and the museum in its transformations. Artefacts become the standpoint from which to study the museum, the people, and the relationships between them:

> In doing so, we study a series of relationships surrounding objects, first on the way to the museum and then as part of the collection. These are relationships between people and people, between objects and objects, and between objects and people. We encounter not only collectors, curators, and scientists but also visitors and audiences. (Alberti 2005, 561)

The biographical discourse is familiar to STS. In parallel to Alberti, objects' biographies have been used by Lorraine Daston (2000) to talk about scientific objects, not just as material entities but broadly speaking as what scientists invent and discover. Daston's and Alberti's claims resonate with material semiotics. Materiality is relational; it cannot be separated from the enactment of relations, which is done through the practices. In other words, through the practices, the performance of the material goes hand in hand with the performance of relations (Law 2009). Alberti refers to Actor-Network Theory when talking about the agency of museum objects and claiming that biographies do not animate things but allow to study the meanings and values attributed to them, in line with the theory (Volonté 2017).

So, if we want to study S&T museum practices and materiality, objects' biographies allow us to do so from a museological perspective akin to material semiotics. By looking into the biographies of museum objects, we can explore the reality enacted in the relations between objects and people. Thus, studying the biographies of objects in their museological life allows us to enter the materiality of everyday practices in science museums and, ultimately, the construction of narratives and knowledge through objects.

When we look at the museum practices, we see that they are highly affected by the materiality of an object, which offers peculiar affordances that shape museum work. Science museums collect objects that enormously vary in terms of shape, dimension, fragility and conservation, materials, and texture. If one must exhibit a space aircraft, collect a telecommunication infrastructure, or preserve a personal computer composed of different plastics and circuitry, every object will impose distinct possibilities, bans, and conditions. Studying these practices biographically is what best allows us to make sense of material culture in science museums because it puts the objects at the centre of the study as much as they

are central to the communities of practice of the museum. As I will argue in the next section, this allows us to define museum practices as particular sociomaterial practices.

5. Museums as Sociomaterial Ecologies?

In the previous paragraphs, I argued how current approaches in PCST and STS only look at museums' public side due to their necessity to study how science is performed in public. I claimed that S&T museums are a fascinating object of study for STS because they are complex organisations, like laboratories, where narratives about science and technology are enacted. Thus, an STS question that is worth asking is what kind of shape technoscience takes in the narratives and knowledge produced in the museum, not only in exhibitions but in all the hidden practices of the museum.

I showed how Museum Studies have produced historical reflections from the practitioners' perspective about the context and role of science museums in relation to knowledge and practices such as collecting, storing, and studying objects. These practices are interesting to investigate from an STS point of view because they allow us to see how narratives practically circulate in the museum environment. At the same time, STS cannot overlook the attention that Museum Studies pay to materiality as material culture, because materiality in the museum is not contingent on the work; it does not only lie in its infrastructures and tools. It is the object of the museum practices and what makes it an institution of its own.

What kind of STS perspective could better understand science museums in their entirety? Surely it cannot leave out either the role of S&T museums and their practices and relationship to knowledge or artefacts and materiality. My suggestion is to study S&T museums as sociomaterial ecologies. The ecological approach (Star 1995; Star and Ruhleder 1996) allows us to see the museum as a unitary organisation where the practices are intertwined and inseparable from the social and material infrastructure, which entails material and immaterial modules made of technologies, standards, know-hows, and visible and invisible labour to maintain the ecology and its equilibrium. Concretely, this means that the practices of collecting, storing, curating, and exhibiting a particular collection or artefact are entangled together and to other practices related to other objects that collectively construct narratives and knowledge about science and technology. The relationship between the private space and the gallery also offers reflections about the boundaries of the organisation and the work required to trace them, made of other practices not strictly related to collections such as exhibition design, public relations, fundraising, and science communication.

The unit of analysis of a similar study should be the objects because material culture is what makes constitutes museums as institutions. While organisation studies akin to STS see technological artefacts as what helps workers do their jobs, in museums, artefacts are not a tool but the object of practitioners' work. The practices are performed with the objects but also on the objects. For this reason, one should understand the ecology of the museum as sociomaterial (Barad 2007; Orlikowski and Scott 2008). Sociomateriality helps put artefacts at the centre of the analysis because it methodologically demands cutting the object out of the broader ecology, without discarding the latter's value (Bruni 2020), in line with the object's shadowing through its biography in the museum (Alberti 2005).

6. Conclusions: STS and Science and Technology Museums

In this Scenario, I claimed the value of considering science and technology museums as venues for STS ecological approaches and how integrating STS with Museum Studies helps to be sensitive to issues regarding material culture and knowledge in the museum and the practitioners' point of view, shifting artefacts and their biographies at the centre of the analysis to investigate how the hidden practices in the museum's "black box" participate in the construction of narratives about science and technology.

The current general shift in Museum Studies and practice towards reflexivity profoundly resonates with the STS call to understand science, technology, knowledge, and expertise as situated in a cultural, social, and political environment. They are organisations that produce narratives and imaginaries about science and technology. Moreover, the exchange between the fields would be bilateral. Science museums are not interesting organisations to study per se. An STS ecological perspective on S&T museums would benefit museum practitioners by offering an external contribution to museum work that could foster a reflexive understanding of the museum in relation to the broader environment of science communication and the relationship between science, technology, and society.

Acknowledgements

Notes

[1] The PCST literature that I review represents the mainstream anglophone tradition of studies in Science Communication in Europe and North America. As far as Museum Studies are concerned, I refer to the British and American mainstream traditions of the last forty years in Museology and Material Culture Studies.

[2] Unless otherwise stated, when writing "science and technology museum", "science museum", or "S&T museum", I will refer to object-based science and technology museums, which differ from science centres because they keep collections of historical artefacts (Friedel, 2019; Friedman, 2010). When writing only "museum", I will refer to all museums in general, regardless of their disciplinary orientation.

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TECNOSCIENZA
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Massimo Airoldi
Machine Habitus: Toward a Sociology of Algorithms, Cambridge, Polity Press, 2022, pp. 192

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A lot has been written about algorithms over the past decade. The idea of algorithms as neutral and value-free is being challenged even at a mainstream level, as works like Safiya Noble's *Algorithms of Oppression* (2018) and Shoshana Zuboff's *Surveillance capitalism* (2019) became talking points in places like the White House. At the same time, productions like *The Social Dilemma* (a docudrama released by Netflix in 2020) reached millions of viewers around the world. So why another book on algorithms when critical approaches to digital technology, its potential negative social impact, and the business models of tech companies have flooded academic classrooms, conference hallways, and even pub night conversations? For Airoldi, it all comes down to the (lack of) understanding of both what machine learning systems and what things like social structures are. If all we have left is reproducing approaches to algorithms that keep splitting the world between the order "we" humans inhabit on one side and the technical order on the other, then there is, in fact, not much one could add to the mainstream critique of algorithms or to avoid the fight between *apocalittici* and *integrati*.

That is where Airoldi's *Machine Habitus: toward a sociology of algorithms* comes in handy. In Chapter 1 ("Why not a Sociology of Algorithms?"), Airoldi fully embraces a sociotechnical view of reality, aiming to comprehend "how culture enters the code of algorithmic systems, and how it is shaped by algorithms in turn" (p. 4). Moving away from debates around human-machine interaction centered on concepts like consciousness and intelligence, Airoldi highlights the importance of an agentic notion of sociality to account for machine systems as social agents inhabiting a techno-social structure, something especially true for machine learning systems. But is that all? Recognizing algorithms as social agents is all that is left as a research agenda? If that is the case, then Airoldi came too late to the party as critical algorithm studies contributions have for more than a decade now recognized algorithms as fully integrated within sociotechnical assemblages (e.g., Gillespie 2014). However, there is much more to the book than that. For Airoldi, it is not enough for STS scholars to address human-machine interactions in terms of "sampling bias," "collection methods," or subjective limitations on the part of the agents involved in the technological process (Symons and Alvarado 2016, 5). Sociological and political inquiries of machine systems should also not have to choose between focusing on some sort of soft "technological determinism" on one side and the resistance capabilities of agentic subjects, changing technology from

below, on the other. To understand machines as social agents, we need to consider how machines are socialized and how socialized machines participate in society. For that, Airoldi extends Bourdieu's concept of "habitus" to the study of algorithms and machine learning systems.

In Bourdieu's words, habitus are "systems of durable, transposable dispositions, *structured structures predisposed to function as structuring structures*" (Bourdieu 1977, 72, emphasis added). For Airoldi, the main insight from Bourdieu's theory of habitus is that it allows us to talk about agents and their actions not as a result of deterministic impulses from the "outside" or self-determined. Agents act within habitus in the sense that their actions are structured structures, that is, the result of embodied dispositions from one's environment and social setting, whilst being structuring structures, in the sense of ordering and changing the very social structure they inhabit. Airoldi uses the concept to complicate (in a good way) sociological studies of machine systems. For him, habitus is not just an attribute of humans as we can look at machines through the lenses of habitus. After all, he says, "the code is in the social world, but the social world is in the code" (p. 28). Cultural propensities and social structures are encoded in machine learning systems that, at the same time, shape what these social structures look like. Our techno-social environment is neither the effect of algorithmic oppression nor human achievements (or failures) but a result of the interactions between human habitus and machine habitus.

Airoldi devotes Chapter 2 and 3 to understand the dynamics of the culture in the code and the code in the culture, respectively. The most common answer in critical data studies and STS for the question "where does the culture in the code come from?" (p. 36) would probably be through the cultural biases that come to the machine through design or from the code's creators. An overwhelming amount of works over the past few years have focused on how to solve the problem of cultural biases in the design of technology and create a more inclusive and equal digital environment. That includes scrutinizing the definitions of what the algorithms are supposed to evaluate (e.g., "relevant," "high risk," "meaningful") and also databases, statistical postulates, and methods employed by companies or public agents for algorithms to function. However, for Airoldi, a sociology of algorithms cannot just be a sociology of algorithm creators (or of *deus in machina*), especially with the rise of unsupervised machine learning systems. The role of trainers, for instance, those who advertently or inadvertently "prepare" the data for machine learning systems, has been overlooked. There is more to the sociotechnical analysis of algorithms than looking at companies, economic models, or designers. Following Bourdieu's habitus, Airoldi invites us to look at the specific cultural contexts which give rise to machine habitus, starting with the local and global data contexts for and through which machines operate and make sense of the

world. Like with humans, machines' predispositions and affordances, inherited by design, would interact with the cultural structures through time, producing specific forms of socialization and internalizing culture in different ways. Those specificities would add more complexity to the study of algorithms in fields like STS, for example.

On the other hand, the very cultural structures in which machines are socialized are also shaped by the code. This symbiosis is never symmetric as the interactions always occur between different habitus and cultural propensities. Humans never respond to machinic input with the expected output and vice-versa. In his words, "interaction orders of humans and machines blend within the layered techno-social order of the Internet" (p. 89). Tracing causal relations between algorithms and social world changes will only produce technocratic and fatalist accounts.

Airoldi highlights that interactions between users and machines always occur in peculiar environments (platforms and their business models), which in their turn are always shaped by cultural and economic fields. Both users and machines learn from each other, as even the famous feedback systems, so commonly mentioned in relation to filter bubbles, work both ways. Finally, interactions between users and machines are always crossed by what he terms "informational asymmetry", the fact that the knowledge the user has of the machine functioning is not always the same a machine has of the user, and "cultural alignment," or whether the propensities of socialized machines "match" with the ones of the users (or whether there is a clash between habitus[es]). He proposes a typology of four types of user-machine interactions (which entails reinforcement, co-production, transformation, and disillusionment), a useful theoretical contribution for STS scholars to address the code's relations and influence on culture vice-versa.

In the final two chapters, "Theory of Machine Habitus" (Chapter 4) and "Techno-social reproduction" (Chapter 5), Airoldi seeks to answer the following questions: "what is the extent of machine habitus in comparison to the original "habitus" theorized by Bourdieu? How do different propensities "embodied as habitus and encoded as machine habitus" (p. 110) mediate human life in techno-social fields? What are the effects of the entangled relations between humans and socialized machines over time and what are the global (overall) effects of such relations? For the first one, to understand the differences between machine habitus and the original habitus, it is important to account for the limitations given to machine habitus by its digital infrastructure, namely platforms. As recent STS scholarship has demonstrated (e.g., Helmond 2015), platforms offer particular affordances to machine learning systems, from a variety of levels, including political-economical, that "modulate possibilities of action" (p. 117). Airoldi brings a concept very dear to STS for the second and fourth ques-

tions: that of *entanglement*s. He warns scholars that there is never an inter-action between autonomous me and an autonomous machine, but a relation between a set of cultural propensities mediated by an active environment (platform) and different habitus (what he mentioned when referring to cultural alignment). "There is nothing personal in automated music recommendation," for instance, as "things like taste and behaviour are a product of shared social conditions" (p. 121). How the author relates the idea of entanglements and its ontological indistinguishability perspective with other terms he uses, like sociotechnical order or sociotechnical evolution, is nowhere to be found in the book, perhaps a shortcoming not only of the book but of certain STS approaches lacking theoretical rigor when using terms interchangeably.

For the third question, he highlights the importance of another concept dear to STS scholars: boundaries. For him, at least four processes of boundaries happen in techno-social fields over time: boundary differentiation (reinforcing the local culture of social subjects – e.g., filter bubbles), boundary fragmentation (nudging users towards certain behaviors or directions they are not familiar with), boundary mobilization (reinforcing the global scale, collective culture of social subjects – e.g., Google's autocomplete algorithm), and boundary reconfiguration (transforming practices of users with a top-down approach – e.g., algorithmic ranking on Instagram).

The inclusion of these typologies and concepts showcases Airoldi's main objective with the book: to amplify the scope of sociological analysis of machine systems beyond calls to "fix" biases. These strategies aim to "provide researchers interested in the social world with ways to include artificial agents in their analyses, and researchers studying artificial agents with ways to consider them as part of the social world" by means of "investigating machine learning systems as social agents culturally entangled with humans in the context of platformized fields" (p. 149).

All in all, Airoldi provides a powerful reimagination of the study of machine learning systems. Fields like STS and Critical Data Studies have been looking at particular instances of human-machine interaction, such as ethnographies of machine design or even of algorithms *per se* (e.g., Delfanti 2021), studies of user reception and interaction with algorithms, and platform studies investigating the political economy of digital platforms. Airoldi adds to these specific research strategies a solid theoretical background that brings together the most fundamental concerns at play in human-machine interaction. While not disregarding the contribution of critical approaches to algorithms that focus on issues of bias and "incorrect" databases, he offers researchers a chance to investigate such issues "in light of the socio-cultural data contexts behind its formation" (p. 156). However, I wonder how further researchers should take the concept of habitus to address those fundamental concerns. Airoldi himself recognizes limitations in Bourdieu's original concept, even though he avoids spending too

much time addressing criticisms of Bourdieu's formulation, especially how habitus in Bourdieu appears as some sort of a "print" with little possibility of change over time. While machine habitus is a fascinating and useful insight, studying techno-social reproductions and machine socialization can move through different paths as the ones formulated by Bourdieu decades ago.

   This book should be of interest to any STS scholar investigating human-machine interactions, in particular to early-career scholars and STS graduate students who want to not only study the impact of machine learning systems on society but also empirically understand the ways in which machines become part of society in the first place and in which users, designers, policymakers, and machines are entangled in techno-social structures.

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Antonio A. Casilli

Schiavi del Clic. Perché Lavoriamo Tutti per il Nuovo Capitalismo? [Slaves of the Click. Why Do We All Work for the New Capitalism?], Milano, Feltrinelli, 2020, pp. 320 [Italian translation of *En Attendant les Robots: Enquête sur le Travail du Clic*, Paris, Seuil, 2019, pp. 400]

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With the purpose to impress the Empress Maria Theresa of Austria, so the story goes, in 1770 the Hungarian inventor Wolfgang von Kempelen built a chess automaton known as "Mechanical Turk". This device was capable of playing chess against a human opponent and it won most of the games played in demonstrations across Europe and the Americas over the course of nearly nine decades. But the Mechanical Turk was an illusion: a chess master was operating the machine by hiding inside of it.

In 2005, Amazon.com marketed its micropayment-based crowdsourcing platform under the same name. According to Ayhan Aytes (2012), Amazon's initial motivation for building its own "Mechanical Turk" arose from the fact that its Artificial Intelligence (AI) programs could not identify duplicate product pages on its site. Following a series of futile and costly attempts, project engineers turned to people to work on computers within an optimized web system. The "Amazon Mechanical Turk" digital laboratory emulates AI systems by checking, evaluating, and correcting machine learning processes thanks to a remote, dispersed, and underpaid workforce of *clickworkers*. They are subjects employed in micro-tasks that can range from translating a three-line text, recognizing and deleting from the internet prohibited contents, composing a playlist, verifying the identity of users of a platform on a sample basis, training an artificial intelligence to distinguish pedestrian crossings from zebras, and so on. Precisely all the activities we now tend to take for granted are automated, as they are made more and more opaque by the pervasiveness of digital platforms, social media, and futuristic rhetoric on digital innovation and AI. This type of invisible and hidden work, outsourced and collectivized, hidden behind interfaces and camouflaged within algorithmic processes is now commonplace, and sometimes entirely unpaid. The case of Google's reCAPTCHA is emblematic: to prove that we are not a robot, we have to train Google's AI image recognition system for free, by checking the boxes containing buses, cars, or mountains.

Far from being at the gates of an era in which robots will "steal" jobs from humans, Antonio Casilli's book aims at opening the black box of digital platforms by showing how contemporary forms of AI are not that much "artificial" after all. Consider for example the hard physical work of the miners and the repetitive work in the factory on the assembly line needed

to produce a smartphone or a tablet; cyber work in distribution centers and cognitive factories exploiting outsourced programmers around the world; the low-cost crowdsourcing work of the workers of the Mechanical Turk, or the intangible unpaid work of various social media and/or platforms users.

Casilli assembles different references and materials: mainly texts and researches from the broad spectrum of social sciences (and therefore not strictly Science and Technology Studies), but also newspaper articles, and reports published on the internet by companies (Google, Amazon, Facebook) or government agencies, as well as video documentaries. In this regard, I highly recommend watching *The moderators* (https://fieldofvision.org/the-moderators), a documentary that in twenty minutes shows in an extremely effective way the training, the job practices, and the working conditions of between fifty and one hundred million workers worldwide, mostly concentrated in India, in Southeast Asia, in Sub-Saharan Africa but also in Brazil, Venezuela, or in Romania. Countries where workers' rights and trade unions are easily ignored, where informal work represents a normal and direct option for a vast portion of the population, and where "micro-benefits can serve as a gateway to the labor market for a great variety of people with different levels of education, language skills and work culture" (p. 105, my translation).

Digital platforms and automation processes, the author argues, are in fact to be read in continuity with the macro phenomena that have characterized the last thirty years: dissemination of information and communication technologies; financialization of economy; globalization of markets, transport and goods; international financial crisis. Casilli shows how each of these phenomena played an "enabling" role in the establishment of platform capitalism, on a par with different forms of "invisible work" or "shadow work" that we have witnessed over the years: domestic and care work, cognitive and intangible work, as well as the work performed by users, consumers, or by an undefined "crowd" in processes of labour gamification (*playbour*) and/or in hybrid combinations of production and usage (*produsage*).

The text convincingly shows how in a scenario marked by the economics of surveillance, reputation, and emotion (as well as by the quantification and the commodification of trust and traces through cryptocurrencies), the horizon is set by the extraction of data and the reorganization of information through AI systems that combine human work with that of machines. And it is equally convincing in depicting how a handful of megacorporations – the (un)famous GAFAM – Google, Apple, Facebook, Amazon, Microsoft – increasingly dominate territories and create new infrastructures and mechanisms for the accumulation of capital and the exploitation of human and planet resources.

Alongside texts such as *The Platform Society* (van Dijck et al. 2018),

Ghost Work (Gray and Suri 2019), *Surveillance Capitalism* (Zuboff 2019), or *Atlas of AI* (Crawford 2021), the book by Antonio Casilli aims at highlighting the various forms of digital labor on which digital platforms, algorithms, machine learning and AI are based. What is then the original contribution of this book and why should it be read by STS scholars?

First, it is extremely well-written and well-supported. Antonio Casilli constantly mixes theories, concepts, numbers and "exemplary cases", calling into question the readers and stimulating them to build their own opinion, not necessarily convergent with that of the author. In this regard, it should be noted that Casilli's book is not intended to be a canonical scientific monograph, but a text capable of dialoguing with different publics, not necessarily academics or social science experts. Not surprisingly, it has been granted in 2019 by the Colbert Foundation and by the École Nationale Supérieure de Sécurité Sociale (*Grand Prix de la Protection Sociale*), and in 2021 by the Association Régionale pour l'Institut de Formation en Travail Social (*Prix de l'Écrit Social*).

Secondly, it offers an interesting taxonomy of digital labor. As the author writes in the Introduction, originally the book was intended to have quite a different title (*Théorie générale du digital labor*; in English: "A General Theory of Digital Labor"), which was reframed by the Seuil publishing house (*En attendant les robots. Enquête sur le travail du clic* – in English: "Waiting for the Robots. Investigation into the Clickwork") and further re-signified on the occasion of its Italian translation, with the appearance of the word "slave" in the title (a translation and a word about which the author himself expresses some doubts in the Introduction to the Italian edition). After a first section focused on automation processes, the second of the three sections, in which the book is divided, is dedicated to presenting what Casilli frames as three main forms of digital labor (the third section is then titled "The Horizons of Digital Labor"). The first type of digital labor is characterized by the request for a service (Uber or Deliveroo, for example). In doing so, it composes an economy of odd jobs (the so-called "gig economy") which, beyond the service provided (transport, delivery, personal assistance, etc.), produces a variety of data (on customers and their satisfaction, on the timing of the service, etc.) which in their turn, will be re-exploited by the company/platform at stake. In other words, hidden additional work runs through the service provided contractually. "Microwork" is the second type of digital labor described by the author. It is carried out by a crowd of "microtaskers" who perform what machines cannot do or what would be unprofitable to make them do. The microtasks thus performed, most often consisting of a few simple but essential "clicks", invisibly supports the proper functioning of apps and/or websites, turning clickworkers into the "human-based computation" of digital platforms and AI systems. The third type of digital labor identified in the book relates to "networking", the activity of "produsers" and the

establishment of an "economy of ties". It refers to what we all do when we participate in the production or the correction of contents and/or data via social media (Instagram, Facebook, etc.) or dedicated websites. Again, fragmented contributions (more or less complex, but sometimes very time-consuming) are mobilized to improve platforms' performance. But this time the idea of "work" seems even more evanishing, since many produsers will be satisfied with symbolic, reputational, or even simply narcissistic gratifications. We find here the old debate on the understanding of what we could designate as "free work", which takes to my third point regarding why it is worth reading this book.

Contrary to a deterministic and dichotomic view in which platform workers (and users, at large) are seen as squeezed between proclamations of independence and material conditions that expose them to low or non-existent remuneration and to externally imposed rhythms and purposes, Casilli calls for a reappropriation of work. Unveiling the opaque logic of algorithms and artificial intelligence, digital labor may act as an engine of change, enacting new collective subjects and novel forms of workers' organization. In this call we find the last pillar of the theoretical approach proposed by Casilli, which dates back to the Italian operaist and post-operaist thinking: "a galaxy of authors [such as Sergio Bologna, Silvia Federici, Maurizio Lazzarato, Christian Marazzi, Cristina Morini, Antonio Negri], who have managed to conceptualize the processes of externalization and socialization of work, but also the effects of absorption of life itself in the sphere of work" (p. 31, my translation). In my view, mingling this theoretical tradition with an STS stance represents one of the main theoretical contributions of the book, in that it allows to revise the "excessive faith in the Marxist prophecy on the general intellect, which led to underestimate the material conditions of work in the age of digital technologies" (p. 31, my translation). At the same time, it allows recalling the attention on the inherently political dimension of some concepts commonly used in STS (such as those of "black-box" or "invisible work") and on how a processual stance toward work and digital technologies – that is, a stance oriented to underline the organizational side of digital processes – can enrich the debate on digital labor.

Finally, I particularly appreciated Casilli's ability to re-frame some words while offering a sort of updated vocabulary of some of the dynamics related to digitization processes. For example: "automation" = invisible human work; "gratuity" = pricing logic and incentive architecture of social platforms; "financing" = decline of the corporate paradigm; "platformization" = virtual circulation of labor; "Clickworker" = foreigners at work; "Fragmentation" = prerequisite for automation; "Sharing economy" = work on demand.

Having opened the black box of digital platforms, Casilli concludes with an ambitious proposal, which invites us to recover the meaning and

political dimension of the term "platform", which I will certainly not reveal in this review, hoping in this way to further intrigue readers reading this book and the dynamics related to digital work.

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Kate Crawford
Atlas of AI, New Haven and London, Yale University Press, 2021, pp. 327

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Artificial intelligence (AI) is an unknown territory. It is what Renaissance cartographers would have called *terra incognita*: a Latin expression signifying unknown lands that have been barely explored. And what is more mysterious and undocumented these days than AI? The concept of AI evokes a multitude of diverse non-biological intelligences capable of learning independently, thinking in a rudimentary manner and acting without being supervised, in a variety of urban spaces and domains, ranging from cheap restaurants to the highest levels of governance (Cugurullo 2021). Somehow paradoxically AI is everywhere, and yet its geography and politics remain largely uncharted.

It is precisely in this context, rich in cartographic and epistemological challenges, that Kate Crawford's work, researcher at Microsoft Research and chair of AI and Justice at Paris École Normale Supérieure, is situated. Over years of empirical research, she has extensively explored what AI is made of, where AI is coming from, what it is impacting on and how. The results of her studies are now culminating in a fascinating book: an atlas of

artificially intelligent technologies, which is simultaneously science and art, a geographical inquiry and a political intervention.

Crawford's *Atlas of AI* is an unusual atlas, since the author adopts a prominent narrative approach and, rather than a mere collection of maps and analyses, the book offers a collection of stories. Crawford is a gifted storyteller, and her tales of AI are divided on the basis of six main themes that form the core chapters of the book: *Earth*, *Labor*, *Data*, *Classification*, *Affect* and *State*. In the first part of the book, *Earth*, the author takes us on a journey to Nevada where AI, as a material product, is made. AI is presented as an *extractive technology* whose creation requires many minerals and metals and whose life depends upon electrical energy. The line of inquiry is here very much in sync with the work of economic geologists and critical geographers who have unpacked the supply chains of the critical materials that are behind the provision of smart tech (Zhou et al. 2021). Not only is Crawford's critique sharp. Her voice speaks the language of multiple disciplines, and a key strength of this book is in the solid bridges that it creates to connect diverse fields of research which together can fully illuminate the nature of AI.

The second part of the book, *Labor*, convincingly shows the human aspects of AI, stressing that the industry of AI would not be possible without the physical and mental exertion of thousands of human beings. To explore this critical aspect, the journey continues in the US where Crawford lets us enter an Amazon's fulfilment center in New Jersey. The space is gigantic and the labor dynamics that we witness are a Marxian nightmare: those very humans who are working hard to create robotic technologies are themselves being treated like robots.

The third and fourth parts, *Data* and *Classification*, are deeply interconnected, since they deal with the production of the digital information that AIs are fed with, and how artificially intelligent entities categorize and metabolize these flows of information. Data is everything. It is everything in the sense that it is the most important resource for any company wishing to create and train an intelligent machine. Data is also everything because every piece of both the digital and physical world contains some form of information that AI companies can extract and then feed their machines with. Crawford exposes and denounces the culture of data extraction which seems to know no limit despite its many flaws in terms of privacy and ethics. Singing from the same hymnbook of critical data scholars like Kitchin (2022), she shows how data is not neutral and its metabolization inside AI tech reproduces power relations and biases. The datasets employed by AI contain human-made worldviews which often amplify social inequality under the banners of rationality and scientific objectivity.

The same leitmotif continues throughout the penultimate part of the book, *Affect*, which deals with one of the most controversial topics in AI research: emotions. Here the author, taking a stand unlike that of some

STS scholars (see Hillersdal et al. 2020), equates *affect* with *emotion* and asks the following critical question: can artificial intelligences recognize our emotions and then predict our behavior? In the AI industry, the answer to such questions would be an obvious *yes*, but Crawford does not take the mainstream discourses surrounding AI as articles of faith. Instead, she traces back and critically unpacks the roots of contemporary facial recognition systems, stressing for instance that many datasets are built upon the work of actors who are simulating emotions. Her conclusion is that what the AI is commonly learning from are thus faked emotions whose impact is however very real. AI hiring companies use these flawed systems to evaluate people's suitability for a job, and police officers rely on predictive systems to identify potential suspects. AI is becoming the lens through which society and its future are observed, but this lens is often cracked and even a tiny crack on the surface can generate a huge distortion.

In the final parts of the book, via two interconnected chapters, *State* and *Conclusion*, Crawford digs deep into questions of politics and power. These final chapters are in the tradition of Science and Technology Studies. The work of STS scholars such as Winner (1978) is employed to portray AI as an instrument of power which, far from being politically neutral, is frequently designed to punish rather than to support. This is because, as Crawford explains, most AI systems go back to military systems, which is a point that resonates with Suchman's (2020) recent studies. Their original logic was to find and eliminate threats, and now the same punitive logic is filtering down to schools, workplaces, hospitals and police stations. It is leaving the battlefield to enter our everyday life.

By reading *Atlas of AI*, the picture that emerges is that of a technology that, to paraphrase Winner (1978), has got out of control: an autonomous technology. Essentially, this has happened for two reasons. First, because while in the beginning AI technologies were instruments in the hands of the state, intentionally crafted for military purposes, they are now being increasingly privatized. States do not control AI anymore. The governance of AI is a complex mix of private and public forces and interests, which mirrors the classic neoliberal implementation of smart tech (Karvonen et al. 2019). Second, because we scarcely understand AI and its capabilities, and we will never be able to fully control what we do not fully understand.

Atlas of AI is the perfect medium to begin to understand AI. Crawford wisely avoids any form of jargon and her message comes across clear and loud. The book also contains a wide array of notes and references which the more experienced readers will find very useful to go deeper into the several themes that Crawford's atlas illustrates, but also to find new directions for future research. There are many more uncharted lands that await AI researchers, including emerging human-machine relations, thorny ethical dilemmas and questions of governance at a time when autonomous technologies are making decisions about our life (Stilgoe 2018). There is a

sense of urgency that social scientists in particular cannot help but feel. The reason is that AI is not simply *terra incognita*. It can also be *finis terrae*: the end of the world. The radicality of AI tech is such that it might cause the end of cities and societies as we know them (Cugurullo 2021). It is time to be brave, face our deepest fears and explore the unknown. We already have an excellent guide book and it is *Atlas of AI*.

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Maria Paula Diogo, Cristina Luis and M. Luisa Sousa
Ciência, Tecnologia e Medicina na Construção de Portugal, Volume 4: Inovação e Contestação [Science Technology and Medicine in the Construction of Portugal, Volume 4: Innovation and Contestation], Lisboa, Tinta-da-China, 2021, pp. 704

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Ciência, Tecnologia e Medicina na Construção de Portugal, Volume 4: Inovação e Contestação [Science Technology and Medicine in the Construction of Portugal, Volume 4: Innovation and Contestation] aims to use science, technology, and medicine as lenses to look over the 20th century of the Portuguese history and examine their role in building the 20th century of the Portuguese society.

The book broadly covers this period of time, going over the four regimes in the recent history of the country – the last decade of the Monarchy (1900-1910, with some chapters going back to the last quarter of the 19th century), the First Republic (1910-1926), the military dictatorship and the Estado Novo authoritarian regime (1928-1974) and, finally, the contemporary democracy started with 1974's Carnation Revolution and marked by the integration into the European Union (then European Economic Community) in 1986.

The book is an edited volume that brings together 25 chapters by leading scholars in History of Science and Science and Technology Studies in Portugal. It is the last book in a four-volume collection entitled *Science, Technology and Medicine in the construction of Portugal*, edited by Maria Paula Diogo and Ana Simões. These volumes are part of an effort by researchers from the CIUHCT (Centro Universitário de História das Ciências e da Tecnologia) to increase the public visibility of these disciplines and to highlight the role of science, medicine, and technology in the history of Portugal.

The chapters are independent and cover a broad diversity of topics such as the emergence of scientific disciplines in Portugal, the development of scientific and higher education institutions, the relationship between science and political regimes, the technological development of some economic sectors (for example concrete, uranium extraction), the relationship between Portuguese science and colonialism, and science communication.

The chapters are organised in chronological order and, although the division between the political regimes of this period widely influence some of the chapters, the lack of further organisation was a deliberate editorial choice as stated in the introduction. The book aims to highlight how using

science as a lens to scrutinize the 20th century can help to emphasise the continuities between different regimes. Some chapters do focus on one of these political regimes (e.g. Chapter 1, on higher education during the First Republic or Chapter 13, on the concrete industry during the Estado Novo). However, many span over several periods like Chapter 13 analysing the relationship between tropical medicine and colonialism and chapter 19's account of the history of racial anthropology: both range from the late monarchy (starting from mid 19th century), through the 1st Republic, and into the Estado Novo regime, highlighting some of the continuities between the three political regimes of the period.

Nevertheless, the chapters tend to cluster around some key themes for each period. The initial chapters, broadly covering the first quarter of the 20th century, mainly focus on the role of science in the construction and consolidation of the Republican regime (Chapters 1, 2, 3, 4) and the role of science in the Portuguese colonial project (Chapters 5, 6). The central section explores how key scientific institutions operated within the Estado Novo regime (Chapters 7, 8 ,9, 10), the role of the regime in developing key industrial sectors like concrete, plastics, or road construction (Chapters 12, 13, 14, 16, 17), and colonial science during the same regime (Chapters 18, 19). The last chapters analyse the dynamics of the "opening" of the Portuguese scientific system to the new democratic regime, both towards greater integration at the international level (Chapters 20, 24, 25) and new forms of public engagement with science and technology (Chapters 21, 22, 23).

The chapters are diverse in how they approach these topics. Some focus on particular institutions in the national context (Chapters 2, 7), while others on the development of a scientific discipline (Chapters 3, 6, 15, 19) or economic sector (Chapters 5, 12, 13, 14, 16, 17). One chapter examines the career of a prominent scientist, Egas Moniz, the only Portuguese granted a Nobel Prize in Medicine (Chapter 10) and another the history of a Portuguese science periodical, *Brotéria* (Chapter 11). A few chapters explore science policy and its impacts (Chapters 1, 9, 18, 20, 24, 25), science communication (Chapters 4, 18, 21, 22), and one focuses on the sociotechnical conflict around nuclear energy (Chapter 23). The volume also covers a diversity of disciplines but some are clearly more represented. There are several chapters on engineering or different engineering specialities. Chapter 2 explores the history of engineering education in the late 19th and early 20th centuries, Chapter 15 analyses the impact of the Marshall Plan on Portuguese engineering and some other chapters explore different engineering specialities (Chapters 12, 13, 14). Some chapters are on topics related to medicine: the influence of medicine in 20th century republican ideology (Chapters 3), the history of tropical medicine during the colonial period (Chapter 6), the research of the neurosurgeon Egas Moniz (Chapter 10) and agricultural science (Chapter 5). The remaining

discipline-focused chapters are on biology (Chapter 11), nuclear physics and engineering (Chapter 16), and anthropology (Chapter 19).

The authors come from a range of disciplinary backgrounds: social history, history of science, sociology, anthropology, geography, museology, and science communication. With such a diversity, the volume's cohesion comes not from a particular theoretical framing but mainly from its dialogue with the sources and previous Portuguese historiography in an attempt to reframe and expand the understanding of the role of science and technology in the Portuguese history. The chapters often draw from the authors' previous research and while they address topics covered beforehand, their reframing for this volume is nonetheless a valuable contribution to the scholarship on science and technology in Portugal.

It is nevertheless possible to identify some broad themes that are present throughout the book and give it a conceptual cohesion. One is, as mentioned by the editors, the role of science and technology in Portugal throughout the 20th century, pushing against the narrative that these areas were not a relevant force in shaping Portuguese society for most of this historical period. The volume contributes to highlighting, instead, how the role of science and technology changed according to the objectives of different political regimes and along with the evolution of the international context. For example, the chapters (e.g. 15, 16) on the Estado Novo period show how rather than isolationist, the regime had a pragmatist and selective approach towards scientific and technical development, which benefited from increased international involvement of the regime starting from the post-war period. Another important theme is the persistence of the semi-peripheral status of Portugal in the global science system, explored in previous work by other authors (Delicado 2014; Nunes 2001). Even though it is not a novel framing, the volume emphasises how this semi-peripheral status expressed itself in different periods of the 20th century. For example, Chapter 19, on the history of Portuguese Racial Anthropology, highlights the ambivalent relationship in the post-WWII period between Portuguese anthropology, aligned with the national colonial project, and "foreign science", that is, the foreign practice of anthropology that increasingly reflected the anti-colonial sentiment of the period. Similarly, Chapter 24 explores how the shifting patterns of mobility of Portuguese scientists flowed with changes in national science policy.

The volume follows from previous efforts of other scholars to highlight research on science and technology in 20th-century Portugal (see Nunes and Roque 2008; Saraiva and Macedo 2019). Importantly, it adds to a more nuanced understanding of the role of science, technology, and medicine in Portugal, often only perceived by its pattern of fragmentation, weak investment, lack of innovation, and dependence on political power. The book also explores how science, technology and medicine were mobilised throughout the 20th century with variable political enthusiasm to address

some of the country's challenges: from the need to educate the elites of the emerging Republican regime, to the Estado Novo's selective endorsement of technological modernisation, to the impetus to democratise science and higher education towards the end of the century.

The development of STS and History of Science in Portugal was shaped by the same historical pattern of weak political investment that affected Portuguese academia in general, exacerbated by the constraining influence of a traditionalist political regime that lasted for most of the 20th century and had a selective approach to modernization and general distrust towards the social sciences. However, the emergence of both disciplines quickly followed the political commitment to develop the national science and technology system, especially from the decade of the 2000s (see Chapter 20, 24). The improved status and increased social presence of science in Portuguese society (see also Chapters 21, 22) attracted a new generation of scholars that saw them as relevant objects of social and historical inquiry. This volume is also a valuable addition to scholarship on science and technology for gathering and highlighting some of the more prominent research from what are still fairly young, but nonetheless relevant, national STS and History of Science communities.

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Bethan Mitchell
Engaging with Actor-Network Theory as a Methodology in Medical Education Research, London and New York, Routledge, 2021, pp. 150

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Actor-Network Theory (ANT) has proven to be particularly useful for analyzing and understanding technoscientific practices in health-care settings. From the study of laboratory practices by Bruno Latour and Steve Woolgar (1979) to the multiple ontologies identified by Anne Marie Mol (2002), researchers inspired by this approach highlighted how the heterogeneity of the phenomena involved in various ways in the practical of scientific products and care practices can be understood only considering their relational and dynamic dimensions. Technoscientific objects and practices, according to ANT, are not universally given entities, endowed with unique and immutable properties. On the contrary, they need of being analyzed in the environment of use and in their socio-material networks to identify their salient characteristics. How can this perspective also be useful for studying the production of knowledge in a medical educational program? This is the question Bethan Mitchell intends to answer with the book *Engaging with Actor-Network Theory as a Methodology in Medical Education Research*.

Analyzing two empirical case studies situated in UK, the author takes the socio-materiality position of ANT by considering knowledge and learning in its development through space and time, bringing together objects, people, knowledge, institutions, and relationships. Starting from this assumption, the author aims at bringing those who are not familiar (especially in the educational field) with ANT into this approach, and at producing new scientific arguments regarding the production of knowledge in medicine. The book tries to reconcile both communities in an argumentative path structured in successive steps that gradually provide the intellectual tools to understand when applying ANT to medical education research.

The volume consists of eight chapters, with a brief introduction acting as a prelude to the book. The first two chapters are mainly aimed at those who are not familiar with ANT to illustrate its main theoretical and methodological characteristics, by briefly retracing the salient stages of its historical development. Although these chapters do not provide those familiar with ANT with new content, they are relevant for them too for understanding the book's purpose and structure. The third chapter provides the historical and theoretical coordinates to frame the UK institutional system in medical education and pharmacy studies; it deals with the specific setting in which the research was carried out: a peculiar regulatory device that

falls within what is called "improvement science". This label defines a systematic approach that identifies desirable improvements in the medical field (in terms of quality, efficiency, equity, and value), and validates their reliability and credibility so that such improvements can also be disseminated in contexts other than the medical one.

The author defines the two case studies as Student-Led Improvement Science Projects (SLISPs). These consist of two training courses, which represent an elective part of the formal curriculum in medicine and pharmacy, whose participants act as "change agents" to improve existing practices: the first case refers to medical students working on an improvement to the process of antimicrobial prescribing practice in two different wards; the second case regards an inter-disciplinary students group investigating insulin prescribing practices and how these could be improved. It is not always easy to understand the articulation of different levels the study refers to: educational, professional, organizational, and cognitive. All are filtered by the ANT reflective and socio-material perspective. Although the author makes considerable efforts to clarify the above-mentioned levels, at times the text is not so easy to follow, which may be problematic for readers not already accustomed to the multilevel complexity of ANT reporting.

The fourth chapter describes the methodology of the study and is significantly called "the research assemblage", to show how the ANT approach permeates the entire research path and is not just a heuristic means to address the empirical field. The chapter consists of two parts: in the first, the methodology is outlined by describing socio-materiality and ANT as derived from the practice and professional education (network, symmetry, and multiple worlds are the key concepts); in the second part, the research design, the data gathering, and the analysis procedures are described by using the two SLISPs cases. The next chapter focuses on exploring SLISPs in the hospital setting. In the first case (about antimicrobial prescribing as part of a wider project in quality improvement), "the antibiotic story" comes out as a network of interconnecting materials (gentamycin form, roles, ward, etc.) which requires the alignment of humans and non-humans; the second case (about improving medical reconciliation for insulin-dependent patients) shows the effects of non-human actants on the learning process intended as socio-material assemblage. In the sixth chapter, the different enactments of SLISPs become explicit, with a focus on the pedagogies of improvement science and with professional and practice learning orientation. The chapter oscillates between the discussion of ethnographic data concerning the research paths pursued by students and the inclusion of these researches within improvement science. Here, the ANT perspective helps to grasp how improvements are enacted between two main elements: the clinical staff of the ward, who need to be convinced that the SLISPs will improve practices, and the students, who require the time and the commitment to developing the improvement. This analysis also shows

that there is no single, predictable, a priori outcome of improvement science interventions. Mitchell uses the expression "multiple worlds of SLISPs" (p. 111) to emphasize how different realities coexist at different stages of students' research until an alignment is found and produces a stabilization in practice. The overlaps between different ontologies generate ambiguities and controversies that students are led to resolve by moving through material assemblage (lockers and electronic equipment) and organizational spaces (rooms and areas for group work). Exposure to the indefinite, and to the areas of possibility that this uncertainty produces, is seen as a primary source of learning for students. Learning itself, as improvement science, is not predefined, unique, and immutable in practice: Mitchell's work shows how it is "distributed through space and through assemblage of objects" (p. 115).

The last two chapters address the key points of Mitchell's investigation. The network perspective applied to educational practices shows that learning is not just a heroic, benevolent individual act, as it is usually conceived in medical education (Bleakley 2012), and makes it possible to grasp the disruptive force that accompanies the intrusiveness of improvement processes in daily practice. The assumption that learning and improvement are positive in themselves is only an ideal: in their development they can bring disruption and uncertainty to organizational routines and professional procedures, forcing their stability and legitimacy. Objects also move changes in preexisting practice. They "invite" practice through colors, shapes, dispositions, accessibility, and degree of visibility. These characteristics are partly inherent to the objects themselves and, at the same time, are the result of interactions within the network in which they are situated. The ANT perspective applied to medical education opens the "black box" of learning and reveals the ambivalences that inhabit it: expectations and impossibilities, commitments and resistances, convergences and divergences. The main merit of Bethan Mitchell's book lies in this disenchanted look at learning processes within the boundaries of improvement science. From the analysis of the practices, one understands the transformative scope inherent in these processes but, at the same time, the complex articulation they require and the challenges they can bring.

In conclusion, the answer to the question that opened this review (How can this perspective also be useful for studying the production of knowledge in a medical educational program?) is definitely positive, even though the book does somewhat suffer the same fate typical of publications that intend to reach different targets and audiences. It is difficult to maintain the right balance in the dual register of argumentation throughout the text. However, Bethan Mitchell succeeds quite well in this task, ensuring an appreciable readability and an adequate degree of scientific depth of the content, thus managing to satisfy ANT scholars looking for new stimuli

and a new scientific contribution, and those who are interested in the production of knowledge in medicine for professional or educational purposes.

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Ilenia Picardi
Labirinti di Cristallo. Strutture di Genere nell'Accademia e nella Ricerca [Crystal Labyrinths. Gender Structures in Academia and Research], Milano, FrancoAngeli, 2020, pp. 124

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The book *Labirinti di cristallo. Strutture di genere nell'accademia e nella ricerca* [*Crystal Labyrinths. Gender structures in academia and research*] by Ilenia Picardi outlines a framework aiming at unravelling gendered practices in academic and scientific institutions.

The author adopts the theoretical perspective provided by feminist studies in the field of Science and Technology Studies (STS) as a toolkit capable of discussing the complexity of the metaphorical and iconographic representations of "crystal ceiling" and the "leaky pipeline" and of observing how gendered practices construct academic paths similar to "crystal labyrinths". With the labyrinth's metaphor, Picardi shows how women *do science* by oscillating between innovative disciplinary mobility and hybridisation dynamics practices (Sciannamblo and Viteritti 2021) and the reproduction of male-dominated career models. *Crystal labyrinths* expose the rhetoric of merit as a system designed to justify the low presence of women in high positions because they are supposedly less competent than men in fields such as science, politics, and business. Indeed, Picardi's book highlights that the current systems of evaluation of competence and consequently of career progression in academic and research work are underpinned by gendered processes.

The volume is articulated in six chapters, and it is grounded on empirical evidence coming out from both quantitative and qualitative analysis techniques.

In Chapter One the statistical analysis describes the gender dynamics in recruitment processes as a consequence of the latest reform – dated 2010 – of the Italian academic system. The data provided by Picardi show the substantial precariousness of academic careers. Such precariousness becomes structural when the sex variable is introduced. The author introduces what she calls the Glass Door Index (GDI), with the aim of operationalising the gender gap that occurs in the transition from low-waged positions to permanent positions. The GDI has the potential to show how evaluation policies and reforms, which have introduced important transformations in the selection of academic staff and in career regulation, make Italian women more exposed to the risk of precariousness than their male colleagues. The reform acts as an invisible door limiting access to academic career progression, reinforcing the gender gap in those disciplinary fields – for example in scientific-technological disciplines – where the presence of women is already inherently lower due to historical and cultural factors. In Italy, the extension of the precarious status causes delays in the time needed for career stabilisation, affecting especially the recruitment of women in the 25-40 age group. There is an invisible door that limits the access to scientific careers, reinforced by evaluation systems that have a differential impact by gender, especially in an age range when women, as the author points out, may be faced with the choice between career and pregnancy.

Chapter Two focuses on the issue of gender equity in feminist literature. In feminist STS studies the issue of equity unveils gender segregation and discrimination as factors that prevent women from accessing the technoscientific education. Such studies have also questioned social, political, and cultural dynamics, whereby informal discrimination is maintained even when women enter scientific careers (Harding 1986). Picardi, introducing the issue of gender equity, observes the dynamics of scientific production as influenced by practices, values, assumptions, and power relations dominated by a model of scientist, who is generally male, white, and Western.

The concept of gender equity sets the ground for the theoretical framework outlined in Chapter Three, which underpins the analytical reading and shapes the qualitative analysis of Chapter Four. Chapter Three features the dialogue between feminist STS and the gender approach of the "practice turn" in organisation studies, launched by Silvia Gherardi (2019). Like Gherardi, Picardi turns the analysis to the gender structures and processes that disclose the role of sociomaterial practices in the production and reproduction of power asymmetries in organisations. The concept of practice allows looking at gender as a process that, running through

the academic institution and research groups, reproduces patriarchal models of recruitment and career assessment. Practice-based literature and feminist STS studies accompany the reader to look at gender in *its doing* through the enactment of *gendered practices* that perform the production of institutional and academic structures understood as *gendered organizations*.

Chapter Four provides the results of an empirical research consisting of semi-structured interviews and three focus groups involving 26 women researchers in STEM and 18 women researchers in Social Sciences and Humanities (SSH), by using a qualitative analysis carried out through the NVivo software. The collected experiences have been codified and aggregated to capture the different dimensions of the examined phenomenon. This chapter aims to provide an interpretative scheme to disentangle the gendering processes that create and reproduce gender inequities in academic and scientific institutions. Picardi identifies three levels of gendering processes, acting and producing academic and research environments dominated by patriarchal logics, which enact gendered practices. For Picardi, the gendering processes are embedded in 1) academic and research institutional structures; 2) the organisation of academic and research work; 3) academic and research culture. These processes, while encapsulating the phenomena in which gender becomes a practice, also structure the practices that reproduce gender discrimination in the institutional contexts of academic research. Gendering processes are portrayed as "crystal labyrinths" that reproduce male-dominated top positions. According to the author, there is not just one invisible obstacle at the top of women's careers, as the metaphor of the "glass ceiling" suggests, but multiple obstacles situated along their – often fragmented – career trajectories. However, the crystal labyrinth metaphor theorised by Picardi risks excluding the sociomaterial density of emancipatory practices against the homologation to male models.

In Chapter Five, the author presents an analytical exploration of the mechanisms that underpin gender practices. The mechanisms are embedded in the scientific-reputation system based on the concepts of merit and excellence: women's careers are, therefore, mainly evaluated by groups of men according to spatial and temporal mechanisms built on a patriarchal model of science. The concepts of "merit" and "excellence" reinforce, in certain ways, the biases linked to evaluation criteria, which, even if proclaimed as objective and neutral, contribute to reiterating gender discrimination. Women's careers are assessed using evaluative and quantitative criteria which, on the contrary, tend to favour linear paths and work rhythms congenial to the model of work historically and culturally free from caring roles. Women must work twice as hard to be considered at the same level as their male colleagues: a phenomenon known in literature as the double standard of excellence. The chapter ends with an interesting

discussion about the temporal dimension in the Italian academic context. The author captures how the dimension of time is plural and multidimensional. Time, entwined with politics, power, knowledge and control, imposes constraints and rhythms, generating gender asynchronies that, in turn, produce tensions between personal time and work time, especially in the 30-40 age class, in which women define intimate relationships and future projects, even those of motherhood. Tensions between private and professional life can cause a loss of planning for the future, and in some cases, as some of the stories point out, a "forgetting to choose to face the choice of motherhood" (p. 68, my translation).

The book ends (Chapter Six) with a critique of the supposed objectivity of scientific career evaluation methods. The author notes that gender discrimination in academic environments can only be investigated by acknowledging the social character of science. Analysing the constitutive and normative elements of science means observing the systematic operation of social mechanisms – male-dominated leadership and network patterns, gender asymmetries in the distribution of research funding – that sustain the processes of recruitment, reputation building, and promotion in academic careers.

In writing this review I adhered to a feminist epistemology – which underpins the entire structure of the book – by situating myself as a young post-doctoral researcher. The reading of this book is striking for its criticism of equity and temporal mechanisms of research, which are reflected in the homologation to the male scientist model and in certain "nonchoices", such as the renunciation to have children narrated by some of the women who have been interviewed. It is an intrinsically political book that shows how the rhetoric of merit translates into "replacing the *future* category with that of the *extended present*" (p. 95, my translation, original emphasis). This volume contributes to disentangling the labyrinths of gender mechanisms in order to rethink the structures of the organisation of scientific work – and the production of knowledge – claiming the right to choose and plan the future.

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