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CAN WE PLAY SCIENCE?

Philosophical Perspectives on participation in Science Research

Mestrado em História e Filosofia da Ciência

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SUMÁRIO

Podemos jogar ciência? Abordagens contemporâneas oferecem a possibilidade de participar na investigação científica. Muitas destas abordagens são feitas através duma gamificação da investigação científica usando a internet e ferramentas da Web 2.0, enquanto outras têm abordagens comunitárias que não estão dependentes do on-line. Como um trabalho de Filosofia da Ciência, este estudo preocupa-se sobre o significado de tal transformação. Isabelle Stengers é próxima à prática científica e sabe como o cientista é definido pelas suas paixões, por uma forma de se reportar ao *mundo* (Stengers 1993). No seu trabalho encontramos um ímpeto para re-inventar, re-enquadrar como as ciências se relacionam com a especialidade e a democracia. Será que estas abordagens participativas podem fazê-lo? Será que uma nova ciência está em movimento? Considerando as três ecologias de Félix Guattari, do nível mental, ao social, ao ambiental, ele considera que um valor maior se ganha abordando os diversos niveís de prática na sua singularidade (Guattari 1989). Neste estudo, um conjunto diverso de práticas participativas são investigadas, como os jogos de ciência cidadã Foldit e CosmoQuest e as redes de Do-It-Yourself biology e Nouveaux Commanditaires Sciences.

Ciência cidadã on-line lida com desafios concretos apresentados à investigação científica e coloca novas questões científicas, contando com a contribuição cognitiva de cidadãos. Há uma quantidade enorme de informação e continua a aumentar. Este “conhecimento-intensivo-em-informação” dá foco a inferências sintéticas, como o processo de fazer hipóteses, a abducção. Seguindo Charles Sanders Peirce, verificamos como o raciocínio abductivo construiu muitas perspectivas de interesse na epistemologia e filosofia da ciência. Seguindo cronologicamente o pensamento Peirciano, viajamos da fundação da retroducção nos silogismos aristotélicos até à sua aplicação numa lógica de ícones, em que as premissas se tornam em imagens. A partir da interacção com o ecrã onde a ciência é um jogo, a iconicidade dos elementos ganham relevo.

Em segundo lugar, focando no conceito de experiência, tomamos a filosofia de John Dewey. Ele não tem a solidez lógica de Peirce, mas parece mais sistemático. Na interacção entre sujeito e natureza, o conhecimento torna-se instrumental. “Coisas na experiência” específicas servem como guias, como características que são sinais, índices de algo que prevalece na experiência. O que guia as inferências é parte da experiência do sujeito e envolve uma ligação entre a consciência e a natureza, que substancia uma ligação ao “universo completo”. O naturalismo empírico de Dewey faz um contraste interessante com o pensamento diagramático Peirciano.Para Dewey, qualquer esperança

duma lógica da descoberta está perdida. Também o Pragmaticismo de Peirce não está preocupado com consequências práticas, como o Pragmatismo clássico. Em comum, sem dúvidas, está a importância dada à experiência.

Considerando o nível social, usamos a emergência de esferas públicas como enquadradas por Habermas para ter um entendimento mais fino de como ferramentas on-line como os forums contribuem para o esforço intelectual conjunto da ciência cidadã virtual. Para participar no uso público da razão, é preciso de ser capaz de o fazer. O modelo heavyweight de produção de pares têm altos valores limites à participação. Mais, o papel do *gatekeeper* é criado, que pode ser reconhecido quando se abrem as portas da prática científica em jogos on-line, tal como nos salões franceses do século XVII. Outros jogos de investigação cientifica, como *CosmoQuest* e *Zoo Universe* têm valores limite à participação mais baixos. Quem quer que se registre, consegue imediatamente uma oportunidade para 'fazer ciência', usando as suas capacidades cognitivas para com os objectos no ecrã. O que é tida em linha de conta é o voto da maioria, pois muitos jogadores recebem a mesma imagem.

Cientistas profissionais já assinam artigos científicos em publicações bem cotadas com peer-review. Assim é o caso do *Foldit*, do *Polymath* e do *Galaxy Zoo*. Interessantemente, muitos são assinados sobre um nome colectivo, que se relaciona com este enquadramento colectivo. Em tensão, existe uma dimensão agonal muito presente na gamificação da investigação científica. Há uma relevância dada ao pacto de competição, equivalente ao contrato de *Agon*. Colan Duclos dá ênfase ao elementos de tensão, stress, aleatoriedade e incerteza que fazem o jogo agonal.

Um terceiro nível em análise é o político. Seguindo o argumento de uma re-encenação da comunidade de iguais com Jacques Rancière vemos que a comunidade de iguais: (i) é parte da interacção aleatória entre o que está lá e o que força a mudança; (ii) é fundamentalmente um processo de partilha; (iii) refere-se a um evento equalitário anterior e a um texto equalitário. O texto equalitário do movimento Do-It-Yourself biology corresponde ao *Biocommons white paper*. Ali está circunscrita uma forma inclusiva de abordar os comuns, a incluir não só “bens naturais”, como água, ar, terra, mas também organismos inteiros, processos bioquímicos e outras descobertas e conceitos biológicos e bioquímicos feitos pelo Homem. Biotecologia tem, então, com o Do-It-Yourself Biology, uma nova visão política e económica baseada na igualdade.

Ainda, seguido o raciocínio de Rancière, podemos ver como este movimento tem que lidar com a desigualdade da organização social, tal como os fundados de Icaria tiveram que fazer no passado. Mas isto não significa por força que um tal empreendimento está

fadado a fracassar. O “significador equalitário” que é agora parte integrante da sua identidade pode-se desvainecer, tal como o antigo *apeiron* grego, o desejo sem-limites pode enfraquecer.

Se há perspectivas de ciência cidadã em favor do progresso e aceleração, outros querem *desacelerar,* tal como com os *Nouveaux Commanditaires Sciences* (NCS), pois a desconstrucção da investigação científica, no sentido de a fazer mais socialmente inclusiva, precisa de tempo. Inspirada pela emancipação de Freire, NCS usa a investigação científica para fazer trabalho comunitário. Acreditamos que participar na investigação científica é um acto de empoderamento.

A aventura da Emancipação Intelectual foi aquela que juntou Rancière e Jacotot no livro de 1987 *Le maître ignorant : cinq leçons sur l’émancipation intellectuelle*. A lição do poeta no âmago do método de Jacotot é feita para soltar a vontade, para ser um participante activo. As decisões que vêm da sociedade que têm decisores em tópicos que concernem à comunidade científica é um tópico em discussão nos estudos sociais da ciência. Para Funtowicz e Ravetz uma exigência que vem dum decisor seria interpretado como um caso de ciência pós-normal, no sentido de legitimar a expertise de outros actores em decisões políticas. Em oposição, Collins tem dúvidas sobre o reconhecimento de expertises locais ao mesmo nível que a investigação científica. Ele preferiria criar ambientes nos quais o foco seria reconhecer e compreender a atitude científica. Em relação à descoberta de Jacotot, a educação está em tal relação com a não-educação, tal como a *emancipação intelectual* está para o *embrutecimento.* NCS e Jacotot estão, antes de mais, focados na dimensão da emancipação, enquanto Collins, a par de muitas outras iniciativas, estão focados na pedagogia.

A ciência cidadã on-line está a crescer em número de participantes, projectos e escala. Estas soluções lidam com desafios novos concretos à investigação científica que parecem fadados a ser mais desenvolvidos. Podeser mais do que uma moda ou uma linha de fuga. Podemos estar perante uma re-territorialização destas abordagens massivas à investigação científica.

Do outro lado da moeda, os movimentos contra-progressistas também lidam com uma resingularização da investigação científica. Este jogo é possível, mas a escala e eficiência deste processo de heterogénese continua por qualificar.

ABSTRACT

Can we play science? Contemporary approaches offer the possibility of participation in science. Many of these approaches are done through a *gamification* of science research done using the internet and web2.0 tools, while others, have community-based approaches that aren't exclusive to the on-line environment. As a work of Philosophy of Science, this study is concerned about the meaning of such transformation. Isabelle Stengers is a close relative to scientific practice and knows how the scientist is defined by his or hers passions, by a way of reporting to the *world* (Stengers 1993). Inspired by the three Ecologies of Félix Guattari, we engage the diverse levels of practice in their *singularity* (Guattari 1989). In this study, a diverse set of participative practices are researched in connection to relevant philosophical perspectives.

“Data-intensive knowledge” brings forward the synthetic inferences, as the process of making hypothesis, abduction. From the interaction with the screen, the iconicity of the elements come forward. Following Charles Peirce, we travel from the foundation of retroduction in the Aristotelian syllogisms to the application of abduction in a logic of icons, in that the premisses become images. Focusing on the concept of experience we take John Dewey's philosophy. The experience to the subject involves a connection to the “complete universe”. Dewey's *empirical naturalism*, gives an interesting contrast to Peirce's *diagrammatic reasoning*. Considering a social level, we use the emergence of Habermasian public spheres. To participate to a public use of reason, one needs to be able to do it. Moreover, the role of the *gatekeeper* is crafted, that can be recognized when opening the gates of scientific practice in on-line citizen science games. In tension, there's an *agonal* dimension very much present in the *gamifications* of science research. On a political level we follow Jacques Rancière, and see how Do-It-Yourself biology statement of equality will have to deal with the inequality of social organization. Just as the “egalitarian signifier” that is part of its identity might fade away, as the old greek *apeiron*, the unbound desire might get dimmer. If there are perspectives of citizen science as in favor of progress and acceleration, others want to *decelerate,* as with *Nouveaux Commanditaires Sciences* (NCS). On the work of Rancière we see that education is in such relation to un-education, as *intellectual emancipation* is to *stultification,* giving an insight into a dispute at Social Studies of Science.

On-line citizen science might signify a *reterritorialization* of this massive approaches to science research. On the other side of the coin, the counter movements of progress also deal with a *resingularisation* of science research. This play seems feasible, but the scale and efficiency of this *heterogenesis* process remains unaccounted.

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ABBREVIATIONS

CP x.y = Collected Papers of Charles Sanders Peirce, volume x, paragraph y.

EN = Dewey 1925

KEYWORDS

Citizen Science

Abduction

Experience

Public Sphere

Intellectual Emancipation

Chapter I

INTRODUCTION

Can we play science? Really? As a student of Philosophy of science, I'm concerned about the meaning of participation into science research. Isabelle Stengers, philosopher, wrote in 1993 the book *L'Invention des Sciences Modernes* (Stengers 1993). She is a close relative to scientific practice and knows how the scientist is defined by his or hers passions, by a way of reporting to the *world*. In her book I found an impetus to re-invent, to re-frame how sciences are related to expertise and democracy. Could it be that these participative approaches to science research could do that? Could a *new* science be set in motion?

In the foreground of this last question is the work of Felix Guattari, the known collaborator of Gilles Deleuze. The hopeful call of Stengers for resingularization of science research is inspired in her reading of Guattari. Considering his three Ecologies, from the mental, social to the environmental, he considers that a greater value is found by engaging the diverse levels of practice in their singularity. Such process of re-definition is made through these interchangeable glasses, he says (Guattari 1989). Is Citizen Science made by some loose, transient practices or is there really new *territories* of science research on the making?

On the on-set of my exploration of these on-line games of science research I found promptly a platform that was opening to participation the folding of proteins. I registered into it and, soon after, I was puzzled. The character of the communication was different from what I experienced before. The biochemistry I learned at school was taught by books, much studying, laboratory work and doing exams. After school, I worked in Science communication in a Science Museum. I was doing activities to communicate scientific knowledge and engage people in scientific culture. The communication that I have with my peers is about science but again different.

As Olga Pombo, philosopher of science, expressed, these can be understood as three different levels of communicative processes of science: The science taught at schools is intergenerational, representing a vertical process. The horizontal communication is the one among peers. And the communication between science and society is transversal

through several actors, as Science Museums, research institutions communication offices and the diverse media channels (Pombo 2011, p. 137).

The participative call for participation in science seemed to mix those channels of communication. Focusing on that line of identity of transversal communication, this shift, of having citizens participating in 'real science' what did that meant for the citizen? Many of these on-line citizen science games show scientific knowledge in a very different way than what I learned at school. The concepts become operative, reasoning becomes diagrammatic. I found it closer to the way reasoning presents itself. This search took me to the work of Charles Sanders Peirce, American philosopher of the beginning of the twentieth century. In the first chapter of this work I explore how Abduction, the process of making hypothesis, evolved through the work of Peirce. What relevance does Peircean abduction has for the epistemology and heuristics of science research?

Another concept that gained attention is the one of experience. A main focus on all the participative approaches to research. I chose to approach experience with the lenses of John Dewey. Dewey came to implement pedagogical programs that inspired many of the 'hands-on' approaches to science communication and citizen science practices. As a philosopher, the concept of experience is deep-seated in his well-organized thought. Moreover, Dewey was contemporaneous of Peirce and both are commonly associated with the classical American Pragmatism, in spite of Peirce gaining some distance from the philosophy of Dewey and William James, another well-known Pragmatist. Peirce came to state his own philosophy as Pragmaticism, exactly to gain that distance from the 'common' Pragmatism. What distinguishes the perspectives? How do they deal differently with experience and reality?

In my research I started following a set of on-line games of science, but developed more deepness, participating and communicating about two of those: the protein game *Foldit* (explored on chapter two) and the smaller platform for mapping other Planets and the Earth's Moon (explored on chapter four). With this latter one, *CosmoQuest*, I was mapping the Moon on my laptop, but also following the forums. I wasn't such an active player, but I was curious about the communication taking place among this community. Playing science research generates also other levels of communication on the scientific

endeavour. The gates of scientific practice are open, not just for professional researchers, but to these citizen scientists. But what historical roots do have this 'opening of gates' of science research to non-professionals? And how is characterized this on-line citizen science movement? On the fourth chapter I explore these questions and have a focus on the public sphere. My starting point is the seminal work on *The structural Transformation of the Public Sphere* by Jürgen Habermas, and the social sciences studies on citizen science. The main question treated here is: Are the 'citizen scientists' involved in an idle play or are they really reasoning together?

I was striving to find some community approach in participative science. Some formal definitions of citizen science admit a collaboration between professional researchers and citizens. On-line Citizen Science and other approaches I knew about are done by a precise contribution, but could I come upon more inclusive approaches? In a meeting forged by chance, I found a small European network, the *Nouveaux Commanditaires Sciences*. It transformed me to gain understanding of the approach this platform has. With a pool of researchers, mediators and citizens there's a focus into developing local scientific research. I joined this community and mediated this perspective to a community I cared about in my vicinity. A fuller account of our praxis is focused on Annex I.

Stengers is active in the recognition of a political dimension *constitutive* to sciences. Practices as the one I'm involved with the *Nouveaux Commanditaires Sciences* is active to this political statement. Besides this movement that involves me personally, I found another participative science research movement with a clear political message. The bio-hackers, that took biotechnology out of institutional laboratories and into community laboratories. What political statements are these movements doing? What lines of identity can we find?

The critical concepts of the philosopher Jacques Rancière is of good use for a better understanding of what these initiatives deal with and what problematics we find. Rancière's works on Equality and Emancipation brought me the most meaningful insights. What philosophical roots do a statement of equality have? What does it mean to become intellectually emancipated? These were the questions that I was researching

about in Rancière's papers and books, which considerations I deal with in chapters five and six. One of those books, *Le Maître ignorant* (with the english title *The Ignorant Schoolmaster*) was very significant to my life. Personally, on my view points on what emancipation could mean. Professionally, in my intervention as a facilitator/ mediator. And in my reflection. The lesson of the master emancipator that Rancière was tracking on that book helped me to analise some pressing questions in Social Studies of science.

On the considerations about public participation in science research, the positions of Funtowicz and Ravetz are well known in the field of Social Studies of Science (Funtowicz Ravetz 2000). They advocate that the Normal Science, as defined by Thomas Kuhn was transformed by the inclusion of other stakeholders in the decision-making process. Among the diverse works on this field, I found of interest the recent position of Harry Collins. Through the book named *Are we all Scientific Experts now?* he positions the criteria for a defense of scientific expertise (Collins 2014). What contrasts do these approaches have? And what relevance Rancière's reasoning has for this issue? How are these concepts he worked on, equality and emancipation, relevant for science research?

Throughout this work I search for answers for these questions. To each chapter, an introductory narrative is used to give some proximity and deepness to what is considered and a different participatory practice is articulated with philosophical considerations. In the end of this process, my query refers back to the plea of Stengers that set me off. The articulation of these diverse perspectives bring finally some fruitful insights. What common heuristic strategies to Citizen Science are identified? How are these different platforms related to the science research challenges? And using Guattari's terminology, how can Citizen Science correspond to a *resingularization* of scientific practice?

Chapter II
TINKERING
WITH SCIENCE RESEARCH
- FOLLOWING ABDUCTION
WITH CHARLES PEIRCE -

Summary

Science research is changing. There's an increasing number of projects that, to find answers to large-scale questions, include non-professional researchers, taking use of the shared cognition. In this work, I take the heuristics and philosophy of Charles Sanders Peirce to shed some light on human reasoning. Abduction, also called retroduction of formulation of hypothesis, is the central concept on these pages, crossing Peirce's work since the end of nineteenth century to the beginning of the twentieth. Here we find what is understood as abductive reasoning and to find out how the concept was transformed and appropriated to other contexts, perceptual and cognitive. From Peirce, many other thinkers reflect upon abduction.

Protein folding – not the book, but the game!

I've never been a great fan of on-line games. But I had to try this one, *Foldit*, a protein puzzle. I studied Biochemistry in college, so I was intrigued about how could anyone just play the science research I learned at school? Easily enough I installed the program on my computer. It is one of the oldest and more iconic games of participation in science research, anyone can register and come to deal with real-life scientific problems. In this case the problems proposed by *Foldit* are to 'fold it', to fold properly the different protein 'puzzles'.

At this on-line game, the attempts that users have to solve puzzles are part of a protein modeling strategy. From the basic building blocks of proteins, a linear chain of amino-acids, the challenge is to figure out the structure of the protein, how it is arranged in space. This computer modeling is an alternative to experimental physics experiments done in laboratories. The *Foldit* science research uses crowdsourcing to work. Computer models are manipulated to find out the perfect folding that the protein can have. Solving puzzles corresponds to a guess at the final structure. And if the final structure of the protein is discovered, what then? The player would win. Depending on

the case, that information could be useful for the design of biocompounds to have a clinical or industrial application.

So, I played this game. I got to be excited from the start. New players in this platform need to do tutorials and so, I did. The basics of thermodynamics of protein folding I learned at school were translated into the user interface. From the moment I grabbed parts of the protein on the screen, I've realized that, by moving it, the score on top of the screen would change, as you can see in Figure 2.1. The score was related to the *Free Energy*, the thermodynamical *Energy* that is able to be used to do *Work*. As I manipulated the two main chains of the protein, these two helixes that appear on the picture, other element appeared on-screen. The red balls acted like a warning system. They were giving the alarm that the side chains were too close, so that the atoms that compose the amino-acid's side chains would clash. This is translatable as *van der Waals Forces* in thermodynamics.

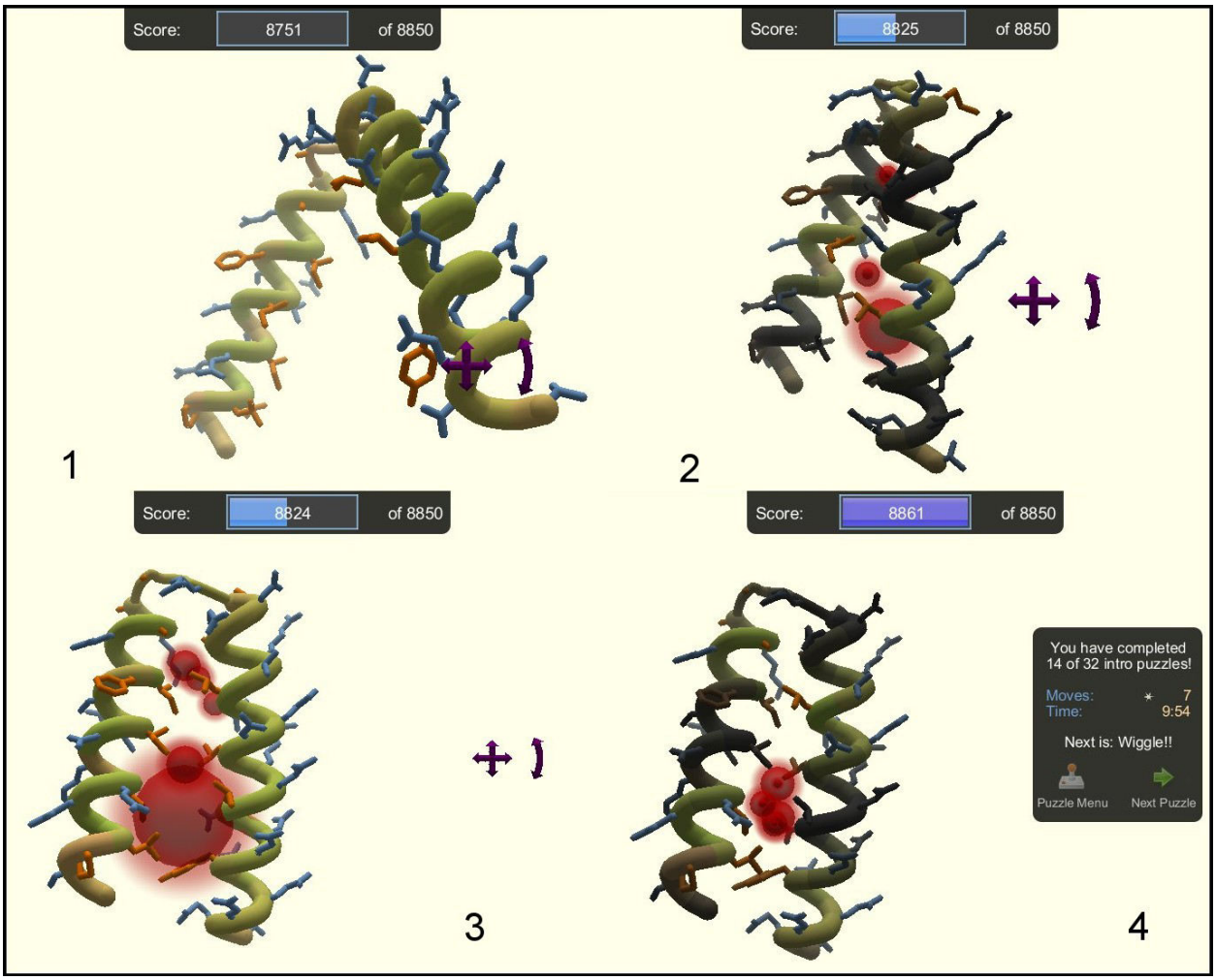

Figure 2.1 – Tinkering with FoldIt. Sequentially, from step one to four, I played my protein puzzle tutorial. The protein I had to manipulate was constituted by two alpha helixes separated by a turn. I could manipulate one helix in relation to the other and relate the variables that appeared with my performance. The upper blue bar gives indication of the score and the blue and yellow little structures that appear on the protein on-screen are side-chains of the amino-acids that compose our protein. The 'red ball' was the concept to apprehend in this phase. It was introduced into the game as a marker for the proximity between the protein side-chains (Foldit 2015).

Protein folding was gamified. I was so intrigued by the game because these thermodynamics I learned at school for the protein arrangement were there explicitly adapted and translated into visual and interactive items. The Free Energy of the System related to the score and the red balls to *van der Waals Forces*. Foldit has an

introduction, tutorials for gamers to learn the rules. As I advanced through those, other concepts were presented, always as tools to fold correctly the given protein.

People power solving scientific problems

Under the title “People power”, *Foldit's* network been described in 2010 in N*ature's News Feature* (Hand 2010). This has become one of the most notorious citizen science games, that involve others into professional science research. The described strategy, of “taking advantage of humans puzzle-solving intuitions” (Foldit 2015), has been rewarding. In 2015, Foldit has over half a million registered participants (Curtis 20215, p. 98). It appeared in 2008. Since then, as one of the founders David Baker stated at the “People Power” article: “There's this incredible amount of human computing power out there that we're starting to capitalize on” (Hand 2010, p. 685).

This path, for Baker, started in 2005. He was a biochemist at the University of Washington, in Seattle and, in that year, himself and his colleagues announced *Rosetta@home*. This was a distributed computing project, in which volunteers download a fraction of a software that runs on personal computers while those are 'unoccupied' by their users. In other words, it takes advantage of informatics deductive reasoning to find solutions. The problem taken here, for *Rosetta@home*, was already the one that concerned Baker the most, protein folding.

So, several years latter, *Foldit* was formalized through the cooperation of Baker's Department of Biochemistry and the Center of Game Science of the University of Washington. The game's architecture is one of the most complex, taking advantage of web 2.0 tools (as forums and discussion boards) and involving users in the game in a step-wise-manner.

Players of *Foldit* can play individually or in groups. The active involvement of volunteers allowed some legitimacy with the scientific community. The work done resulted in several research articles that have been published in these years, three of those with best acknowledged *Nature Publishing Group*. Players organized in groups take identities and compete even with professional researchers. In example, Foldit's groups

the *Contenders* and the *Void Crushers* celebrated their discovery of an ideal protein structure before professional AIDS researchers working on the same problem. Their work was recognized, as they became co-authors of that study (Khatib et. al. 2011).

The *agonal* dimension is fundamental for *Foldit*'s community. Players and teams compete. And what tells them apart is their strategies. Now, strategies in Foldit come together using different possibilities. When playing, gamers can use programmed sequences, the so-called recipes. These sequences of moves use a specific scripting language, that can be incorporated into the gamers strategy (Curtis 2015, p. 94). What I found surprising is that there's a big diversity in the strategies taken. More than the diverse paths taken to find a solution to a given puzzle, there's also a diversity in the mental representations taken to find one good solution (idem, p. 159).

The “capitalization” of this human reasoning set forward as a motivation for Baker, is synonym of something else for some researchers. To Michael Kerns, computer scientist at the University of Pennsylvania, in Philadelphia this is a sign that: “We're at the dawn of a new era, in which computation between humans and machines is being mixed” (Hand 2010, p. 685). Kerns connects the shared cognition between computer algorithms and human reasoning to the concept of distributed thinking.

Tim Gowers is a professor of Mathematics at Cambridge, awarded a Fields Medal, he is one of the World's leading mathematicians. Gowers enjoys writing on-line, on blogs, and in January 2009 he wrote a post with the name: “Is massive collaborative mathematics possible?”. What he proposed was to use that blog as a medium to find solutions to an unsolved mathematical problem. The resolution of the problem would be open, inviting anyone in the World to contribute, posting their idea as a comment to the blog' post.

The “quite unexpected result”, using Gowers words, was that an actual solution to the mathematical problem was found this way. The proof was published under a collective pseudonym, D. H. J. Polymath (Ball 2014). Nowadays, *Polymath* is a blog used to host Polymath projects, of massively collaborative mathematical research. With time, it developed and perfected its collaboration rules (Polymath blog 2015).

The shared cognition, either from Foldit or Polymath diverse researches, bring to light how the reasoning is put together. Is it all logic? Is it translated you algorithms? What particularities does human reasoning have?

Abduction, Induction, Hypothesis

Abduction is the process of making hypothesis. Charles Sanders Peirce was the first to describe it. Peirce's thought was organized in triads, multiples of three, in which the sense of the World presented itself to him. This way, the abduction belongs to a family of inferences, to which belongs also induction and deduction. The latter of the three, the deductive reasoning, is the one typical of syllogisms, as in the syllogism *Darii*, that can be summarized in the following form:

All S is M; Some M is P:
Therefore, S is P.

Exemplifying,
All men are mortal.
Enoch and Elijah were men.
∴ Enoch e Elijah were mortal.

Peirce dedicated much of his thought to logic and systems. Abduction, also named as retroduction or simply by hypothesis, is found throughout his texts. When he wrote about the reasoning triad in 1878 (CP2.619), he found the root of abduction – here called as hypothesis – in Aristotle syllogisms.

Enoch e Elijah weren't mortal.
All men are mortal.
∴ Enoch and Elijah weren't mortal.

This is a typical syllogism of second figure (in that the middle term in the results appears as a predicate in the premisses) and is, therefore, a deductive syllogism.

Peirce figured how this indirect logic relation can be understood as a formulation of a hypothesis or a retroduction. The same way, induction has its roots in another syllogism:

Enoch e Elijah weren't mortal.
Enoch e Elijah were men.
∴ Some men weren't mortal.

This is a typical syllogism of third figure (the middle term is a subject in the two premisses) and is, also, a deductive syllogism. But here is denoted a propper characteristic of formulation of a general conclusion from specific examples, that characterizes inductive reasoning. Enoch and Elijah weren't mortal, but we don't know other non-mortal men. Although, we infere: “Some men weren't mortal”. Induction appears as an ampliation of our observation' limits.

Abduction, here coined as hypothesis, also works beyond the observable limits. Using Peirce's words:

“Hypothesis is where we find some very curious circumstance, which would be explained by the supposition that it was a case of a certain general rule, and thereupon adopt that supposition. Or, where we find that, in certain respects two objects have a strong resemblance, and infer that they resemble one another strongly in other respects” (CP 2.624).

Therefore, both the hypothesis, or abduction, together with induction, belong to another class of inferences distinct from deduction. As the last one in analytical, the former are ampliative in their action. Another distinction built later, with the development of Logic, is that our synthetic inferences differ radically from the first-order-logic (analytic-deductive). The synthetic inferences can be defeated by new information, as I exemplify:

The synthetic reasoning is ubiquitous, is part of everyday life. As I joined the on-line game *Foldit*, I was excited about learning how to fold proteins on my screen. All players strategies have to get their protein to a more stable final position. Proteins follow thermodynamic rules finding their final structure. As I manipulated the backbone of the

protein on my screen, immediately I had an image in my mind. When I was at school I saw this diagram, that showed me that all proteins had the same thermodynamic behavior to reach a more stable position. My reasoning jumped to a conclusion, all wining game strategies should be similar. There should be one winning strategy that dealt properly with the thermodynamic constraints to reach the final stable form of the protein. This situation can be translated by a syllogism:

All wining *Foldit* game strategies fold proteins.

The thermodynamic constraints of protein folding is the same for all proteins.

∴ Wining *Foldit* game strategies is the same for all proteins.

Some time after, I was surprised. I realized that players and teams come to develop different strategies to find solutions. Other players have come to this conclusion as well, through the on-line sharing spaces of the community. That fact came to be acknowledged by an independent study, Foldit participants “follow different paths and mental representations to find one good solution” (Curtis 2015, p. 159). My previous inference was defeated by this new information. Of course, I thought, seeing my mistake. The Thermodynamics diagram I envisioned showed a probabilistic *Free Energy* behavior. This *Free Energy* is best described as the “usefulness” or process-initiating work used in that system. All proteins follow a similar path during their folding, becoming more “comfortable” in the end, with more “useful” *Work* available. But mechanistically, in how they “move”, how they might attain that attain that final position, there's many possibilities!

In contrast, the first order logic, deductive, can never be defeated by new information. Due to this character the synthetic inferences are called *non-monotonic*. Peirce, in his time, attested how these inferences were *weaker,* by comparison with the deductive reasoning. And he complemented, still in *Deduction, Induction, Hypothesis* of 1878, that hypothesis was a weaker inference than induction.

Introducing the formulation of hypothesis as an inferential logic, Charles Peirce centered this concept in his path. Peirce, himself, dedicated to geodesy and astronomy

and seemingly the connection of his philosophical thinking and experimental science was materialized by abduction, central to scientific practice. Exemplifying this connection, Peirce used in the history of science someone that, dedicated to the study of asters, embodied the concept of abductive reasoning, Johannes Kepler.

Science's best

Kepler was an astronomer mathematician. A very clumsy experimentalist that inherited in the beginning of the XVII century from the rigorous hands of Tycho Brahe a great volume of experimental data. From Rudolph's II Court, Kepler followed a sinuous personal path of construction and interpretation of all that data about the trajectory of celestial bodies. His finding represented the “greatest piece of Retroductive reasoning ever performed” (CP 1.74), Mars' Orb fitted, not to a circular path, but to an ellipse with one of the foci at the Sun.

In his book *Astronomia Nova* of 1609, Kepler also presents a self-reflection about the discovery process. Analyzing the motives that sparked the interest of Peirce in Kepler, Ana Paula Silva finds a set of reasons (Silva, 2007). Beforehand, Kepler's finding has a huge significance for the understanding of the World and for an epoch. The way he got to that result, his dynamic method, was motivated by the interest in the causes of phenomena. Peirce praised these and the moral qualities of Kepler. The “extraordinary ingenuity” (CP 2.97) and capacity to acknowledge his own mistakes composed in Kepler the masterful example of abductive reasoning Peirce was aiming at.

Was Kepler a one time event for Peirce or did he found other scientists that were a motive for appraisal? Peirce recognized, in fact, many “heroes”. On the edge of the twentieth century, Peirce wrote on the preceding century great men in Science and there abound examples of good science (Peirce 1901). That paper didn't come out of thin air. As early as 1860 Peirce reflected upon the greatness in humans and even in the fall of 1883 was teaching a course on the psychology of great men on John Hopkins University. The interest in studying the biographies of the best examples of scientific practice transpired into his 1901 paper. It is mostly meaningful for him the age he was

living. He appreciates the nineteenth century in historical continuity with the preceding time, and drafts an identity for the science of the century just finished (Houser 1993, pp. XXIII-XXIV).

In Peirce's own words: “To an earlier age knowledge was power, merely that and nothing more; to us it is life and the *summun bonum*” (Peirce 1901, p. 274). What marked the XIX century' greatest men of science was unsurprisingly the same set of qualities Peirce found in Kepler, the “emancipation from the bonds of self, of one's own prepossessions, importunately sought at the hands of that rational power before which all must ultimately bow – this is the characteristic that distinguishes all the great figures of the nineteenth-century science from those of former periods” (ibid.).

The XIX century' scientists that gave proof of great reasoning for Peirce were many, as Charles Darwin and Russel Wallace, Carl Gustav Jacobi, Louis Pasteur and many others. When writing these words, Peirce was organizing these contributions from Mathematics, to logic, physical sciences, chemistry, naturalism, astronomy, geology. Michael Faraday appears in a special position, as he “had the greatest power of drawing ideas straight out of his experiments and making his physical apparatus do his thinking, so that experimentation and inference were not two proceedings, but one” (idem, p. 272). Faraday is portrayed in unique synchronism between physical experimentation and thought. But, in general, no great men lives without his reasoning, where the synthetic inferences take a central role. So it was with Kepler and in his time, Peirce finds yet another example, the one of Dmitri Mendeleev:

“The most wonderful capacity of “catching on” to the ideas of nature when these are of a complicated kind was shown by Mendeleef in making out the periodic law of the chemical elements, as one might make out the meaning of a pantomime, from data so fragmentary, and in some cases erroneous, that the interpretation involved the correction of sundry facts, corrections since confirmed, as well as the prediction of the very particular properties of the unknown gallium, scandium and germanium, which were soon afterwards actually met with. Minute examination of all his utterances convinces one that Mendeleef's mental processes in this unparalleled induction were

largely subconscious and, as such, indicate an absorption of the man's whole being in his devotion to the reason in facts" (ibid., p. 272).

Inference for the Best Explanation

Abduction continues to take a role in contemporary Philosophy of Science. A related debate of special interest is the one where is discussed the *Inference for the Best Explanation* (IBE). The problem of finding the best explanation between the possible hypothesis is something that Peirce didn't dedicate himself to, but that is at the core of the discussion on modern science epistemology (Douven, 2011). About the discussion on the final meaning of IBE, several definitions are formulated. All of them have in common inferential rules that embrace explanatory considerations and a conclusion that makes some statement about the truth of the given hypothesis.

The 'classic' text book definition of abduction tells us that from the candidate explanations is inferred the best explanation. How? It should appeal to *theoretical virtues* – simplicity, generality and coherence with the established theories –. Charles Peirce proposed methods for abductive reasoning but here, this definition tries to separate the wheat from the chaff. These theoretical virtues have been targeted from a purely logical interpretation, in such a way that they are better objectified. The purely logical form of the initial explanations is also part of this same frame that allows the finding of the better absolute explanation.

But what is the validity of the set of candidate hypothesis? Is it possible that we have a bad harvest, in such a way that when we select the best wheat, we're just choosing "the best of a bad lot"? That's how Bas van Fraassen positioned his critic in 1989. The incongruence of reaching an absolute conclusion by comparing a set of premisses had different attempts of resolution. The hypothesis which truth is assessed aren't just the best of possible potential explanations, but they are *satisfactory*, tells us Alan Musgrave or are *good enough*, according to Peter Lipton (ibidem.). Reformulations were then built of the concept of abduction to meet the truth of IBE and the debate went on.

The inference to the best hypothesis is important, because as a process it allows to select the hypothesis closest to the truth, essential for the the scientific method to be reliable. Then again, behind van Frassen's arguments is another concept of science, that doesn't need to be faithful to reality. Afterall, “in the paradigm case in which one theory is an extension of another: clearly the extension has more ways of being false” (van Fraassen 1985, p. 280). The increase in the explanatory power, of more information, with the arrival of a broader theory implies, inevitably, that it has more ways of being false. Other popular objection of van Frassen was of abduction as a probability. Following his analysis, the probability of this inference is redundant or incoherent. Rationally, it's meaningless to follow the path of abduction.

Similarly, also induction has a problem of justification (Barberousse et al., 2001). No inductive reasoning, has the one I've done about *Foldit*'s strategy on a previous section can be logically justified in an absolute fashion. But are the mechanisms of association of ideas that compose these inferences fundamental to scientific activity? Karl R. Popper would tell us that science goes forward not for the value of these inferences, but by conjectures and refutations. But doesn't the formulation of conjectures itself include an abductive judgment? Richard N. Boyd doesn't have any doubts about it, the scientific method owes much to abduction. And assuming that the theories that compose the sciences are, at least, close to the truth, we can deduce that abduction should be a reliable law of inference (Douven, 2011).

This polemic continues and is deep-seated in the contemporary epistemology of science. Boyd justifies the value of the *Inference to the Best Explanation* with the value of theories that come from it. But isn't that a circular argument? Another thinker, Stathis Psillos says no, that Boyd's argument uses the same justification' rule, not the same premisses and is, therefore, valid (ibidem.). Either for Psillos or Boyd, it is clear that human inferences constitute a tool that allows science to be closer to the truth of reality.

The Ideal Realism

Abduction is at the core of the philosophical discussion between realism and anti-realism. Quoted above about his objections about the *Inference to the Best Explanation* (IBE), Bas van Fraassen represents an anti-realist position. Far from the Cartesian Skepticism, his theory of knowledge accepts science's constructivism, to the extent that the produced theories are empirically adequate. The belief with van Fraassen isn't in the substrate of Reality, but in the empirical fit of the produced theories (Monton, Mohler 2008).

It could be inferred that the framing of abduction is in a realist current, in that this inference is used with a proper logic of relation with reality. In the polarity of arguments around IBE its visible where it is the most suitable. However, the notion of abduction with Peirce is sinuous, due to the particular nature of his philosophy.

The work of Charles Peirce has an unique depth, with a certain wanderer quality. Peirce is one of the founders of modern Logic and the pioneer of Semiotics. The concepts inherited from his philosophy are pertinent for contemporary thought, no doubts about it. But overall, the taste for his philosophy is equivalent to liking an house that is continually rebuilt inside-out (Murphey in *The development of Peirce's* philosophy in Houser, 1992). The own Peirce's scholar community reflects this very same range of positions through different perspectives. The author's work is divided through several determinants in different phases, as his philosophy develops. Is Peirce realist? The answer must take into account his chronological evolution, such is the complexity of the identity of his writings.

In fact, Charles Sanders Peirce was a realist, he believed in the external existence of Reality. Although, if something characteristic exists in the works of Peirce is his systematization, how a concept is connected with so many others. Chronologically, in an initial phase, Peirce seems to identify himself with *Nominalism,* in which the common names don't represent nothing of the real objects, just a convenience. Still, there's traces of realism in the early Peirce, obvious in the final phase of his defense of *Pragmaticism*. Analysts as Max Fisch map in Peirce's work this process of meeting realism as beginning in 1868 (Fisch, 1986). Curiously, Peirce's metaphysical statement

with his *evolutionary cosmology* and the development of his *Semiotics* in a latter phase, claim, together with *Realism*, an *Idealism* in which the nature of thought becomes a link. In this sense, Nathan Houser finds in Charles Peirce a return to the ideals of his father with a *Ideal Realism* (Houser 1992).

"It is certain that the only hope of retroductive reasoning ever reaching the truth is that there may be some natural tendency toward an agreement between the ideas which suggest themselves to the human mind and those which are concerned in the laws of nature." (CP 1.81).

The experience has an important value for Peirce, that returns to the values of his father. It marks a rapprochement to the classical empiricism of Lord Bacon, emphasizing the richness of experimental observation. Retroductive reasoning, the process of making hypothesis, is at the front and center to Peirce's connection with reality. But how does in his method the conditions come to be that discovery is articulated with reality?

The authority

Popper in *Conjectures and Refutations* designs his method. By considering the period of *Renaissance* he draws a parallel line between the empirism of Francis Bacon and the *rationalism* of René Descartes (Popper, 1963). Epistemologically these represent two extremes: How do we have access to knowledge, through an experience of our senses or through our reason? *Novum organum* published in 1620 by Lord Bacon presents a scientific method in which the observation has a central role in the interpretation of nature. In antagonism, the 1637' *Discours de la méthode* of Descartes presents a method that starts from a first moment of *skepticism*, in that the doubt fired over the real allows to attain the discovery of truth by the work of reason. Popper shows, in his analysis, how these are closer than what was thought. After all, both represent a positivist epistemology by stating in different terms a 'manifest truth'. Peirce's method is also based in a reading of reality, as Lord Bacon's, but mediated operatively by reason, as with the before mentioned *Ideal Realism*. What Popper brings forward is how

Bacon's observation and the Cartesian reason represent a source of authority. To attain the truth, either for Bacon or Descartes, is an authoritarian process of the human senses or reason. Can we find in Peirce the manifestation of an authoritarian method in this sense?

In *The fixation of belief* of 1877, Peirce identifies two poles as guiding principles of reason: doubt and belief. To David Hume, empiricist, the habit, the repetition of factors of similarity, contiguity and causality are the basis for the construction of mechanisms to associate ideas. With Peirce, his 'new method' is also developing constructively, developing “beliefs in harmony with natural causes” (CP 5.382). The synthetic and analytical inferences are the tools of the scientific method that allow to have answers from reality. Ultimately,

“The genius of a man's logical method should be loved and reverenced as his bride, whom he has chosen from all the world. He need not contemn the others; on the contrary, he may honor them deeply, and in doing so he only honors her the more.” (CP 5.387)

Later, in 1903, Charles Peirce would give further substance to his method, the *Pragmaticism* (or *Pragmatism*), in a series of conferences in Harvard. The ‘logical method’ above referenced was, then, this *Pragmatism*, which aims to making thoughts clear. At its basis, “the question of Pragmatism is the question of Abduction”, tells us then Peirce (CP 5.197). Understanding the inferential logic coming from the Aristotelian syllogisms, it seems that the logic of abduction is gradually built from elements, the propositions and by forming hypothesis and selecting the *inference for the Best Explanation*. Here is materialized the authoritarian Ideal Realism, depending on human logic. We return here to another problem, how to prove logically our synthetic inferences? Or, in Peircean terms, how to fix our beliefs?

Symmetry of Abduction

When Charles Sanders Peirce was born, Charles Darwin was thirty years old. In 1859, the latter Charles published his *Evolution of the Species*, when the first Charles had twenty years of age. The concept of Evolution has an impact in Peirce's work. Still at the time of *The fixation of belief*, much before his metaphysical vision maturate, natural selection as an evolutive mechanism is used to justify Man's reason, as “logical animals”.

“That which determines us, from giving premisses, to draw one inference rather than another, is some habit of mind, whether it be constitutional or acquired” (CP 5.367).

Still, in 1859, in *The order of Nature*, the correlation becomes unequivocal.

“It seems incontestable, therefore, that the mind of man is strongly adapted to the comprehension of the world (…) How are we to explain this adaptation? The great utility and indispensableness of the conceptions of time, space, and force, even to the lowest intelligence, are such as to suggest that they are the results of natural selection. (CP 6.417; 6.418)

The ‘habit of the mind’, constitutional or acquired, is materialized in Peirce not just as an inference, but also as an *instinct*. Reusing as reference the Harvard Conferences, 25 years latter, we find in Peirce's seventh conference the concept of *perceptual judgment.* Aristotle was announcing it, *Nihil est in intellectu quod non prius in sensu – Nothing is in the intellect* (for Peirce meaning any representation) *that wasn't before in the senses* (here understood as *perceptual judgment*) (CP 5.181). The ‘habit of mind’ can, then, to be a perceptive judgment, as if the real object would determinate or would shape our mind. But how is this judgment framed by our senses? For Peirce,

“However man may have acquired his faculty of divining the ways of Nature, it has certainly not been by a self-controlled and critical logic. Even now he cannot give any exact reason for his best guesses. It appears to me that the clearest statement we can make of the logical situation -- the freest from all questionable admixture -- is to say that man has a certain Insight, not strong enough to be oftener right than wrong, but strong

enough not to be overwhelmingly more often wrong than right, into the Thirdnesses, the general elements, of Nature. An Insight, I call it, because it is to be referred to the same general class of operations to which Perceptive Judgments belong. This Faculty is at the same time of the general nature of Instinct, resembling the instincts of the animals in its so far surpassing the general powers of our reason and for its directing us as if we were in possession of facts that are entirely beyond the reach of our senses. It resembles instinct too in its small liability to error; for though it goes wrong oftener than right, yet the relative frequency with which it is right is on the whole the most wonderful thing in our constitution". (CP 5.174)

And how are these Perceptive judgments related to abductive reasoning?

"abductive inference shades into perceptual judgment without any sharp line of demarcation between them; ; or, in other words, our first premisses, the perceptual judgments, are to be regarded as an extreme case of abductive inferences, from which they differ in being absolutely beyond criticism." (CP 5.181)

In the spectra of abduction these two poles are defined. The abduction as an operation uses logic in the search for truth and is rational. On the other hand, we have this abduction as perception, an enlightened comprehension, as an insight, a gut-feeling closer to our senses. This definition of the concept of abduction, makes it closer to the concept of symmetry.

György Darvas, a scholar, approached the study of symmetry across cultures, as a phenomena, a concept and as a process (Darvas 2007). On his book *Symmetry*, Darvas gives a definition of Science and Art as methods for acquisition of knowledge and a classical polarity is described. Science, as working with rationality searching for truth and Art, as working with feelings looking for beauty (ibidem., p. 374). This is related by the author to a material antisymmetry of the brain as an organ, due to its unequal distribution of functions (ibid.). When approaching the full concept of abduction in the work of Peirce, we can find an holistic tendency, an all-englobing potency.

So we find in Peirce what I call *symmetry of abduction*. Abduction can come as an operation, relation or process, but as well as a perception, element or product.

To Harry Frankfurt, in his critic to Peirce, here resided the great paradox. So, if the hypothesis is the product of a human faculty of imagination, how can it result, simultaneously, of logical inferences? (Frankfurt, 1958). Aware of this difference, it's common to find a chronological division in Peirce that divides the abduction in two periods. First between the years of 1860 and 1890 a ‘syllogistic’ or ‘evidential’ phase. And in a second phase, from the 1890's, the 'methodological' approach, in which the abduction is ruling the genesis of ideas (Paavola, 2007). Can the two approaches co-exist? Normatively, as an object, Philosophy of science takes abduction as a process, as with the *Inference to the Best Explanation* or, in alternative, abduction as a perception. The analogy can also be built around another fundamental schism, the one of the *context of discovery* and of the *context of justification* (Hoyningen-Huene, 2006).

Logic of discovery

The finding of the elliptical trajectory of planets by Kepler was accompanied by a self-reflection about the process of discovery. In the study of Peirce about Mendeleev's discovery of the Periodic Table, he also found written notes. His data were fragments, and his reasoning was self-recognized as partially unconscious. The logical research from the beginning of the 20th century was marked by the logical positivism, born in Wienn, Austria. All the *psychologism*, of idiosyncratic finding, including Mendeleev's unconscious reasons, had no foundation. With this tradition, science's method has logic as its tool and deals only with aspects of justification of scientific discovery. It's in this sense that Carl Hempel and Paul Oppenheim design the *deductive-nomological model* and, after, the *method of conjectures and refutations* of Karl Popper. The other side of the coin, the one of the context of discovery, has a much more obscure history in our culture. As Imre Lakatos notes,

“There is no infallibilist logic of scientific discovery, one which would infallibly lead to results; there is a fallibilist logic of discovery, which is the logic of scientific progress. Popper, who has laid down the basis of this logic of discovery, was not interested in the metaquestion of what was the nature of this inquiry and he did not realise that this is

neither psychology nor logic; it is an independent discipline, 'heuristic'" (Lakatos 1976 in Aliseda 2004)

The eminent challenge is to integrate perspectives that have already appropriated the concept of abduction as a process, as programs of research in artificial intelligence, cognitive sciences and historical research. Atocha Aliseda followed this path as was following a *logic of discovery* in the formal study of abductive reasoning. Such a endeavour involves a dilated re-conception of 'logic' itself, as going back to a time before the formalism of Gottlob Frege. In her proposal, Aliseda presents us a Taxonomy for the abduction in a relation between three concepts:

T, C ⇒E

In this definition we have an observation (E); one element produced by abduction (C); and a background theory (T). With this taxonomy, three parameters are defined, determining the types of abduction we can have: (i) *Inferential Parameter* (⇒), establishes the logical connection, that can be a combination factors including deduction, statistics, etc; (ii) The *triggers* or types of observation (E) that are found establish if we have before us a novelty or an anomaly; (iii) The *results* (C) are the types of explanations produced that can be facts, laws or theories (Aliseda 2004).

This way, the beginnings of a logic of discovery proposed by Aliseda wants to give value how the abductive process can result from a variety of different parameters. Already the *diagrammatic reasoning*, that has its roots in Peirce's work is also constitutive of a field of study that can be defined as a *logic of icons*. Building the representation of a problem, an individual can manipulate such representation, experimenting, for then to appreciate the results. In close proximity to Aliseda's proposal, Michael Hoffmann presents six different types of abduction. These are captured by the combination of different sources for the new idea with two other Peircean concepts; the *hypostatic abduction* (to create a sign by the transformation of a predicate in an abstract name) or the *theoric transformation* (by looking to a problem by a new point of view) (Hoffmann 2007). Just like Aliseda was giving relevance, abduction comes as a central process that multiplies in different forms. For her, this situation

materializes the corpus of logics of discovery, as alternative logics, different ways of human reasoning. Historically, Aliseda draws an analogy with the emergence of non-euclidean geometries in the XIX century (Aliseda, 2004), that started-out as having a dubious legitimacy but that do have an increasing impact. Curiously, it does allow us to draw another comparison. The abductive reasoning is central to a method in a way that, just like the non-euclidean geometries, doesn't need to be faithful to reality.

Pragmaticism and the New Elements

The abduction continued as central to Peirce's work and in his last years was integrated into Pragmaticism, philosophical method and, simply, a way of life. Its application doesn't find truth or reality, "it's just a method that reveals the meaning of difficult words and of abstract thoughts" (Aliseda 2006). The application of the method is done by its maxim,

"Consider what effects that might conceivably have practical bearing you conceive the object of your conception to have. Then your conception of those effects is the whole of your conception of the object" (CP 5.18)

Pragmaticism can then be appreciated as part of the scientific method, on a first moment to check the coherence and meaning of a certain hypothesis (Pietarinen 2007). By the application of diagrammatic operations, in which it is central the abductive reasoning, the logical consequences of the concepts under discussion are verified. All the experience is, for Peirce, a thought operation, in which we apply signs in reasoning.

In 1904 in *New Elements*, Charles Peirce went deeper with his semiotics (Peirce 1904). During inference, it's considered that the relation between *interpreted sign* and *interpretant sign* works as a *dialogue*, analogous to the one between premisses and conclusion. Signs can be divided into three forms: The *Index* finds itself in a real relationship with the object, just like the weather-cock is related to the wind, and can be thought as representing a deduction; The *Symbol*, determines the interpretant sign and

represents induction; The *Icon* represents abduction. It possesses the qualified property, but still, “an *icon* can only be a fragment of a completer sign“ (Peirce 1904, p. 306).

This visual interplay came together more clearly with diagrammatic reasoning through *Existential Graphs*, part of Charles Peirce’s latest writings. Peirce’s Existential Graph, as the also called Existential System of 1897, “represents one recognized universe, real or fictive” (CP 4.421), later defined, in 1906, as a “system for diagrammatizing intellectual cognition” (Peirce 1906 in Pietarinen 2011) or as “moving picture of the action of the mind in thought” (Peirce 1905 in Pietarinen 2011). The complex architecture of representations had a clear aim: “a method of representing diagrammatically any possible set of premisses, this diagram to be such that we can observe the transformation of these premises into the conclusion by a series of steps each of the utmost simplicity” (CP 4.429). Existential Graphs can act as a key that opens the door of the interpreting mind, using Ahti-Veikko Pietarinen’s metaphor (Pietarinen 2006, p. 22). Still such a broad conception of a Logic of Signs wasn’t integrated into Logic research, being even considered for Pietarinen as anti-foundational (Pietarinen 2010, p. 44). *Semeiotics,* on the other hand, was marked with Charles Peirce’s concepts.

Charles Peirce established what Ahti-Veikko Pietarinen calls the Logic of image, mostly in his latter, 'methodological' phase of abduction (Paavola 2007). In opposition to the *iconophilia* of western culture, Peirce ends up basing his logic in the visual relationship. Peirce divided a class of icons, the *hypoicons*, in *images*, *diagrams* and *metaphors*. The *existential graphs* are the result of a logical theory of graphics, but, according to Pietarinen, is neglected a more extensive development of the logic of images and metaphors. Still, it is a valuable statement of image as constitutive of thought and reasoning as iconic (Pietarinen 2006).

Tinkering

Diagrammatic reasoning can explore other senses (Pietarinen, 2010b), but still is highly understood as visual. The user interface of the protein folding game *FoldIt*, as many others, uses these visual clues to work.

Our manipulation of parts of the protein model, transforming it, uses the reasoning processes indicated by Peirce. Our hypothesis at hand is tested by manipulation and deduction. When finding an unusual object we rehearse a usage, looking for the best fit. We build our models of understanding of the problem and try our hypothesis. We look for a solution for the puzzle and we might even just be aware of it after the solution presents itself, after manipulation or facing of the problem from a different angle. Quietly or abruptly, we are tinkering.

This tinkering process finds a similar concept in the work of Lorenzo Magnani. Dedicating himself to the study of model-based abduction, he developed the notion of manipulative abduction, a “thinking through doing” substantiated by Peirce's insights (Magnani 2004).

The “thinking through doing” speaks to the before-mentioned appraisal by Peirce of Faraday's research practice. As if Faraday was using his experimental material to do the thinking with him, giving light to the synchrony between the physical action and thought. Playing protein folding makes this play very visible. *Foldit* is one of the citizen science games with more investment in the design of the game. So it is relevant to follow its heuristic problems.

Continuing Magnani's reasoning, with thinking through doing, “some templates of action and manipulation can be selected in the set of the ones available and pre-stored, others have to be created for the first time to perform the most interesting creative cognitive accomplishments” (ibidem., p. 229). A 3D model manipulation, like the protein puzzle of *FoldIt*, gives us a good visualization of the process. But experience isn’t restricted to the manipulation of objects. Considering the collaborative possibilities of *Polymath*, we can imagine this play at work. Working through and around a mathematical challenge has this in common with manipulating a protein on a screen. But how do these templates of action and manipulation that Magnani distinguishes come to our minds while performing?

As we've seen, there's a symmetry of abduction in Peirce. The perceptual judgement is a product of the percept, from the sensorial activity, but, for Peirce, this judgement is itself an extreme case of abduction. It comes to us in different settings, maybe out of

apparently nowhere. Mendeleev was also an example set forward by Peirce, that was able to “catch-on” the ideas of Nature, coming up with the concept of a Periodic Table of Chemical Elements. This process, as we've seen before and according to Peirce's analysis, had plenty of subconscious moments. The sudden abductive suggestion is an act of insight, “although of extremely fallible insight”, he adds (CP 5.181). While tinkering, we try different possibilities, either aware of the try out, or just playing through without being aware of this process. We are prone to error in this abductive path. But it is the error that makes the learning process meaningful, through try-outs that lead us to solutions. The creation of new hypothesis associated to the cognitive accomplishments of this method serve as a base for more inductive generalizations that make sense (Magnani 2004).

Idealization/ Concretization

Abduction can, then, be conceptualized as a logical vector that, articulated as a methodological tool, can produce coherent (but not necessarily truthful) hypothesis. Xavier de Donato Rodríguez does an interesting work in this field, by opposing abduction with another process, the binary *idealization*/ *concretization* (Rodríguez, 2007; Rodríguez et Santos, 2008). The idealization comes as a derivation from the mother-concept to another situation that can approached as marginally correct or ideally truthful, in analogy to what is done when building a model. The *concretization appears*, hand-in-hand, searching for a bigger predictive power and a broader empirical applicability, increasing the explicative power to incorporate the verified anomalies.

For Rodríguez, at the core of the scientific method, we find this process of idealization/ concretization. Making a more clear idea about it, he describes this process as leading “from idealizations by constructing models to the concretizations which make our theories more accurate” (Rodríguez 2007, pp. 335-336). This method of Rodríguez has, of course, a parallel with Peircean diagrammatic operations and the abductive reasoning and integrates the movement to reinvigorate scientific discovery' non-monotonic logic (as through synthetic inferences). Abduction, as idealization, can be used to create a false image of the World. When applied to theories, laws, models and mechanisms can

create *degrees of contingency* of deviation from reality, but that has the power to be used as a scientific tool, as Santos and Rodríguez exemplify with biological models (Santos Rodríguez 2008).

Discussion

Foldit's game of protein folding can be related to the work of Charles Sanders Peirce. The weaker connection is related directly to the visual elements. After all, Peirce's logic becomes visual, iconic. With my play of the protein puzzle' tutorial, the molecular size as a concept had a character of Firstness, as a “thing-in-itself”. The red balls warning me of danger while I manipulated the protein chains had a character of Secondness, while my apprehension of that concept, the creation of a new habit of mind related to Peirce's Thirdness. Peirce's philosophy and his search for truth isn't dependent of a mind/matter duality, passes to a triadic relationship between signs, objects and interpretants.

Of greater interest to the understanding of shared thinking in participative science research is how abduction is central. We've seen how tinkering relates to this scientific practice and how effort has been put to build-up a Logic of discovery and acknowledge the contribution of synthetic inferences.

Following Peirce, we see how abductive reasoning has many perspectives of interest in the epistemology and philosophy of science. Beyond the *Inference to the Best Explanation*, the concept is rooted on other forms between the consideration of operative abduction and abduction as perception. Curiously, by following chronologically the thought of Charles Peirce, we travel from the foundation of retroduction in the Aristotelian syllogisms until its application in a logic of icons, in that the premisses become images.

Chapter III

VALUE OF EXPERIENCE WITH CITIZEN SCIENCE - THE PHILOSOPHY OF JOHN DEWEY -

Summary

Citizen Science movement gives a chance to citizens to cooperate in science research. The emphasis given is on the value of experience, much inspired by the pedagogic model of John Dewey. In this chapter I explore the concept of experience, as framed by Dewey in *Experience and Nature* of 1925. We see how experience fits Dewey's Metaphysics and theory of knowledge and how come the social sphere is manifest. The subject-nature intertwines and, as a result, the old dualism is dissolved. As in Greek classical thought, to nature are greeted qualities and a humanistic project of cooperation *by* and *in* nature arises.

The bird field

One sunny afternoon I was returning from my getaway weekend with Jeroem and Helena. We were traveling by car, Helena was driving. They picked me up on a small village where I was camping overnight. We were set to return to the huzzle and buzzle of the city life using the small roads. They were excited about it, as the weather was playing along for them to spot some birds.

I know Helena from college. When we were studying at the University, she and the other biologists friends of mine always surprised me. As they got deeper in their studies, they gained knowledge, of course. But my surprise was how each of them would focus into a concrete *taxon*. I remember "ant boy", that could spot and identify ants anywhere or the "fungi lady", that would collect fungi to analyze and others to see. Helena wasn't that specifically into birds, but now with Jeroem they shared this passion as amateur ornithologists.

"Is that a hawk?!" said suddenly Helena. She was driving so she wanted us to check it. To the front and then to our side and up, there it was. I could see it from the side window of the car. It could very well be a hawk, but birds ain't my thing, I can't distinguish a cuckoo from a finch. "Yes! It's an hawk! But its going that way!" Jeroem pointed to our left, it wasn't on our road anymore. Rapidly Helena brought the car to an halt, Jeroem

was quick grabbing the bird guide and the binoculars. We were outside to the empty road trying to spot the bird.

My friends were totally there living that experience. We followed a small fire-road for a few steps hoping to find the hawk. There were bushes and the summer breeze. We could here some bird chirping a bit farther away. They had their heads up, scanning all the horizon with care, speaking on low tones. Suddenly and it was so fast, Helena focused her eyes near the ground to our side and took quickly the binoculars from Jeroem's hands. “Did you hear that?!”. What? I didn't hear nothing. With her big and smiling eyes she opened the bird guide and shown us the page. “It's a Woodchat shrike! It's the first time I see that!”.

The bird that Helena found that day was significant for her. She had never seen that shrike species. It amazed me how she directed her attention so promptly in reply to a bird chirp that was for me inaudible. In that moment, it was like both her and Jeroem were part of that landscape, attentive to all those little sounds and small visual signs in the air and in land.

Citizen Science

Citizen Science is synonym with Public Participation in Science Research. This approach to scientific practice was boosted by the North American government. The American National Science Foundation (NSF) fostered participatory mechanisms for science research since 1992 (Bonney et. al. 2009a, p. 10, 15; Wulf 1999, pp. 133-134). The definition of citizen science developed in the past two decades includes goals in science education, as well including professional researchers and using trustworthy protocols for collecting data (Bonney et. al. 2009b, p. 978). When myself, Jeroem and Helena were spotting birds, we weren't contributing to any data collection, were just doing it for the pleasure of it. But we could have been enlisted to participate in a collaborative research, spotting birds and giving the feedback, using internet and Web2.0 tools. *Cornell Lab* is mostly exclusive to the United States of America, but has several projects spanning across the Country, addressing different Ornithology and Ecology research questions

that are open to participation, mostly by collecting data. They've already published 20 articles of scientific research with these volunteers (Bonney Cooper et. al. 2009).

Generally, citizen science projects in USA can be collaborative or co-created, but are mostly contributory , according to the American *Center for the Advancement of Informal Science Education* (CAISE) report (Bonney 2009, pp. 11, 18). One of those who signed that CAISE report is the co-founder of the Cornell Lab, Richard Bonney. As one of the front-men of Citizen Science, he contributed to shape what citizen science means.

Alan Irwin used 'citizen science' in 1995 to refer to the involvement of citizens in addressing local environmental issues that relied on the collection and analysis of scientific data (Irwin 1995). Bonney, one of the authors of the mentioned CAISE report, redefined the concept to refer to a “project or activity in which the public collects and/ or analyses data to help understand large scale research questions” (Bonney 2011). European frames to the concept of citizen science, as by the consortium *Socientize*, define that people contribute to it through “intellectual effort”, “surrounding knowledge” or with “their tools and resources” (Socientize 2015, p. 6). When tackling with societal changes, *Socientize* claims that “promising solutions need to be tested, demonstrated and scaled-up” (idem, p. 13), which seems aligned with CAISE's “large scale research questions”.

In the last five years, the number of active citizen science projects has been increasing gradually (Curtis 2015, p. 38). Cornel Lab of Ornithology opened more than two decades ago. In the mean time, with internet, web 2.0 and more citizen science tools is able to study large-scale patterns in nature. For that to happen, a much bigger collection of data is collected all across the USA (Bonney et. al. 2009b, p. 978).

Besides the impact of the scale of information and its circulation, it is meaningful to understand that many of these citizen science initiatives take place inside schools. A similar situation is occurring in Europe. NSF finances Public Participation in Science Research (PPSR), as European Union finances Inquiry Based Scientific Education. It is expected that these choices will have, on a long-run, some impact on the educational system, improving the motivation of students towards science (Bonney et. al. 2009a, p. 10;

Osborne 2008, p. 13). The pedagogical approaches implemented, as other 'learning-by-doing' are inspired in the work of John Dewey. He was politically active in the reform of Public School, as with other social issues. Contemporaneous of Charles Peirce, he was also a philosopher, well known for his Pragmatism.

From Absolutism to experience

John Dewey started to have an interest on philosophy during his senior year in Vermont University in the late seventies of the nineteenth century. According to his own description of his intellectual development (Dewey, 1930), during his studies we got from Thomas H. Huxley a sense of interdependence and interrelated unity (EN, p. 14) and later came to admire his teacher H. A. P. Torrey for his love on pantheism (EN, p. 15). Other academic, prominent American experimental psychologist at the time, G. Stanley Hall, provided Dewey with an appreciation of the power of scientific methodology as applied to the human sciences (Field, 2005). Another professor, George Sylvester Morris introduced Philosophy to John Dewey with a Neo-Kantian philosophical viewpoint, with an interpretation of Immanuel Kant as through Georg Wilhelm F. Hegel and introducing the organic model of nature as stated in the german idealism. It was a starting point of sorts through a path of Absolutism to Experience (Dewey, 1930).

In his early years, Dewey was empathic to the work of Auguste Compte. The idea of science as a regulative method of an organized social life was tempting to him. For the same reasons, Plato was appealing, as the “highest flight of metaphysics always terminated with a social and practical turn” (Dewey, 1930, p. 18). In parallel, his social life was also enriching, as he stated to get more from situations and people than books. Therefore, he strongly disagreed with the Hobbesian Social Contract Theory, that stated the the social, cooperative aspect of human life was grounded in the logically prior and fully articulated rational interests of individuals. He felt himself as being a sort of a chameleon, with many diverse and even incompatible influences. His philosophy proved, still, to be logically consistent, but not systematic (EN, p. 19). William James proved to be a strong influence, as Dewey came to admit that James’ thought acted in

him “as a ferment to transform old beliefs” (EN, p. 20), as it was with the nature of Experience.

Experience

Experience was emancipated by John Dewey in *Experience and Nature*. In his historical reading (EN, p. 3), experience wasn’t acknowledged as it should by the Cartesian school and by the materialism of the Galilean-Newtonian method. In the basis of his philosophic theory, Dewey gives a new scope to the interplay between experience and nature: “experience, if scientific enquiry is justified, is no infinitesimally thin layer or foreground of nature, (…) it penetrates into it, reaching down into its depths, and in such a way that its grasp is capable of expansion” (EN, p. 3a). Ultimately, experience belongs not to the individual, being *of* and *in* nature. On this point, one of the happiest metaphors that Dewey presents to us is of experience as a house (EN, p. 232). As such, it has the same dependence upon objective physical and social events.

To further elucidate of what experience means, Dewey divides it in two levels. The primary experience is gross, macroscopic and crude, as the infrastructure of our house, while the secondary experience is refined, dealing with the products of reflection (EN, p. 3-4). Science always reports back at the primary level, to verify the inference that was built, the refined products and methods. In this method, that Dewey terms as ‘denotative’, the scientific theory in the background gives emphasis to certain aspects or details, giving it significance.

The ferment that William James afforded to John Dewey was such that became essential to the theory of *Experience and Nature*. James work presented experience as a *double-barreled* word. *What* is experienced in one side, *How* it is experienced on the other (EN, p. 8). The before mentioned denotative method acknowledges it, and Dewey further improves this concept: there’s different ways of experiencing. Just like James compares consciousness to a stream, with rhythmic waxings and wanings, Dewey finds this continuity shifting his attention from the *What*, of objective subject-matter, to the *How*, of method (EN, p. 235).

In a critical viewpoint upon this matter, William E. Hocking identified a problem in this approach. Dewey described a multitude of ways of taking experience, which for the sake of science should be a matter of things and not of 'sensa'. This all-inclusive notion of experience is "beginning and ending of all thinking" (Hocking 1940, p. 231) and what Dewey accomplishes is a 'psychological englobement', co-extensive with experience. Reality, in these terms, is also double-barrelled, says Hocking, being distinguished into the psychological englobement and an *object of search*, defined as the "independent being, on which other being depends" (Hocking 1940, p. 235). When replying to Hocking, Dewey targeted such ambiguous definition, "Now reality is, I fear, more than a double barreled word" (Dewey 1940, p. 160). But what is reality for Dewey?

John Dewey's empirical naturalism is his method of scientific inquiry. Once inquiry is successful in resolving a problematic situation, mediatory sensations and ideas, as Dewey says, "drop out; and things are present to the agent in the most naively realistic fashion" (in Field 2005). These statements positioned Dewey within the territory of 'naïve realism'. His empirical naturalism frames the inquiry in a process which initiates with a check or obstacle to successful human action, proceeds to active manipulation of the environment to test hypotheses, the before mentioned inquiry phase, and issues in a re-adaptation of organism to environment that allows once again for human action to proceed. Experience, in this sense, is antagonist to the exclusive truth of experience as the exploitation of the inner life, as seized up by the Romanticism of the 18th century.

Objects

After the Romantic approach to knowledge, modern thought came to affirm the objects of science as the perfect and true reality. But then comes a problem. The little bird that Helena found for her first time meant and still means something more to her, than any other bird we found during that walk. Dewey poses the question, how can the objects of love, sensory and ideal appreciation and devotion be included within the reality? (EN, p. 135). After all, "it is as much part of the real being of atoms that they give rise in time, under increasing complications of relationships, to qualities of blue and sweet, pain and

beauty, as they have, at a certain cross-section of time, extension, mass or weight" (Dewey, 1940, p. 156).

In such a frame, what makes an object of science? Dewey describes the four necessary characters: First, there's the assumption that immediate things are transitory, while the spacial-temporal-orders/ the universals are constant. Second, from the need to get control over things there's the need for substitutions. Techniques, as mathematical functions, and systems of mutual conversion and exchange bring things within grasp. The third and fourth characters are consequences of the use of the objects of knowledge as means. The individual thing is treated as a composite of parts, although perceived as a whole, in a clear rapprochement to Gottfried Leibniz' *monads*. Through a method that makes use of objects to establish relations, the elements come through as important factors. These relations established become central, becoming laws of constancy among variables (EN pp. 142-146).

Knowledge, in this sense, becomes instrumental in the guidance and control of the interaction between the subject and the nature. Specific "things in experience" are part of the search that Dewey's theory makes, capable of providing the needed support and guidance (EN, p. 158). Such is the case of the "tools of knowing", as the bird-guide and the binoculars, as their functions become *models* to follow in interpreting phenomena (EN, p. 150). For the instrumentalist, immediate qualities are dimmed and features which are signs, indices of something else are distinguished (EN p. 128). Just like a subtle chirp quickly identified by a trained ornithologist. But, in this light, the before mentioned qualities, as the sweetness and blueness can be laws of constancy, but what about the beauty of atoms? How does the aesthetic takes part in experience?

Dewey makes a distinction among objects. Either they are known and are used as tools or they are fulfilled products of the use of tools, as objects of appreciation and affection. Besides, the instrumental theory of knowledge just describes what is "proper". As Dewey states, "in many cases the pursuit of science is sport, carried on, like other sports for its own satisfaction" (EN, p. 151). After all, according to this naturalistic viewpoint, the subject is part of nature, working for "ends-in-view", but also enjoying the immediate satisfactions of "consummatory experiences". The forging from "uncertain

agencies" to "efficient instrumentalities", marks the scientific experiment, as the "indestructible union of the instrumental and the final" is possible thanks to the intelligence of the individual. In a dialectical process, when inducing the remaking of objects, there's a new object as result of the experiment but also a new self (EN, p. 246).

Subjects

Individuals are subjected in experience to what is uniform, the universals. As consequence the individualism, characteristic of modern thought, is eliminated. Individuals become "specimens" of some generic relation or law. Still, they are "saved" by another kind of Being, crafted by History and Anthropology (EN, pp. 146-7). In the fourth chapter of *Experience and Nature*, *Nature, Mind and the Subject*, John Dewey describes such history of the Subject. In his history, the nature of the individual is framed between two poles. For the ancient Greek, the individual had self-completion and sufficiency, while for the moderns individuals are particulars, transient, partial and imperfect (EN, pp. 208-9). The dominant externalism marked the 17th century, as the exaltation of the spirit marked the 18th. The action of reformers as René Descartes introduced the modern cleavages and, worst of all, the popular subjectivism. The mind, defined as the ordered system of all the characters that constitute kinds, is part of the problem as defined by Dewey.

Dewey acknowledges two main factors for the popularity of subjectivism (EN, pp. 227-230). On one side, the constructive power of mind renders a multitude of objects as in art, industry and politics. On the other, the exploitation of inner life allows the inner reveries and enjoyments and constitutes freedom for the natural man. These can be consummatory experiences, but, while interacting with nature, "knowledge of [inner] dispositions and attitudes renders us exactly the same sort of intellectual and practical service as possession of physical constants" (EN, p. 238). How does it process, then, the experience for the subject? The solution described by Dewey rests in the active participation of the self. As obstacles become challenges, the individual remakes his personal desires and thought, in a move of integration with the movement of nature he

directs its consequences (EN, p. 242). The subject's needs and likings can be reflections of a connection "spontaneous as the ties and bonds of associated life; uncalculated manifestations as H_2O bonds" (EN, p. 243). Or they can be still part of a private sphere, connected to bias and preference. The feelings of resistance and frustration have different cultural interpretations, but, for Dewey they are commonly related to an inadequacy of the present psychological knowledge (EN, p. 238-9). Actually, it is all due to the relation of man to nature manifest as an intermixture of support and frustration (EN, p. 421). Deepening his naturalism, John Dewey recognizes that such ambivalence of human existence is rooted in nature itself.

The ambivalence of human existence stated by John Dewey raises further problems about the ontology and epistemic action of the subject. How can the epistemic subject recognize the relational qualities, as feelings, from the ones that arise from him? The solution is the relaxation of conventions and dogmas, a freedom of thought that comes from a freedom of thinking (EN, p. 222). Connecting James concept of consciousness as a stream, Dewey there sets the mind, as life goes between things of which the organism is but one (EN, p. 282). Such frame evidently implies an emergent "theory of mind".

Emergence and continuity

Mind, as Dewey analyses, is but an emerging aspect of cooperative activity mediated by language. The linguistic communication is important as other forms of communication for other "feeling creatures", as it objectifies the feelings. For Dewey, language gets to be closer to natural events than the purely physical. In fact, from the physical, to the psycho-physical to the mental, Dewey relates an increasing complexity and intimacy of interactions (EN, p.261). In addition, contrasting with the older associative theories of interaction, Dewey offers some principles of emergence. He introduces the concept of field, which reflects the three different levels of interaction, being set in three correspondent "plateaus". The first plateau, the physical is the one of mathematical and mechanical systems and physics; the second, the psycho-physical, is the one of Life; and the third is where the intellect fabrics response to meanings by association,

participation and communication. As two distinct “fields” interact, with tighter and looser ties, the new ‘emergent’ field releases new energies and new qualities are appertain. Then, the work of science is to form by translation and substitution a homogeneous medium (EN, p. 272).

All this theory set forth by John Dewey is a formulation of the adaptation of nature and life and mind to one another, strongly antagonized by the modernist dualisms. In *Nature and Experience*, just like the history of the subject was critically analysed, the one of the body-mind was thoroughly explored. In the analysis of Dewey the problem rests not in the solutions proposed, but in the statement of the problem. The denial of temporal quality and the dogma of the superior reality of “causes” couldn’t be accepted. Also, a continuity should be acknowledged between tools, objects and faculties. Although, from the critical viewpoint of W. Hocking, if theory splits the amalgam of experience into two aspects, the mental and the physical, that severance must be accepted as a better version of truth (Hocking, 1940, 238). But for Dewey that’s purely a sign of social insanity. For him, there’s the concrete need to resettle the organism in nature, the nervous system in the organism, the brain in the nervous system, “not as marbles are in a box, but as events are in history” (EN, p. 295).

In consonance with the rhythmic harmony of the subject in nature, Dewey renders a vision of knowledge as historic. According to it, all sciences, aside from mathematics, are histories of human events but, still, science as a process rests at an opposite pole from history. Science, in this sense, is defined as the intelligent management of historical processes and has as result the integrated accumulation, the conservation, of human preparatory and anticipatory activities (EN, pp. 163, 257). The use of causal explanations makes a breach in the continuity of the historic process, breaking it in two phases. Such fixed points in time aren’t logical in this naturalistic frame, once that “reality is the growth phase itself” (EN, p. 275).

In Dewey’s historical approach there’s a sense of continuity. By his words, thinkers like Descartes “little noted how much of tradition they repeated and perpetuated” (EN 224). This process came to a “community of selves”, returning to the empirical fact, wrote Dewey in a reference to Josiah Royce, but still “the transcendent ego remains a plague”

(EN, p. 225). Within the empirical naturalism, the subject must be acknowledged for its limitations and capacities within nature and the operations of the self as the tools of tools, *the* means in all use of means (EN, p. 246).

Inferences

According to the empirical naturalism, the proper objects of knowledge are in the orders of relation, constructs of a conceptual order, distinct from the sensible world. Making the connection between the kinds of knowledge, the sensible and the rational, are the inferences (EN pp. 138-9, 159). Using as reference John Stuart Mill and Aristotle, John Dewey recognizes that science is a matter of inference, which "rests upon certain truths immediately possessed" (EN, p. 154). This capacity gives "breadth" to experience, making it "stretch to an indefinitely elastic extent" (EN, pp. 4a-5a). When breaking loose the freedom of thought of the mind, the individual may undertake "hypothesis diverging from accepted doctrines and traditions" (EN, p. 219). Dewey further elaborates about the operative functions of the self, the inferences.

Recognizing that "thinking is art", Dewey presents the characteristics of deduction (EN, p. 380). Deduction has nothing to do with truth, it just needs to make sense, but it doesn't need to be consistent or correct. The accumulative character of knowledge is included, as the meanings that figure in deduction are those that are conclusions of prior inquiries. In fact, the inquiry process rests upon another kind of inference, the induction, which is defined as the experimental art of changing external things by appropriate external movements. The empirical basis for the distinction between the apparent and the non-apparent, the "making sure", rests, then, upon induction. This practical sense of induction is central to the practice of science, as the "act of knowing is always inductive" (EN pp. 138, 154, 380-1). Dewey states that the truths that guide inferences are immediately possessed but then, why so much emphasis on the importance of "making sure"? If there's something guiding the inferences, what is it?

William Hocking when further analysing Dewey's thought identified a property at the backbone of experience. He identified it as a "persistent and mystical sense of direction

in the succession of our hypothesis" (Hocking, 1940, p. 244). In fact, Dewey stated that when confirming a hypothesis, a flow of action goes in one direction. For him, "overt action is an instatement of established organic- environmental integrations" (EN, pp. 313-4). The problem identified is one that Dewey explained as an "impossible" gulf between the physical and the mental, which was in fact a case of deriving the uncertain from the regular, *that* from *this* (EN p. 349). The solution, the thing that guides the inferences, is part of the experience to the subject and involves a connection between the consciousness and nature (EN p. 352-3). Such a connection to the "complete universe" is an effect of taking as object the proper object of science, which shows a "symmetric dovetail" that links idealism and materialism (EN p. 159-60).

Qualities

The object and the method of art and science must then recognize nature as such or "nature pitched through the door returns through the window" (EN, p. 293). The resolution offered by John Dewey to the modern bifurcation passes by acknowledging qualities and values ascribed to mental states, as Hocking stated (Hocking, 1940, p. 240). But for Dewey this modern crisis that splits nature is a consequence of this need. As in the classic Greek cosmology, the qualities and values of natural science must be completely fused with the material of what was taken by the moderns to be science (Dewey, 1940, p. 156).

Therefore Nature has qualities in itself (Dewey, 1934, p. 398), qualities that are part of the condition of the emergence of mind. Emotion works as an indication of intimate participation (EN, p. 389), as the mixture of support and frustration that the subject feels. How does this philosophical and epistemological tilt proposed by Dewey works for science? How does science study qualities? "When studying inanimate things, qualities as such can be safely disregarded", says Dewey (EN, p. 366). Why? Well, for Dewey, qualities are "vector directions of movement", hence the qualities of the non-moving aren't productive. The things get more interesting when such a level of extensive and delicate relationship is established between "feeling creatures".

Social Dewey

The philosophy and metaphysics of John Dewey gets more interesting with the increased complexity of more intimate connections. Qualities in social communication become productive of results as the processes of abstraction, generalization and inference are associated with signification (EN, p. 269-70). The acknowledgement of this process has repercussions to the understanding and function of social structures. The moderns treated the Aristotle's metaphysics as the "Jonah of Science" and threw bodily overboard (EN, p. 134). Returning to the ancient Greek expression of experience as the "genuine expression of cosmic forces" (EN, p. 134), is connected to the return of a social communitarian fruition and enjoyment of art.

Nowadays, as in 1925, the idea of the application of science or art is identical with "commercialized". The proposal of Dewey is the "broadening the idea of application to include all phases of liberation and enrichment of human experience" (EN, p. 165). Such an openness of human existence to connect is in tune to what Dewey describes as the "omnipresence of conjoint behaviour", the association mechanisms that are inherent to the Universe (EN, p. 288). Discovering the state is a practical problem of human beings living in association, also recognizing qualities as friendship and poetical discourse in this interaction (Dewey, 1927, pp. 288, 292). These questions come together in Dewey's definition of nature. But the empirical naturalism of John Dewey is a naturalistic humanism, it believes in man. The human experiences in all levels, including the aesthetic and moral, reveal elements of the real things and offer knowledge and understanding upon the complex.

Discussion

In this chapter I introduced citizen science, as a frame of some researchers and institutions to involve others than professional scientists, into science research. In example, Cornell Lab of Ornithology is one of the leading institutions involving 'citizen

scientists' into Ornithology and Ecology research. Even if just collecting and analyzing data, these 'citizen scientists', most of them kids, are in touch with science research practice. In the small bird field I described, a specimen was identified. But it meant a lot more than just a tag.

Experience is a loaded concept. It's a pivotal part of what makes sciences, its history and the philosophical thought. Because Helena and Jeroem were there on that field, but were so much *in* there, we explore on this chapter views on Experience and Nature with John Dewey.

As we've seen, Dewey's empirical naturalism is a process that might start with an obstacle to successful action, proceeds to the inquiry phase, where the inquiring subject is also transformed, and so on, it continues to another experience. The initial obstacle in this process is often seen as having a tragic sense of life. Imagine that at the bird field, Helena and Jeroem were actually frustrated while looking for the hawk. According to Dewey, as we've seen, this emotion can be an inherent quality to nature itself. The critical work of reason that follows is often apprehended in Dewey studies as being a positive evolution. During the inquiry phase, Helena found things in experience, used her “tools for knowing” and got to find what was relevant by the theoretical secondary level of experience. That bird was a Woodchat shrike! That finding was a narrative of the positive work of reason, in the sense of a Melioristic optimism.

This path of experience is one that we can get further insight if we compare the concept as by Dewey to the work of Charles Sanders Peirce. For John Dewey, experience is one key point of his relation to reality, one where ‘paupers and princes meet as equals’. Both thinkers were commonly linked to Pragmatism. While Dewey was a spokesman believing the pragmatist maxim that all hypothesis had 'practical consequences', Peirce wasn't so keen on that vision (Hookway 2015), he reframed the question with his own Pragmaticism. Considerations on the role of inferences are here on the key note that differentiates both thinkers.

Peirce taught logic at John Hopkins University to John Dewey. It was before the first developed his Semiotics and New Elements, so the last wasn't so impressed. For

Charles Peirce, abduction (the process of making hypothesis) is central to the concept of experience. A retro-deduction, where logic can act. As Giovanni Maddalena stresses, Peirce's 'iconic turn', makes a contribution to this development. The Icon stands as a representation of reality. As it might be in three kinds of relationship: with itself, immediate with others and mediated; it has a “reckoning” function, that allows hypothesis to work in logical terms (Maddalena 2004, pp. 402-403). Besides abduction, Peirce defines induction and deduction as his triad of inferences.

For John Dewey, inferences take an important role of connecting the sensible to the rational Worlds. There's truths guiding those inferences and those truths are immediately known. So, there's a continuity that is, this way, assured, but, simultaneously, any hope for a logic of discovery with Dewey is lost.

Some citizen science projects (as *Foldit*, explored on the last chapter), believe that human cognition can come to be translated into software algorithms. Dewey probably wouldn't buy that possibility, but wouldn't he appreciate this participative vision? As these games of science research participation come inside the school borders and involve other public domains, can it come to be that they are contributing to the liberation and enrichment of human experience?

Chapter IV
PUBLIC SPHERES
IN ONLINE CITIZEN SCIENCE

Summary

In this chapter we deal with Jürgen Habermas' concept of Public Sphere, relating it to the turn of the 21st century' coming together of Astronomy' virtual science games. We start by portraying a Moon Mappers' player, Drhaugh and his frustration upon his “discovery”. These games certainly put the citizen scientists in closer contact with the uncertainty and error of real science on the making. But without the formal education, without that dimension of Science, how can this gaming be acknowledged as “real science”? An historical perspective of the emergence of these games is offered: From the volunteer computing of SETI@home to web-based volunteer image classification Stardust@home; the development of Galaxy Zoo, Planet Hunters and others from Galaxy Zoo guise to the Moon Mappers of the smaller-scale CosmoQuest. Astronomy based citizen science games are developed by professional researchers that deal with concrete scientific challenges. Knowledge is becoming more and more data intensive and involving the human cognition as an outsource is a way to deal with certain scientific questions. Following the viewpoint of Jürgen Habermas on the subject, he shows us how the public sphere came to be. To enter such spaces, to be part of those discussions and decisions, people needed to be able to do it... At a first glance it can be drawn here a parallelism between science research as an idle play or as a space where people do engage and reason together. Or, in other words, regarding Feyerband's anarchist epistemology or Lakatos' rationalization in practice. More depth into our subject matter will show us, though, that that is a fragile image. Web 2.0 design tools being used by different citizen science on-line games may reinforce the pedagogical process and the community aspect, the public use of reason. Understanding how citizen scientists use the public sphere can bring us to new political and philosophical issues that can transform the scientific practice.

Drhaugh's frustation

Drhaugh likes to stroll around the park while spotting Craters on the Moon using his portable device. That habit isn't much different from playing some online game. But with a meaningful subtlety, it supports scientific research on the Moon surface, its geomorphology and atmosphere. Understanding better the Moon, we can get further insights on other Planets and Satellites. There's a huge amount of data, of images taken by telescopes of the Moon surface. Computer programs act upon these images with their algorithms, generating catalogs of Craters for age dating. There's been computer programs' running these algorithms for decades. But this identification isn't as accurate as the human eye. *Moon Mappers* is the game by the *Cosmo Quest* platform that opens-up this research. More accuracy is found in Crater' classification transforming this science research into an on-line citizen science game (Cosmoquest 2015). The results of Moon mapping of the players, including Drhaugh, give a positive feedback into the algorithm design, improving the programs that identify craters.

One day while taking his walk at the park, Drhaugh got an image that puzzled him. The identification of rare objects on the Moon's surface (other that just craters) is one of jackpots you might get lucky enough to get. Most times they're connected with ancient exploratory missions. Drhaugh, a newbie to Moon Mappers, was excited about his finding and was quick to emblazon his discovery in a forum of the on-line game (Figure 4.1).

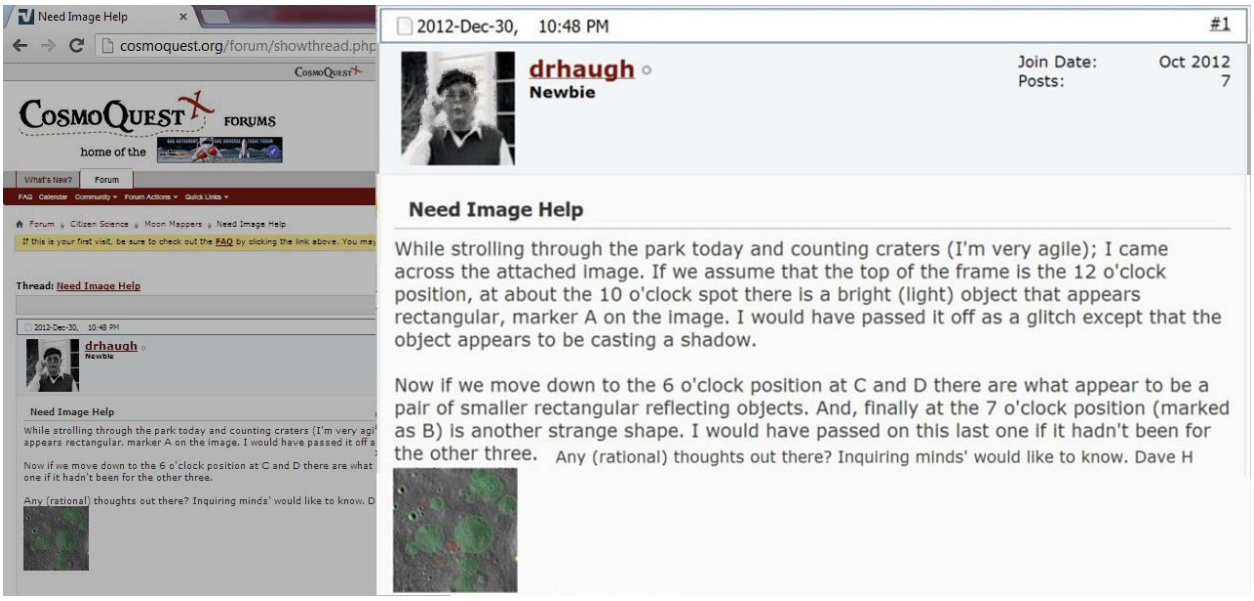

Figure 4.1 – Drhaugh needs help mapping the moon. In the image we find on the right side a close up of a thread of discussion of an on-line forum. An Internet forum or message board, like the one Drhaugh participates, is an online discussion site. Internet forums have a tree-like structure where different topics are discussed. Within the sections or subsections, users can start a discussion – a so-called thread. Other users can reply to the initial message (also called post) or to other users' comments (Holtz 2012). This forum belongs to Cosmoquest, a platform where Moon Mappers, the game to identify Craters on the Moon, is allocated. While playing, Drhaugh found a bright light object on the Moon's surface, uncommon to the usual Craters he was used to count. What could it be? On December 30, 2012, he asked for the help of other members of this community.

Could the strange object be an old artifact? Other community members, moon mappers around the World could help on this research, so he thought. And so it happened. Some hours after his post, an older user replied. He hinted that strange bright object might be part of the old Russian rover Lunokhod 1. The following research on image databases seemingly confirmed that, Drhaugh was assured of his finding, he believed it was a rover in that image of his. Still, next day, after the New Years Eve of 2013, a much more experienced Team Scientist commented the discussion thread. It couldn't be the old Russian rover in that image, it was probably just a big rock, a boulder. The reply of Drhaugh to that discussion thread, still on January 1st revealed his frustration. "Good thing we're starting a New year or I'd be really depressed".

Cosmic adventurers, Astronomy's on-line players of research games

Technological development in the 1990's brought us, among other tools, the private use of Internet in private computers. In the very end of that decade, *Seti@home* was launched. Using the computational power of private computers, radio data was processed to look for signals for extra-terrestrial intelligence (Anderson 2004, p. 2). In the same year of 1999, the USA's *National Aeronautics and Space Agency* (NASA) was launching the *Stardust Mission*. From it, a participatory project was also starting to run. From 2006 until nowadays, *Stardust@home* uses the internet to recruit volunteers to identify tracks made by interstellar dust in samples that were flown on NASA's Stardust sample-return mission to Comet Wild-2 (Fortson 2012, p. 3). The major difference between these two is one that has been previously named in the previous chapter. *Seti@home* uses the resources of the computer, what has been called distributed computing, while *Stardust@home* depends on the human interaction, which is known as distributed thinking (Curtis 2015, p. 4).

In this period, a PhD student working at Oxford University, Kevin Schawinski, was studying extra-galactic astronomy. During his study, he took on the task to build a complete

sample of early-type galaxies based solely on their visual appearance. He analyzed about 50,000 galaxies using the *Sloan Digital Sky Survey* (SDSS) depositorium (Fortson 2012, p. 2). At this point Schawinski, together with another researcher, Chris Lintott, became motivated to visually classify all the SDSS galaxies, which amounted to over a million. *Stardust@home* had already over 20'000 volunteers, so inspired by such an example, their idea was simply to "outsource" the visual inspection task (ibidem., p. 3). By chance they came to cross paths with yet another research group, interested in developing an interface to classify and characterize the sense of rotation of spiral galaxies. Together, they forged *Galaxy Zoo*, one of the most famous games among citizen science' cosmic adventurers (ibid.).

Galaxy Zoo, launched on-line in 2007, was just the first of many virtual citizen science projects (Curtis 2015, p. 38). In its first six months, it provided the same number of classifications “as would a graduate working round the clock for three and a half years” (Citizen Science Alliance 2015). Nowadays *Citizen Science Alliance*, that joins seven different institutions, Museums and commercial entities is the North American consortium that hosts *Zoo Universe*, the growing collection of virtual citizen science projects that started out with *Galaxy Zoo* (ibidem.). On its first five years of activity, over 600 thousand users were registered (Reed 2013, p. 610). Among the citizen science products of *Zoo Universe*, astronomy is still one of the the most popular. Besides *Galaxy Zoo*, other games use the same participative strategy, as *Planet Hunters*, a game where the participants help to look for evidence of Exoplanets (planets outside of our solar system) within data collected as part of the NASA's *Kepler space mission* (Citizen Science Alliance 2015).

CosmoQuest is yet another citizen science game being developed in the last years. What appealed to me about it is that, by comparison with others, is a small platform with a strong informal education architecture. It had roughly 300 thousand registered members and 700 active users at June 15th 2013. It was created two years before, in 2011, by the *Center for Science, Technology, Engineering and Mathematics* (STEM) of *Southern Illinois University Edwardsville* in cooperation with *Astrophere New Media* and other partners (CosmoQuest 2015). The first project of *CosmoQuest* was *Moon Mappers*, a simple application to map the Moon, the one that caught Drhaugh on his daily walks. The forum where Drhaugh left his concern about his finding is just one of the social communication tools available. Just like some Citizen Science Alliance, synchronous internet relay chat and blogs are used to facilitate the communication within the community (Curtis 2015, p. 40). On this case, participants that join the game can immediately start spotting and cataloging Craters by size on images taken from remote telescopes. The scientific relevance of this undertaking is to understand the effects of Sun angle on Crater identification and measurement. Therefore, for *CosmoQuest* the use of human cognition for spotting craters is a touchstone.

Crowdsourcing solutions

All these different platforms we've been approaching use the involvement of citizens as volunteers and we've been presented to a concrete motivation to do so. As we've just seen, part of the set up of *Galaxy Zoo* was due to the experience of one researcher, Schawinski. He took his PhD to visually classify innumerable Galaxies. The SDSS digital depositorium he was using was big. Too much for himself, alone, to process. But from all that collected information, research questions naturally popped out... Though some of those would be dependent on the human cognition, just like in the role that Schawinski was just involved. Transforming partially this research into a game that could involve many volunteers was a way to get this research done.

Research in Astronomy and Astrophysics, just like many other scientific fields, involves more and more information. And this fact has been recognized on an institutional level. A North-American interagency working group reported on digital data for the *National Science and Technology Council* in 2009. According to their study, science research outputs, the data produced, is increasingly “born digital”, available only electronically. The rate at which these digital data are produced was reported to be increasing as well, resulting in massive growing data flows. This effect has been coined as a “data deluge” (Interagency Working Group on Digital Data 2009, p. 6).

"Crowdsourcing is a natural solution to many of the problems that scientists are dealing with that involve massive amounts of data" (Young 2012). These words are of Haym Hirsh, current director of the Division of Information and Intelligent Systems at USA's *National Science Foundation* and show how this solution has been acknowledged. Even though seemingly “natural”, it is an action that needs to be problematized.

European Science Foundation is an organization active in networking and coordinating activities in Europe for 40 years, now focused, from 2015, in supporting scientific decision-making (European Science Foundation 2015). In a 2013 report focused on Science in Society, there's a concern about austerity as an economical and political frame in Europe and how that jeopardizes the care for our futures (Floud Fuchs Ceulemans Hynes

2013). The report is clear in its accusation, when tackling with the involvement of citizens into science research there's overall a prevalence of an utilitarian, “managerial logic” (idem p. 24). Here the authors are mainly concerned about the projection, collective debate and engagement into social and technical developments. Concerning on-line participation, as with virtual citizen science tools, the authors expect to find here a big diversity in concepts and practices but are, overall, concerned with the concrete engagement of the participants, that might help to integrate science in society (idem p. 29).

Zoo Universe is one of the major flagships when it comes to virtual citizen science. In another institutional report written in 2014, concerned with a variety of practices coined as 'Science 2.0', *Zoo Universe* is given as an example of how the public might be seen as a resource or as a partner (Science Europe – Shaping the future of research 2014, p. 2). This report is, again, European, coming from *Science Europe*, an association that joins research funding and research performing organizations (Science Europe 2015). The ‘Science 2.0’ that this report focus on, is grounded in a certain vision of science as a community practice, founded on the open sharing and incremental exploitation of ideas and data (Science Europe – Shaping the future of research 2014, p. 2). And with much significance, it declares more than once, that the variety of these practices are driven by the science researchers themselves (ibidem., pp. 1, 3).

Overall, according to these accounts, there's a clear concern about the engagement of the society into science culture. This more '*data intensive*' knowledge production is, for some thinkers, pushing science research into other heuristic and epistemological paths (Martins 2011, p. 121). On the reports just presented, some stress is given out to how to have people involved, about the importance for spaces for debate and engagement. And if we take it from here, there's much to go go further, to explore about virtual citizen science. Still, a legitimacy is given to researchers to activate these other ways of dealing with problems, involving other actors than the traditional researchers. But historically, when did this problem appear before? When and how did the “citizen scientists” came to be?

Scientists, citizen scientists

The development of Science research seems to create new roles. With citizen science, the scientist can be mixed with the public or, as in the given examples, located upstream from the observation. The boundary lines between diverse participant status in knowledge production has been built in various periods, but it was in the nineteenth century Great Britain that William Whewell created the term ‘Scientist’, rooting the modern professional role (Vetter 2011, p. 129). With creating such professional boundaries, Whewell probably also had in mind enterprises that involved many human resources, as the citizen science’ non-professional scientists, or “subordinate labourers”, as he referred to them (Rozwadowski 2004, p. 32, footnote 7). Whewell in 1835 conducted the “great tide experiment”, a big science experiment aimed to unfold the nature secrets about tides. Floods had the greatest social interest, being the cause of great devastation and mortality. The tides were measured every fifteen minutes for a fortnight at over 650 tidal stations, that included Great Britain, France and the United States (Reidy 2006). Since those days much changed in these societies and states. The “great tide experiment” of Whewell seems, still, to be in the same line of action than the diverse citizen science movement, recruiting many others to make that scientific venture achievable.

Participative projects in science research are, since then, recognized by the scientific community, from smaller scale to global spanning undertakings. The times we live now are quite different from Whewell’s XIX century, but still we have institutions that continue to dictate the ‘public interest’ on these subjects. Through the veil of liberal mass media and opinion leaders, there’s still the need for a “naïve faith in the idea of a rationalization of domination”. Jürgen Habermas, the German sociologist and philosopher, expressed these words in his seminal work on the structural transformations of the public sphere (Habermas 1989, p. 238). Whewell's “subordinate labourers” were up-to-date on the experiment they were taking part or were just there used to facilitate the logistics of the big experiment, taking the role of workhorses? In the alternatives being drawn, for a socially meaningful participation in science research, it becomes evident the need for spaces where people can reason.

Making Public Opinion

Habermas from the roots of Wilhelm Hennis, Ernst Fraenkel and Gerhard Leibholz defined two paths for the definition of public opinion (Habermas 1989, p. 238). The first is psycho-social, in-between rationality and accessibility, where the individual searches for authority and obedience to the most informed, most intelligent and most moral citizens. The second path defined is institutional. Through Fraenkel, the public opinion is built through a feedback mechanism: the elected parliament, through discussion, acts upon the government that makes policies communicated to the public opinion. Leibholtz disagrees, giving the fact that the majority in government represents the *volonté générale*. Whichever the interpretative path chosen there's a functional context underneath. Gabriel Tarde in 1901 was the first to analyze public opinion as "mass opinion". From this work other similar viewpoints sprouted, defining public opinion as a product of a communication process among masses (Habermas 1989, p. 240-241). Trying to define among these the politically relevant processes, Habermas defined two areas of communication (Habermas 1989, p. 245). The first is the realm of informal, non-personal, nonpublic opinions and includes acculturation and socialization processes of the individual. From this one, another dimension of formal, institutional opinions is built.

For a concrete example, lets consider the middle eighteenth century Paris. From 1744 Jean Jacques Rousseau moved there, mostly occupied as a composer and music theorist. On 1750 he had just published his first successful philosophical work, *Le Discours sour les Arts et Les Sciences* (Bertram 2012). His position on this work was a strong statement of sciences, arts and philosophy as corrupted practices. That's the probable reason that Voltaire, another of the main figures of the Enlightenment, described Rousseau provocatively as a misanthropist. The poem that describes Rousseau in such a way is now on the walls of the Procope, the coffee place where both prominent thinkers usually met.

Lets continue and consider the evening of December 20th 1752. That was one of the two exhibition days of *Narcisse ou l'amant de lui-même*, a play from a novel written by

Rousseau on his younger days, but that he kept anonymous for this regard (Shaw 1955; DeArmitt 2013, p. 18). The play was taking place on the Theatre, the *Comédie Française*, that was just across the street from Procope. That's the reason why this coffee place portrayed on Figure 4.2, was on those days populated by, not only actors, writers and over-all theater lovers, but by the most famous writers as Piron, Destouches, d'Alembert, Voltaire, Crébillon, d'Holbach, Rousseau, Diderot and many others (Lepage 1882, p. 38). Rousseau went to watch the play of Narcissus just like many other on the public. What took place afterwards left a strong impression, as the Chevalier de Mouhy, a writer of sensationalist tales recorded about that day: “We leave to the newspapers to make the comments, but we'll say that this comedy that just fell gave place to a singularity that will entertain our readers” (Shaw 1955, p. 116). Narcissus failed, but the singularity that Mouhy gives reference is related to the disclosure of the identity of Rousseau as author. As Rousseau himself related the events of that evening in later years on his *Confessions of Jean Jacques*:

“The indulgence of the public, for which I felt gratitude, surprised me; the audience had the patience to listen to it from the beginning to the end, and to permit a second representation without showing the least sign of disapprobation. For my part, I was so wearied with the first, that I could not hold out to the end; and the moment I left the theatre, I went into the Cafe de Procope, where I found Boissi, and others of my acquaintance, who had probably been as much fatigued as myself. I there humbly or haughtily avowed myself the author of the piece, judging it as everybody else had done. This public avowal of an author of a piece which had not succeeded, was much admired, and was by no means painful to myself. My self-love was flattered by the courage with which I made it: and I am of opinion, that, on this occasion, there was more pride in speaking, than there would have been foolish shame in being silent. However, as it was certain the piece, although insipid in the performance would bear to be read, I had it printed: and in the preface, which is one of the best things I ever wrote, I began to make my principles more public than I had before done”. (Rousseau 1764-70, translated by Mallory 2012, p. 450)

Figure 4.2. - Engraving by Bosredon of the historic Café de Procope, in 1743. Located in the 6th arrondissement of Paris, in the street now named *rue de l'Ancienne Comédie*, Procope was in a privileged site. In the eighteenth century, Procope was like a literary salon that used to gather many noted French authors, actors, dramatists and musicians.

Rousseau's displeasure of the play and his informal communication of his identity as an author had a clear impact on the public opinion of the events. More, it must have affected his political view point immediately by the writing of the preface to that work. The Procope, as a meeting space, was central to the unrolling of these events.

When tracing the identity of the public sphere, Jürgen Habermas also passes by Paris in this period, but chooses to portray other spaces, the French *salons* (Habermas 1989, pp. 33-34). With the regency of Louis XVI, the nobles lost their social function. Therefore the discussions weren't so entangled with political activism in these spaces. Women shaped the *salons* where nobility, the *grande bourgeoisie* and intellectuals took part. Habermas used other European examples in his definition of the development of the public sphere.

The Public Sphere

Social Structures of the Public Sphere identifies a basic blueprint of the public sphere. Jürgen Habermas, the author, identifies how social spaces for the public use of reason were created, not only in France, but also in eighteenth and nineteenth centuries Great Britain and Germany. At their beginnings, all of them were tied with literature as its medium although having particular national identities (Habermas 1989, pp. 32-34). London, from the middle seventeenth century developed a tea, chocolate and coffee culture that came along with the emergence of a certain "parity of the educated". At the first decade of the eighteenth century there was already 3'000 *coffee houses*, where men could discuss literary issues, at first, but from a certain point also economics and politics. The representation of moneyed and landed British nobles at the coffee house permitted that the discussions had consequences, quite differently from what happened in France.

In seventeenth century Germany, the literary and table societies, the *tischgesellschaften* and the *sprachgesellschaften*, were fewer and even more removed from practical politics than the *salons*.

The *tischgesellschaften*, the *salons* and the *coffee houses* had, though, some institutional criteria in common (Habermas 1989, pp. 36-38). The participants in such spaces had a social intercourse that disregarded status and were problematizing areas that weren't before questioned. In such spaces, "everyone had to *be able* to participate" (Habermas 1989, pp. 38). The *public use of reason* defined the emergence of the public sphere. More than twenty years after this analysis, the author gives an understanding of the public sphere as a space for "intersubjectivities of a superior level" (Habermas 2010, p. 351). Habermas when thinking through the public reason is clearly inspired by the philosophy of Immanuel Kant. For Kant, knowledge was based on pure reason. By the use of reason, an individual was "at the same time as a member of the whole community or of a society of world citizens" (Kant, What is enlightment? in Habermas 1989, pp. 105-106). In *Critique of pure reason*, Kant further elaborates: "The touchstone whereby we decide whether our holding a thing to be true is conviction or mere persuasion is therefore external, namely the possibility of communicating it and of finding it to be valid for all human reason" (Kant 2010, p. 649). The agreement of all empirical consciousnesses is in tune with an intelligible unity of *transcendental consciousness*. Still, through the

public use of reason, one isn't necessarily contributing to politics. Although, in Kant's philosophy of history, conditions would come about under which politics would be permanently merged in morality. The individuals, having conflicting personal intentions, would "check each other" in a way they behave as if they had no such intentions (Habermas 1989, pp. 108-109).

Habermas description of the transformations of the public sphere polarizes reason and domination and acknowledges that the light of reason was revealed in stages (Habermas 1989, p. 35). In further arguments he argues for the need for an effective connection between the public sphere and political power. On his seminal work on the public sphere he further elaborated on the issue, hinting the constitution of a research agenda. Habermas overlooked, as later acknowledged, the role of provincial and national academies and the 'Republic of Letters' in the making of the public sphere (Bensaude-Vincent, 2009, p. 365). Still, his work had a clear impact on the academy. As Roger Cooter and Stephen Pumfrey's reflection on the history of science popularization recognizes, "the publicization of knowledge he [Habermas] formulates must become an essential part of any explanation of the constitution of modernity where science is at the center" (Cooter and Pumpfrey, 1994, pp. 244-245). The appropriation of such Habermasian concepts in the historiographic reading of Andreas W. Daum show a tendency to portray the public sphere of popular science having a negative Habermasian teleology, in decay to the feet of a capitalist mass culture (Daum 2009, p. 328).

Returning to Immanuel Kant's insight, according to the outcome of the communication, one can find certain degrees of difference between his *conviction* and his *belief*, or *subjective validity of judgement*: *opinion*, *faith* and *science*. Only the latter can constitute knowledge (Kant 2010, p. 650). Such considerations have a political overtone. The USA's constitution that supports popular participation in science research is based on Liberty of action of the citizens, being the constitution itself value-free. The german constitution, on-the-contrary, keeps inwardly-freedom values, the subjective principles of action, inherited from Kant's doctrine (Eberle 2008). According to Kant's Formula of Humanity, "act so that you treat humanity, whether in your own person or in that of another, always

as an end and never as a means only" (Kant, Foundations of the Metaphysics of morals with critical essays 47 in Eberle 2008, pp. 3-4).

The north-American virtual citizen science games that we're exploring seem to go against the just-mentioned Kantian categorical principle. Schawinski, as a PhD student, was cataloging so many galaxies that saw in the possibility of involving volunteers a clear chance of having more work done. From that decision, *Galaxy Zoo* was born and many other games sprouted.

Again, in the Habermasian reading of Kant, morals would merge with politics, as individuals having conflicting intentions would "check each other" as if they weren't in conflict. The emergence of a public sphere, as a space for "intersubjectivities of a superior level", would demand so.

As Drhaugh made his "discovery" reported in the beginning of this chapter, a Team Scientist interceded. Without a steady pedagogical structure, how are the comments of the scientific researchers taken by the players? Did the players reading that forum thread recognized and acknowledged the validity of the Team Scientist claim? The danger here is that a scattered membership of people joining these citizen science games don't really constitute a public sphere and hardly attain knowledge, they would be just a bunch of "subordinate laborers" dominated by the game developers and some scientific researchers.

Do these virtual citizen science have heuristic and epistemic value for the scientific enterprise or they portray just an idle play taken by some cybernauts?

The anarchist play?

A game can seem idle, but do trigger detachment and reflection. If we consider a theater play, as envisioned by Bertolt Brecht, an 'alienation factor' would come into play, that would make the audience critical about their subject. Paul Feyerabend was a

philosopher of science that according to the scholar Val Dusek, had much in common in his vision of science and philosophy of science with Brechtian theater (Dusek 1998). Feyerabend's own introduction to science was at his young age in large public outdoor lectures on astronomy by an adult educator (ibidem, p. 35). By the analysis of Dusek, the playful nature that Feyerabend came to develop of his ideal of science owes much to the Dadaist movement. Dadaism was one of the movements which was associated with expressionism, the latter being the movement upon which the early Brecht drew (ibid. p. 31). Just like Dada, Feyerabend uses collage in his works, conceptually, mainly in his account of his autobiography and his controversial work *Against Method* (ibid.).

Whewell, the one of the "great tide experiment" was a polymath and contributed to the philosophy of science. One of his fiercest objector, raising a debate on the meaning and value of induction, was John Stuart Mill. This debate was set up by Mill's work on inductive reasoning but it was his treatise *On Liberty* that became influential to British liberalism. 111 years later its publication, Paul Feyerabend applies it to scientific methodology, forming the epistemological anarchism. With more depth, 1975' polemical *Against Method* validates any problem-solving method. "Anything goes is what a rationalist can say", science is anarchist (Feyerabend 1978, p. 39).

In one of his replies to his critiques, Feyerabend argued for complete *freedom* for the solving of a problem, in such a way that "cannot be restricted by any demands, norms, however plausible they may seem to the logician or the philosopher who has thought them out in the privacy of his study" (Feyerabend 1978, p. 117). Claiming for a free society, Feyerabend appeals to the participation in citizen initiatives, "the best and only school for free citizens we now have". Against the modern scholastic tradition, he defends that an "initial playful activity is an essential prerequisite of the final act of understanding…" In a sense of play as creativity, he continues saying that "creation of a *thing* and creation plus full understanding of a *correct idea* of the thing *are very often parts of one and the same indivisible process* and cannot be separated without bringing the process to a stop" (Feyerabend 1975, p. 26). In other words, Feyerabend abolishes the distinction between the context of discovery and the context of justification, that were explored in Chapter two.

Fayerband's Against method guise of a work against Science as a *neutral structure containing positive knowledge* was aiming for much more. What apparently seemed an anti-rationalist manifesto contextualized by Feyerabend's own experiences, was supposed to be more than a mere provocation. *Against method* was part of the correspondence exchanged with Feyerabend's friend Imre Lakatos, that would reply with a *For method*. Such thing never came to happen with the sudden death of Lakatos in 1974, and left us to wander about how such a logic of discovery would look like (Preston 2012). In a last defense, Feyerabend created spaces in which people could "breathe again". He demanded of philosophers that they be receptive to ideas from the most disparate and apparently far-flung domains, and insisted that only in this way could they understand the processes whereby knowledge grows (Krige 1980, pp. 106–7 in Preston 2012).

The Citizen Science games under discussion aren't best portrayed as a dadaist collage, a statement of complete *freedom*, as in the Against method movement of Feyerabend. They have a concrete structure, that unfolds different roles and social organization than the traditional science research. Feyerabend's perspective comes as relevant in the need to give perspective and understanding to this enterprise. On this behalf, it is of great relevance the social science studies done inside these communities.

On-line Citizen Science: Crowds vs. Communities

Vicky Curtis, a scholar interested in Public engagement in science, conducted a PhD on on-line citizen science projects (Curtis 2015). Her in-depth research was aimed for a better understanding of the phenomenon and, simultaneously, as an utility for scientists willing to develop participative approaches. This study used as foundation three cases studies, projects that Curtis emerged into. These were: the distributed thinking projects *Foldit@home* and *Foldit* (both were approached in the second chapter); and *Planet Hunters*, a *Zoo Galaxy* game.

Previous approaches to virtual citizen science, and to *Zoo Galaxy* beginnings in particular, appraise the initiative of game players and the effort of team scientists to establish communication and treat the participants as equals (Fortson 2012, p. 3; Reed 2013, p. 617). Still, in the available literature, little evidence is given about the profiles and process of on-line citizen science initiatives. Curtis in her study was mainly concerned with the motivations of players and soon raised one critical point of special relevance: Is there true collaboration between citizen and professional science? (Curtis 2015, p. 42). When facing the results, one interesting theoretical framework was approached: the Light and Heavyweight models of peer production (ibidem., pp. 46, 47, 298), that is presented in Figure 4.3. In this frame, the heavyweight players are the ones that can be called a community, while the lightweight gamers are less connected to the common enterprise and are best described as a crowd. In this spectra, a same game can have players that fit into different points. These fits shouldn't be understood as static, as, with time, a novice can become an abide, more heavyweight player or vice-versa. This spread distribution of participant's commitment has been observed by Curtis in all the three games she studied (ibid., p. 162), but we can find in each a more general pattern that positions overall the players as heavy or lightweight.

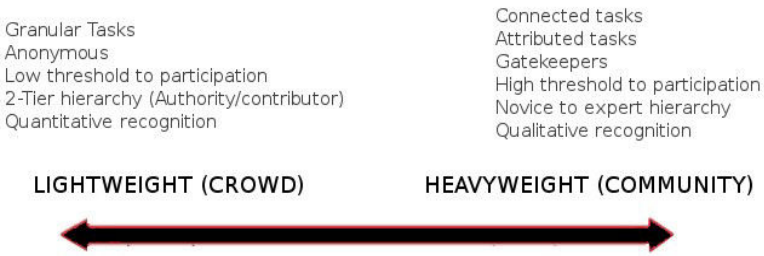

Figure 4.3 – Crowds and Communities – Light and Heavyweight models of peer production. Theoretical frame used by Curtis, 2015 for the open participation and production on on-line citizen science games. On one end we have contributory behavior described as lightweight, generally described as having a weak attachment to a common purpose, enacted through authority determined, rule-based contribution. On the other end we have a heavyweight participation, characterized by a strong-tie affiliation with community members and community purpose, enacted through internally negotiated, peer-reviewed contribution. This frame was adapted from Haythornthwaite, 2009.

Overall, in the last ten years public engagement has been encouraged, but in these games and under Curtis perspective, “the ethos of expert leadership and one-way communication still predominates” (idem, p. 277). Such authoritative attitude is contra-inclusive, contributing more to crowd than community citizen science. Still, all the three projects in this study had roles working for cooperation reinforcement, the community relations managers (idem, p. 288).

In this regard, other roles are taken by players themselves which give substance to a proper community, specially when considering the protein folding game *Foldit* (ibid., pp. 107-108). The metaphor of the gatekeeper, that opens the gate, allowing information to go through, has been mostly spread by mass communication studies in the second half of the twentieth century, but was also imported into other social sciences (Traquina 1993). In this case, it gives reference to the decision making of a community of players that act as gatekeepers deciding, for example, which main topics shall be addressed in the forum. Accordingly, cases as the one that opened this chapter where Drhaugh exposes his doubt and other members, assuming different roles, engage in critical constructive dialogue is something to be cherished. Curtis imports a concept from cognitive

anthropology's communities of practice, identifying this internet forum interaction as “legitimate periplural participation” (idem, p.41). Such heavyweight behaviors are also related to the capacity to perform science research proper.

The *FoldIt* community has become a “self-organizing research community”, with a small number of players occasionally working with the project team (idem, p. 276). *Galaxy Zoo* tries to involve participants in the data analysis and preparation of journal articles. However, this project is overseen by professional scientists and the citizen scientists don't have a chance to cooperate in the formulation of the scientific questions (idem, pp. 276-277). In contrast, the heavyweight core of *Foldit* participants can ask their own research questions and undertake their own research (idem, p. 293). Novice players can be integrated into this dynamic, gradually. As it's shown on chapter 3, when we get to the *Foldit* on-line game, after registering, we have to go through a pedagogical path before we get to contribute to the “real” science. When considering the majority of the astronomy-based games the situation is different.

When first using *Moon Mappers*, of *CosmoQuest*, we can immediately start spotting Craters on images taken by telescopes. The low threshold of participation brings about a common critical point about citizen science games, the accuracy. The solution taken by *CosmoQuest* and *Zoo Universe* games is take into account the majority vote (idem, p. 18). More than one person will classify the same object, bringing the democratic values of scientific practice, although in different terms, into citizen science.

Initially, all of the three citizen science initiatives studied by Curtis were organized in a top-down fashion (ibid., p. 286). That came to change over time. In their essence, these citizen scientists were basically considered as a “free labour resource” (ibid., p. 276), not very differently from the XIX century's participative vision of Whewell. The evolution of the latest years, that Curtis draws on her thesis in one of greater cooperation among citizen and professional researchers, very much dependent on the coming together of able communities.

One of the findings of Curtis, when analyzing the motivations of these 'heavyweight' players was that there was a tension between the competitive and cooperative attitudes

(Curtis 2015, pp. 168-170). Directly from the participants' statements we find this polarity. Many users login to their program to be able to compete and win, only mattering the ranking of the gameplay. For a *Foldit@home* user, this program running on his personal computer was mainly “Hollywood Science” (ibid., p. 301). In opposition, other users of the same distributed thinking program stated a personal experience of disease as motivation to run the program, wanting genuinely to contribute to science research development (ibid., p. 267). We can relate this to the altruist statements of other players, wanting to contribute to public good (ibid., p. 272). In any case, one of the final conclusions taken by Curtis is that these citizen science projects lead to the empowerment of citizen scientists to the production of scientific knowledge (ibid., p. 311).

Play vs. Reality?

Citizen science has a ludic character. The virtual step of gamification, translating scientific research into on-line games is revealing. When registering into a web-site, such as *Moon Mappers*, the new player is agreeing into rules of action. Using Colas Duclos' metaphor, as entering certain Russian Museums, the individual leaves his shoes at the door, exchanging those by slippers. Accepting the rules of the game, the natural liberty is exchanged by this *legaliberty* (Duclos 1997, p. 77). The acceptance of a set of rules, unlocks the *ludic freedom*. Such *ludic contract* is here made mirroring Rousseau's *Social Contract*. The Different competition and cooperation strategies can be envisioned in that time-space, all sprouting from that choice of acceptance to enter and abide by its rules.

Still, the acceptance of the game' rules and entrance into its *ludic space* can take us to an apparent paradox. Citizen science appears often criticized as being an opportunity to take advantage of free work. Still, if considering citizen scientists that play on-line, they do it in their free time, as leisure. If we consider players that do it for fun, for the pleasure of competition or that are transient in their participation, an image of the scientific practice is built, in contrast with the hard work of other citizen and professional scientists.

Curtis reflection on citizen science volunteers motivation finds this opposition. Research hard work and uninterested cooperation in contrast with playing for the ranking and competition (Curtis 2015, pp. 168-170). Engaged volunteers can do it for the pleasure of the agonal play or for the altruist well-being of the community.

Still, if considered by itself in relation to the game, this opposition isn't problematic. An altruist player can co-exist with an agonal player in the play time-space. In real life is different, though. When Whewell created a space for the “subordinate labourers” to take action in science research, he also forged the socio-professional role of the science researcher. Science research became a profession, associated with a profit. To be a volunteer isn't the same than being a free worker, it just means that the primary motives for participating aren't connected to profit.

Therefore, citizen science appears in an interesting position when thinking about the ludic contract, as defined by Duclos (Duclos 1997, pp. 77-79). Serious games are joined by participants to take decision on real-life issues, the design of those games is based on the simulation of those events. Citizen science is much closer to reality that the serious games, but that duality play/reality continues there. Science made by playing, made by agonal fiction, is it science still?

Discussion

Habermas identifies the coming together of spaces for the public use of reason in Europe. To enter the public sphere, everyone had to be able to participate. This agreement was tacit, when approaching Rousseau's *Procope* and the British coffee places of the XVIII century, where only certain gentlemen were entering. Quite different from the French *salons* of the same period, were women were clearly playing the role of gatekeepers allowing the entrance of only certain individuals. The same parallelism can be drawn with virtual citizen science. The theoretical frame adapted by Curtis, that polarizes crowds and communities, shows that these science games can distribute themselves in that range. A player of *Planet Hunters* can more easily be transient and enter the game, like someone going into *Procope*, while a *Foldit* player will have to meet

certain requirements before starting to play “real” protein puzzles, like getting a proper invitation to enter the *salon*.

Understanding how this citizen science movement works, its social rules, references and events, we can, simultaneously grasp its relevance. We're driving through a side road, on the margins of what can be defined as science. Big challenges taken to science research, as the *data deluge*, are being tackled by this participative approaches. This new rules being taken at the small road might transform in the future how the big road might look like.

Science Research is political. From a common understanding, by being part of a public sphere, one can make statements, do actions that are different from the ones taken individually. And the participative take on the science research activity is specially relevant on this political dimension. The inside and outside of the science research community seems more permeable. Other layers are created. Communities appear as public spheres. New possibilities are open to meet ideas and to develop actions.

When considering the motivations of these volunteers, we find some concrete examples of altruist players of protein folding that want to contribute to find cures to diseases. Being part of virtual public spheres, aren't they able to find more density to their practice? In their scientific activity, they will have to deal with error and frustration, a probable long process to deal with the unknown, as the research practice is different from the clean ready-made image given by mass media. Moreover, to find the structure of a protein involved in the action mechanism of a disease is a first-step to develop drugs. But the pharmaceutical industry is also framed by its own political issues. To tackle with the cure of a disease can be a first-step to frame it with its probable causes, genetic and environmental and to join a wider societal discussion.

Curtis acknowledges, on a final remark, that participation on the on-line citizen science projects she analyzed brings about an empowerment to the production of scientific knowledge. But can this participation be more expressive than that? I mean, if taking empowerment as a key concept, isn't it possible that being part of these games, unlocks a different attitude towards other domains, than just scientific knowledge?

Additionally, there's a philosophical and political relevance when dealing with the contrast between the dimensions of the game and of reality. A contrast built by gamers that are focused on the agonal nature of the play, on its competition for ranking, and other gamers that are there for passion for scientific research. Professional scientists, trained at the Academy, deal with a specific way to produce knowledge, translated to what virtual citizen science relates to reality. Many times, through their communication, they represent a naive realism. Agonal players of science that don't give relevance to the research being done focus into the competition designed inside the game, but also into a concrete World view, that can be detached from the origin of those rules. Professional scientists suddenly teamed with citizens are, then, obliged to face and negotiate with these other worldviews.

I didn't follow back Drhaugh. Last time I've read about him, he was frustrated about his discovery. On the image from *Moon Mappers*, he discovered on the surface of the satellite something different, that wasn't a Crater. By communication on the game's forum, he and another gamer were lead to believe it was an old rover. But the Team Scientist reply, on New Year's Eve, was clear: It's not a rover, it's a boulder. Did Drhaugh get over his frustration and used his reason to the understanding of what that really was?

Chapter V
MOMENTS OF COMMUNITY

Biohackers, taking Labs into communities

Rob Carlson was once a senior researcher at Washington University. He had worked closely with the first synthetic biologists, who sought to simplify molecular biology by treating it as an engineering discipline. And simple it did seem. He was aimed to develop a protein-tagging system, but wasn't into institutional research anymore. Could he take the matters into his own hands? Does it sound crazy? The most basic laboratory equipment is extremely expensive, that's a prompt obstacle. Or is it? In 2005, Rob found out that old laboratory equipment was getting easier to find online, even on e-bay. To work with genetics, like he did, he would need some hardware and software, but that was getting cheap as well. That and you could always up-cycle, to cannibalize some old equipment and computers that were once abandoned by public research and could now find a new life in a cozy private space. Rob announced his discovery to the World in an article in Wired magazine: anyone could build-up a laboratory on a small garage (Carlson 2005). He built his own that same year. That was just the start. Today there are community labs, as the Parisian La Paillasse, establishing new territories in science research (La Paillasse 2015).

The 2005' media coverage of the home laboratory of Dr. Carlson had an immediate consequence. The first group laboratories came to be with many new biohackers joining. Do-It-Yourself Biology, or DIYbio, became such global movement spreading the use of biotechnology beyond traditional academic and industrial institutions. It started to take shape in 2000, but it was in 2005 in a report published at Nature Biotechnology that built its reputation and through an article at *Wired* that it started getting notorious (Grushkin et al. 2013, p. 9). DIYbio had evolve to include approximately 3'300, according to the number of online DIYbio message board members (Grushkin et al. 2013, p. 8). People who were originally doing kitchen or garage experiments began organizing and setting up labs in commercial spaces. Most of these volunteers and entrepreneurs are young and north-American, but are also distributed along Europe, Syria and New Zealand (Grushkin et al. 2013, Landrain 2014). They pooled resources to buy, or take donations, of equipment and began the group labs, also known as “community labs”, that sustain themselves on volunteers and membership donations.

Paid classes have a role also, with lessons in synthetic biology, neuroscience, bioart, genetics, and basic biotechnology (Grushkin et al. 2013, p. 5). According to the research done by Synthetic Biology Project of Wilson Center, inside most of the DIYbio laboratories from 2011-2013 were performed mostly the basic bio-technological operations, as it happens in any University (idem, p. 12). Still, when following the practices of these biohackers we realize that the nature of the majority is distinct from the institutional student-researcher and far from the bioterrorist. DIYbio practitioners are a mix of amateurs, enthusiasts, students, and trained scientists.

Most of the biohackers work in multiple spaces and there's a diversity of backgrounds (idem, p. 7). Each biohacking facility has its own identity. The first community labs opened up in the USA, in Brooklyn, New York, and in Sunnyvale, California and are now spread Worldwide. La Paillasse is one of the most recent. Being formed in 2012 in the outskirts of Paris, moved in September 2014 out of the suburbs into the city center, to the deuxième arrondissement of the city (Cheshire 2014). According to Thomas Landrain, founder and president of La Paillasse, these are new 750 m2 “of pure freedom” (Landrain 2014, video at 9 minutes). It all began with Landrain going enthusiastically inside an hackerspace. Once he got there he built the first iteration of La Paillasse, finding old equipment in University Laboratories (Cheshire 2014).

This *biochiner*, antiquing, is exactly the mark of innovation of La Paillasse, according to Landrain, and one of the greatest strengths of the Do-It-Yourself biology movement (Landrain 2014; Grushkin et al. 2013, p. 12). DIYers have succeeded in producing inexpensive alternatives to expensive biotechnology equipment. Such everyday equipment of a lab, as a professional Polymerase Chain Reaction machine, a lab staple used to amplify the DNA (meaning to make more copies of the same genetic material) costs more than $2,000. DIYers developed their own kit version that only costs $600 and are giving openly the schematics online (Grushkin et al. 2013, p. 11). The same logic applies to other lab equipment, as the gene gun showed on Figure 5.1.

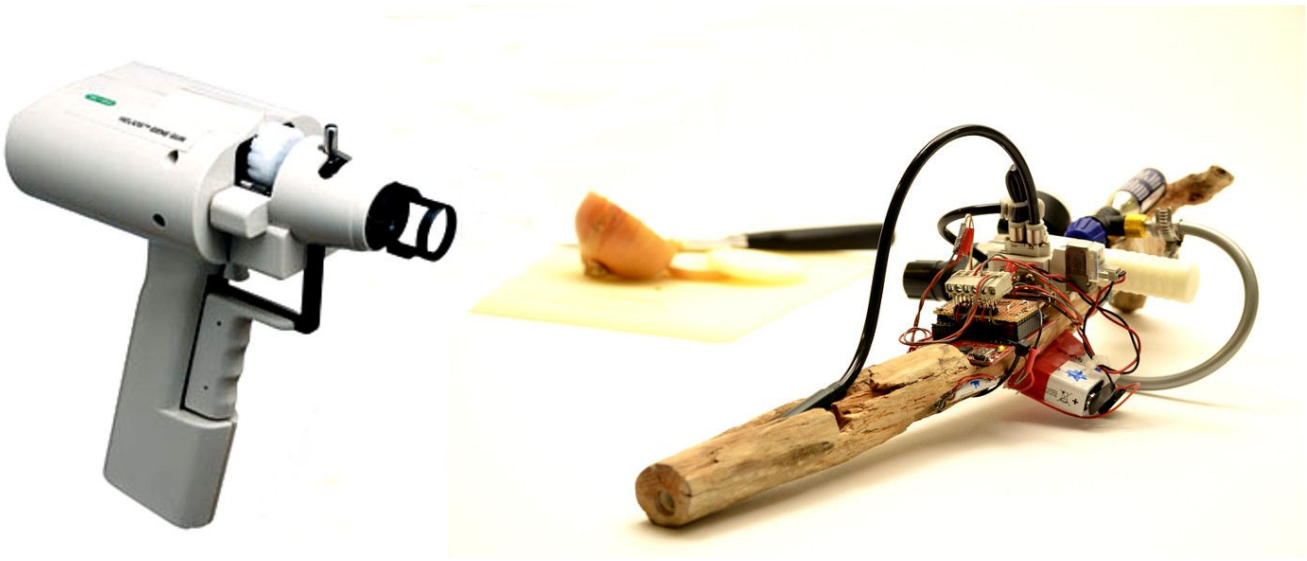

Figure 5.1. A gene gun or a biolistic particle delivery system, originally designed for plant transformation, is a device for injecting cells with genetic information. This technique was developed as an alternative to other, more traditional genetic material transfection methods. The technique fires microparticles that insert the desoxy (or rybo)-nucleic-acid into the target cells. The Helios® Bio-Rad gene gun, shown on the left, is one of the most popular choices in biotechnology laboratories using bioballistics. The one on the right is also a gene gun hacked by Rüdiger Trojok, a biohacker. As the Bio-Rad solution is integrated into scientific research technological problem solving (e.g. O'Brien JA, Holt M et. at. 2001; O'Brien JA, Lummis SCR 2011), Rüdiger's hacking is presented as an effective way to have access to this technology, as to perform a basic transfection into onion cells. The hacked gene gun, shared without peer-review with other biohackers can be done spending 50 euros, while the professional one from Bio-rad can get to 15.000 euros (Trojok 2012).

Affronting the academic culture, Landrain asks “Why should one wait to get a PhD? Why should one wait to get a million dollars in his bank account to set up a lab to experiment his own ideas?” (Landrain 2014, video at 4 m). La Paillasse came out of a need, of looking for solutions for “zero euro laboratories” (idem, at 5m55s).

In-between academic research and open-source culture

DIYbio is deeply influenced by open-source culture in comparison with 'formal' academic research. Open-source is a concept emerging from software development, consisting in the collective effort of individuals towards a common goal in a more-or-less informal and loosely structured way. Most of those are individuals are working on their free time and no single entity owns the end product free of charge to be used. The most famous examples of open source software include the GNU/Linux operating system, the Apache web server, Perl and BIND (Benkler Nissenbaum 2006, p. 395). Some characteristics of the DIYbio movement allow us to see its proximity to the open source culture, that distinguishes it from the more normative science research:

- First, the antiquing and up-cycling culture that is common to both movements;

- Second, in contrast with the academic culture, the communication of results is also done differently, as rather than to wait for some peer-reviewed publication, members are more likely to emblazon their accomplishments on the Internet (Grushkin et al. 2013, p. 8). As the open source developers share openly information, interestingly enough, also some citizen science projects see the same behavior from their participants (Fortson Masters et. al. 2012);

- Third, the cooperative action that arouses in the community labs inherits the unbounded movement of wills of individuals. In a squat house anyone might come in at any minute. From it, the interdisciplinary character of the biohacker' labs is a fruitful consequence, that academic labs are not able to reach, says Landrain. In La Paillasse the seemingly aleatory cooperation between designers and biologists have come to daylight, as a pen that produces its own ink with bacteria or the creation of fabrics with bio-celulose (La Paillasse 2015). According to Landrain statements, “You can work with anyone and you can address those problems that you cannot deal by yourself. Academic labs aren't prepared for this kind of permeability between labs and disciplines, this is making innovation slower” (Landrain 2014, video 22m). In this sharing space, while most DIYers are still learning the essentials of biotechnology, many already have

expertise in electronics and access to rapid prototyping tools like 3D printers and laser cutters (Grushkin et al. 2013, p. 11).

In example of this interdisciplinary permeability, Sarah Choukah says that her membership to the biohacking community Bricobio in Montreal, Quebec, allows “being playful with concepts and tools we would otherwise take for granted or don't know enough about” (La Paillasse 2015). Other community labs, as Bricobio, reach out to the lay public and students with hands-on training and education that would otherwise be available only to university students and those in industry (Grushkin et al. 2013, p. 8). Inside these spaces, the social interplay is more informal and allows the participant more easily to tinker, to play around an object and glass-box it. The focus of the efforts on using the technology can be diverse, as to create art, or to explore genes and proteins. Hence, DIYbio is strongly marked by the desire to a more democratic access to knowledge than in the formal learning tracks (Landrain 2014, 3m50).

Do-It-Yourself biology, tracking lines of identity

DIYbio can be thought as the coming together of a *community based on equality,* in the active affirmation of social egalitarian principles. Inside this movement there is no single voice that can speak on behalf of the others. In spite of the strong care with safety shared among biohackers, there is no way to know what every member is doing at any given time (Grushkin et al. 2013, p. 8). In agreement, according to Landrain, “the mind-framework at La Paillasse is that you know you can do whatever you want, wherever you want and whenever you want” (Landrain 2014, video at 22m10s).

As a broad and decentralized movement, DIYbio is close to its contemporary Occupy movement that started out from 2011 reclaiming the public space for equality of rights against the global market. Manfred Steger and Paul James see Occupy as a type of “justice globalism”, generating world wide protests against inequality and uneven distribution of wealth (Steger, James 2013). Its social organization is characterized as a grass roots movement, decision starting at the basis, just like DIYbio affirmed itself to be. With La Paillasse being originated in a squat, DIYbio also shares this political

motivation as denouncers of a corrupted system (Pruijt 2013). Testemonials of DIYers also address their critical awareness towards the State and Economical Market (La Paillasse 2015).

Still, economical innovation is, paradoxically, one of the aims of the movement. Ideas and products emerging from DIYers already present several academic and industrial applications. As in example, the products developed include: Inexpensive biotech equipment and diagnostic tests for the developing world (Grushkin et al. 2013, p. 8), a pen that lives more and independently, as it produces its own ink with bacteria and the development of biodegradable fabrics (Landrain 2014). The aspirations of DIYbio are bold, as “DIYbio can inspire a generation of bioengineers to discover new medicines, customize crops to feed the world’s exploding population, harness microbes to sequester carbon, solve the energy crisis, or even grow our next building materials” (Grushkin et al. 2013, p. 4). The movement shows a strong humanitarian-ecological ethos and integration into the economic market.

Also in terms of biosafety, all community labs have security rules and overall they are getting more integrated into laboratories' formal administration's demands (Grushkin et al. 2013, p. 9). For all these reasons, DIYbio doesn't seem more prone to irresponsibility or bioterrorism. Since the first reports of Carlson's new home laboratory, the media had overtly speculated about the offspring of bioterrist cells. Just like with other movements of “justice globalism”, there was an immediate mediatization of fear, that got diluted in the following years.

- La Paillasse communitary research centre was itself a squat “where you could get all your equipment for free” (Landrain 2014, video at 6m). Many squats have been social centres, give-away shops or pirate radios (Pruijt 2013). As it was just mentioned, the squat that gave origin to the parisian community laboratory was also an hackerspace, a space where people cooperate in understanding and building up hardware and software. A good part of the cooperation that happens online for the development and management of open source technology is also physically taking place in such hackerspaces. The DIYbio network shares this up-cycling culture, as the idle instruments of academic research are restored and

reused in these continuous search for inexpensive and ecologically viable alternatives;

Another line of identity in DIYbio was claimed through the before-mentioned open source culture. Many DIYers affirm themselves as hackers, that the biotechnology appropriation they propose is parallel with the first hackers in the 1970's that created the personal computers (Landrain 2014). From the hackers movement, an whole set of digital tools has been developed, framed by the open source technology. The licensing of these products fall under the GNU General Public License model, now on its third version since 2007, and allows the free sharing and editing of the works done, unlike the commercial models. The most famous examples of this intellectual licenses are the *Linux operating system* and the *Wikipedia Free Encyclopedia*. Altogether, this alternative socio-economic system of production is described as Commons-based Peer Production. The commons enterprise, besides avoiding the market pricing, also applies a coordination without managerial hierarchies. Some authors make evident how this approach fosters important moral and political virtues (Benkler Nissenbaum 2006).

Taking a step further, some members of DIYbio together with more citizens, took the legacy of the commons into the biosciences. Can discoveries, technologies and products be considered politically as common goods? From a discussion held in Helsinki, at June 2014, the concept of Bio-Commons was settled. Not only DIYbio members were involved. Together they identified requirements and conditions of Open-Source and Citizen-Science concepts to realize Responsible Research and Innovation (RRI) in the Life Sciences. The political frame for the action of the DIYbio became, this way more substantial.

As inclusive spaces prone to experimentation and error, community laboratories are open to people to explore its aesthetic value, producing art. Others were longing for a space to do with genes the same amateur astronomers were doing with the night sky. The biology was “too much important to be left over in the hands of professionals” (Landrain 2014, video at 3m50s), as if the formal science research was in need of democracy.

On the route for equality

Much of the DIYbio identity looks to be rooted in the political affirmation of equality through the words of Tomas Landrain. Biotechnology was taken out of formal laboratories into the fold of hackerspaces, asserted into a political position of global justice. The statements taken by Landrain are also connected to the community lab that Landrain integrates, La Paillasse, that opened doors at September' 2014 in a new wider space in Paris. His arguments on equality, though, go beyond the walls of the community space in the middle of the French capital, they define the DIYbio movement. In this frame, DIYbio can be represented as a re-enactement, a re-invention of a *Community of Equals* (Rancière 1995). The concept was coined by Jacques Rancière, a contemporary thinker that has been described as having as fundamental message, the democratization of knowledge (Nordmann 2007 in Pelletier 2009, p. 13). According to Rancière, democracy can be defined as the space for egalitarian practice on the making (Rancière 1995, p. 90). Such concept of the community of equals can be inscribed in these events of coming together. Still, to reach equality is a political and philosophical problem, that can be appreciated reflecting with Rancière.

Jacques Rancière is Emeritus Professor of Philosophy, at the University of Paris VIII (St. Denis). He has a wide array of fields of study, from politics to aesthetics and education. According to Kristin Ross, we can identify two moments in Rancière's work: an archival and another, critical phase. The archival phase, including his research of the XIX century workers and dynamics, is characterized by an eruption of negativity of *thinking* into a social category always defined by the positivity of *doing*. Such groundwork nourishes a critique of the claims of bourgeois observers and intellectuals (Ross 1991, p. xviii). In the axis of these reflections are the concepts of *equality* and *emancipation*.

After May 1968 with Jacques Rancière

The student demonstrations of May' 1968 had students taking public spaces and implementing other decision-making methods, just in the University as with workers in the factory. For some it represented the inauguration of new politics that related knowledge to power (Ross 1991, p. xvi-xvii), that energized transformations in the following years. Hopes for social change dissipated, the 1970's favored above all the sociological reflection itself.

After May'68, *reproduction* and *distinction* became popular concepts with the new sociology of Pierre Bourdieu. The reproduction and distinction of social inequality didn't have a considerable impact to sociologists, but it did transform the practice of historians, anthropologists and pedagogues (Ross 1991, p. x). With such a critique of social dominance, the traditional schooling was discredited. The science that Bourdieu builds maintains a critical attitude towards social arrangements, whilst keeping the sociologist in the role of denouncer. In the words of the editors of 1984's *L'Empire du sociologue* this discourse is fitting for a time that combines the "orphaned fervour of denouncing the system with the disenchanted certitude of its perpetuity" (ibidem).

The new sociologist, as designed by Bourdieu, could unveil the relations of dominance hidden from other social actors. Rancière formulates the logic of Bourdieu's argument with two propositions (Rancière 1984, p. 28):

1. the working class are excluded from University because they do not understand the real reasons for which they are excluded (from *Les Héritiers*, Bourdieu 1964)

2. the misrecognition of the real reasons for which they are excluded is a structural effect produced by the very system from which they are excluded (from *La Reproduction*, Bourdieu 1970).

The " Bourdieu effect" could be summed up in this perfect circle, a tautology. As Rancière explains, the workers are excluded because they don't know why; and they don't know why they are excluded because they are excluded. From this perspective, Bourdieu's analysis of the division of knowledge between social groups appears as an

explanation of inequality. Other critics of Bourdieu have pointed out that if we take into account misrecognition with its necessary corollary, reflexivity, he find Bourdieu's claims contradictory (Alexander, 1995 in Pelletier 2009, p. 5).

Pierre Bordieu standed in one side of the equation for the renewal of french education. His sociology of education, the transformation of school from the social conditions was opposed by Jean-Claude Milner, with the republican teaching and equality by the diffusion of knowledge. The education's aim at school should be "instruction", transmitting knowledge, not "educating" (Ross 1991, p. xiv). The development of approaches to education that undertook a compensatory attitude to unequal opportunity meant for Milner a sacrifice of true scholarly research (idem, pp. xiii, xiv). These institutional reforms referred back to Bordieu's vision, of the transformation of school starting from the social relations. Jacques Rancière didn't agree with it, but either with the solution appointed by Milner. Milner's focus on "instruction" referred back to the public, mandatory, secular laws on education passed by the republican Jules Ferry on the end of the nineteenth century. For Rancière, this pure, scientific transmission never in fact existed... (idem, p. xv).

Milner and Rancière in spite of their diverging viewpoints on education, were both part of the young theorists of the "cercle d'Ulm", the *Union des Etudiants Communistes*. Just on the other side of the river of the biohackers at La Paillasse, these young students attended classes at the Ecole Normale Superieure, in the 5éme arrondissement of Paris. The marxist Louis Althusser gave them early seminars on Marx. Rancière, through his 1974' La Leçon d'Althusser examined the political core of the althusserian philosophy, the communist opposition between science and ideology, on the light of the post-68 developments and the revolutionary tradition (ibidem). More and more, Rancière gained distance from the marxist tradition. Nowadays, he sees the capitalist domination taking place. The protests of May'68 can be seen as giving to capitalism, after the oil crisis of 1973, the means to regenerate itself (Rancière 2008, p. 53). More accutely, he accuses a shift of Marx to the heart of the system, as a "ventriloquist voice" (idem, p. 50). The subversive logic of contemporary capitalism, he accuses, subsumes all wishes of autonomy and creativity (idem, p. 53).

James and Steger are clear, alter-globalization movements, as the Occupy, work often within many of the same subjective frameworks and precepts as the market-globalist world that it criticizes (James Steger 2013). In agreement, Rancière included in his *Emancipated Spectator*, a 2005' piece of art of Josephine Meckseper (Rancière 2008, p. 41), that is reproduced in Figure 5.2. In the second plan of Josephine's photography, an anti-war protest occurs while in the forefront a full bin of trash overflows. Terrorism and consumption, protest and spectacle are re-directed to a same and only process. This is also an affirmation of equality, the market rule of equivalence (Rancière 2008, p. 45). According to Rancière, Marx “is now lodged at the heart of the system as it ventriloquist' voice. He has become the infamous spectre or the infamous father who testifies to the shared infamy of the children of Marx and Coca-Cola.” (Rancière 2008, p. 50). It's more than a disapproval of the demonstrators that the photography of Meckseper attests. The power of domination has assimilated marxism.

The failure of finding alternatives to the neoliberal globalization, makes us guilty. Even the May'68 students protests can be seen as giving capitalism, after the oil crisis of 1973, the means to recover (ibidem, p. 53). In an earlier work, Rancière places here, in the same identity line, the 1986 french students upheavals against the more 'selective' public university (Rancière 1995, p. 91). “Participation”, “innovation”, “citizenship for projects” are all integrated into the lexicon of the dominant power. Still, the critical reflection of Rancière isn't debouching in a dead end. How to overcome the market domination?

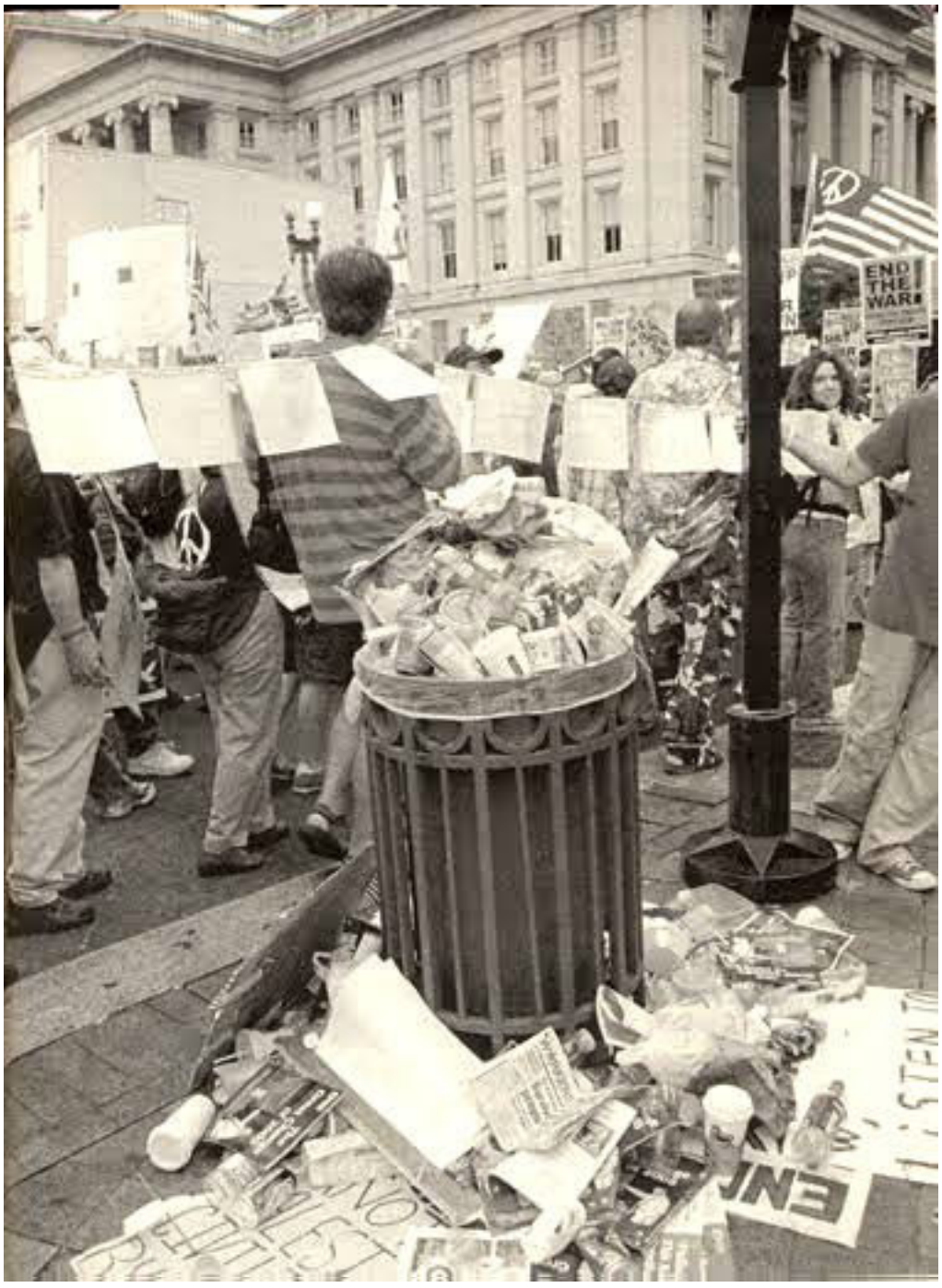

Figure 5.2. Josephine Meckseper's untitled. It's part of a series of photographs of street protests taken after the announcement of the invasion of Iraq in 2003. It was shown in one of the main cultural venues of the second biennial of contemporary art in Seville in 2006. Juxtaposing in the same frame the protests against the war and the consumerism of the same crowd, this art piece gives a clear insight. According to Rancière's own words, Josephine's work “tries to show protest culture as a form of youth fashion” (Carnevale Kelsey 2007, p. 259)

Community of equals, re-enacted

The (re-)invention of the *community of equals*, according to Rancière: (i) is part of the random interplay between what is there and what forces change; (ii) is fundamentally part of a process of sharing; (iii) refers to an earlier coming together of egalitarian event and egalitarian text (idem, p. 90).

If we take Rancière's egalitarian signifier to the heart of DIYbio message, many parallelisms can be drafted. From Rob Carlson's initial step, grounding a laboratory on his garage and finding a new use to old lab equipment, community labs spread around the World. This practice seems to get out of Bordieu's disenchanted' tautology while, at the same time, don't carry out Milner's view on education as top-down instruction. The spaces where biohackers exercise are designed as based on social inclusion and, by contrast with formal laboratories, with a vigorous political base of equality.

But where is the egalitarian text that defines the DIYbio community? The *Bio-Commons Whitepaper*, released in the end of 2014 takes, in part, such a role. The paper is signed by Rüdiger Trojok, involved in the build-up of a citizen science biolab in Berlin (Trojok 2014). Still, this paper claims to be the result of a meeting of individuals, not only DIYbio members, but participants in an open meeting in Helsinki. They present themselves as *citizens*. It's easily understood that this mantle of citizenship is one closer to the republican model, than to a liberal conception. The individuals claim their roles of citizens through their political agency using their own processes of deliberation and decision-making (Leydet 2014).

Starting out from a concrete problem, a public health issue, DIYbio forges an egalitarian text. The need to develop new antibiotics, from the challenges to Human health by multi-resistant bacteria, recruits their involvement. From their statement, not only air, earth, water, but also “discoveries, inventions and man-made creations such as genetic codes, algorithms, novel metabolic pathways and molecular processes designed for and realized in biological media and even entire organisms can be considered as natural goods” (Trojok 2014, p. 5). The aim of the Bio-Commons Whitepaper is, therefore, to

envision a strategy to import the commons concept into life sciences. The way it is drafted implies, although, its own dangers.

The fundamental text of DIYbio establishes the Bio-Commons license as a way to stabilize global collaborations and overcome the over-exploitation of common goods and the failure of the Economical Market. Ethically, it is established as a tool to protect and manage any type of biological knowledge in order to curtail possible misuse (ibidem, p. 21). Still, the products developed under this frame will follow the market regulations. Or in other words, the fierce claim of equality of DIYbio will need to deal with money and an uneven distribution of goods.

Brooding within equality

In 1984 Jacques Rancière gave a lecture with Alain Badiou that further developed his reading of claims for equality and the communist tradition. The Community of Equals is based on this experience, published in *Aux bords du politique* in 1990 (english version - Rancière 1995).

As a starting point, Rancière affirms two kinds of brooding in the becoming of the community of equals (Rancière 1995, p. 63). On one side, a “grudging relief”, as individual will and reason is menaced by the social leveling of the “great whole”. On the opposite side, a 'reasonable' nostalgia, described as a virtue of generosity of 'being together', characteristic of politics.

The representation of socialist and communist *ardour* is connected to the foundational works on the 'utopian socialism' of Pierre Leroux (ibidem, p. 65). His 1838' *De l'Igalité* and 1840' *De l'Humanité* was adopted by the working class press. A dual origin can be traced of this representation. First, the image of a fraternal meal, inspired in the dynamics of old Greece' warrior Spartan fraternity. Secondly, the words of the Epistle to Romans: we are all members one of the other, as one body in Christ. A historical reading of the workers emancipation, place it better in time as a coming to awareness,

as a “self-consciousness of democracy”, going against the oligarch values of work as envisioned by the July Monarchy of Louis Philippe I (idem, p. 80).

As the French communist movement dimmed down, the visionary egalitarian dream of Marx was re-enacted with the Icaria settling. Étienne Cabet, or father Cabet as he was called, lead his followers to the USA where he established a number of communes from 1848 through 1898. Similarly to its French counterpart, tells us Rancière, the Icarian community was torn-out by unequal distribution of goods and roles (idem, p. 78). All the egalitarian narratives we find with Rancière are fated to fail due to an incomprehension of equality.

Rancière's reading of the utopian socialist events place the workers movement as the before-mentioned (re)invention of the community of equals. Still, just like the contemporary re-enactements of 1968, it is fated to doom: “no sooner than its system is it instituted than its system of identification collapses: the communist worker is immediately split into toiler and communist, worker and brother” (idem, p. 76). The recurrent split of the communist movement was unavoidable. The founding text given by Leroux, the “christian formula for equality” is, as maintained by the commentaries of the Church' Fathers, as Gregory of Nanzius, also the formula for hierarchy. In other words, the great Christ-like image of the communist body hides the Pauline image of the body of the church (idem, p. 69). Also, the recollection of the spartan fraternal meal is ill-fated. As Rancière recalls, the spartan fraternal meals were called *phidities*. From a passage of Aristotle's *Rhetoric*, Diogenes said that Athenians found their *phidities* in taverns. Likewise, in contrast with the Spartan meals, Aristotle's Politics favors Athenians communal meals, where each one pays an equal share (ibid., pp. 66, 67, 69). The “inconvenient discordance” between community and democracy is one that Plato well envisioned and that many choose to ignore.

In-between the Athenian school of freedom and easy living and the military discipline of Sparta, many “moderns” plotted their visions of more democratic and civilized societies. Such was the case of Jacques Rousseau and Pierre Leroux, envisioning an Athenian Sparta. The foundation of such communities, tells us Rancière, will be fated to a schism. The voyage to Icaria, founded on the same principles than Laroux's socialism, was also

split, as if the old Plato was getting his revenge (idem, p. 78). Plato's Republic' gives a Community of Guardians, which has as a founding rule that all of what they have of their own in what is common. The government of lower by higher “ties non-belonging to equality” (idem, p. 73). The community of guardians means, in the first place, the rejection of possession and affirms it as the step to equality. The original source of the above-mentioned communitarian miscalculation lies in a singular experience of transgression, that in platonic terms means a revolt of *cardinal* against *ordinal* (idem, p. 87).

As Rancière reviews, true equality, as friendship, contrasts with false equality, as the citizens that claim equality with scales, just like merchants (idem, p. 73). It represents a classic opposition between geometric and arithmetic equality, one that Plato was well aware. The community of labor and another, of fraternity, have different logics. The social bond has inherent a form of organization based on an inegalitarian logic, while fraternity with its acts of wanting to speak and listening has deep rooted a logic based on equality (idem, p. 88). According to Rancière, “a community of equals is an insubstantial community of individuals engaged in the ongoing creation of equality. Anything paraded under this banner is either a trick, a school or a military unit” (idem, p. 84).

The brooding of the community of equals is therefore deciphered. Bringing together the two orders of the social and the labor amounts to “casting the imaginary veil of the One” over the schism that puts these apart (idem, p. 84). Still, the generosity of “being together” appeals to the true meaning of democracy, as the “space for egalitarian practice in the making” (idem, p. 91). Equality and community are in a “never-ending settling of accounts” (idem, p. 65), as the community of equals can always be re-invented. The re-inscription of such an “egalitarian signifier” can happen in reaction to any stimuli, as any apparently insignificant political measure, a word-out-of-place, a badly judged assertion (idem, p. 91). A beast is awaken, an old-Greek *apeiron*, as desire knows no determination and limits.

Discussion

For the worldwide community of *Do-It-Yourself biology* (DIYbio), a re-enactment of a community of equals is made (Rancière 1995, p. 90). As with other denouncements of contemporary justice globalism, the technoscience is denounced as corrupt, the economy of research as elitist. In the DIYbio community laboratories the technology is up-scaled to be more inclusive. The identity of this community is close to the occupy movement, the cyberhackers and the open-source culture, that give references of egalitarian events in the past. Commons-based peer production, an alternative way of facing the economical market by open source technology is adopted in one of DIYbio main texts, the *Biocommons white paper*. There is devised an inclusive way to approach the commons, to include not only “natural goods”, as air, water, earth, but also entire organisms, biochemical processes and other discoveries and man-made biological and biochemical concepts. Biotechnology has, then, with DIYbio, a new political and economical vision based on equality.

In the community labs, a random play takes place. In that setting of up-cycled biotechnology equipment, anyone can enter. The political affirmation of equality makes that sharing between the “lab rats” and other people the central point. The global change of such meeting is stated by the DIYbio movement as one of devising new knowledge and new objects to solve global issues, that enter the economical market. And that is the most critical point following Rancière.

The post-May'68 revolutionary energies had an impact on Rancière's thought. Many egalitarian signifiers came together in the demonstrations and group works but, with time, were subdued by capitalism. Can the biohackers venture be just a new Icaria? Is DIYbio ill-fated because it affirms equality in the unequal world of work? The coming of Plato's revenge might be seen as a warning, as Rancière's narrative might be appreciated without the fatalist tone, but with an hopeful overture. To follow the “democratic passion” might put us at crossroads, but it means exactly this possibility of acknowledging the possible roads, and, this way, to be “prepared to be torn in all directions at once” (Rancière 1995, p. 80).

Chapter VI
ROUTES TO EMANCIPATION

Hay otros días que no han llegado aún,
que están haciéndose
como el pan o las sillas o el producto
de las farmacias o de los talleres:
hay fábricas de días que vendrán

existen artesanos del alma
que levantan y pesan y preparan
ciertos días amargos o preciosos
que de repente llegan a la puerta
para premiarnos con una naranja
o para asesinarnos de inmediato.

[Pablo Neruda, **Esperemos]**

Choosing the question that matters

Just sat in front of me was Mitterrand. At my side was Coline, a fellow facilitator. With other friends, young adults living in the ghetto like Mitterrand, we have gathered an astonishing number of questions, now made into little strips of paper in the table in front of us. All of those questions referred back to the life in the neighborhood. To some of that questions, written in front of us, we didn't have any answer, or just had wild guesses. Those could become scientific research topics, we thought... 'What is the question you think is the most relevant?', I asked Mitterrand. The place we were at, the room of the the inhabitants association seemed like the perfect place to make that decision. Mitterrand is a leader, his mates usually follow his opinions, so we knew his position could be of importance to the work ahead.

Will the sea eat our community? he asked, picking up the piece of paper. For this neighborhood self-built by the Atlantic, the importance of such question was self-evident. The sea is already, in the latest years, reaching the front doors of the ones living there closest to the sea side. Me and Coline discussed such a possibility, of tacking with this question, inviting some climate change researchers into the fold and digging into climate change scenarios and their scientific relevance. But what would Mitterrand and his friends do with such information?

Knowing if the sea is less or more likely to eat up those small houses allowed the inhabitants to deal with that possibility. Mitterrand envisioned that having that information involved going up to the city council and to demand the community relocation. But it could've meant to mitigate that change or also to install protection measures for the neighborhood. Anyway, it was intended as a call to action.

I like kindly to believe that what we were doing that afternoon was part of the road to emancipation. Mitterrand, Coline, myself and probably others involved are transformed by that decision. As Jacques Rancière recalled, emancipation involves such decision, of destroying the frontier between those who act and those who just watch, between individuals and members of a collective (Rancière 2008, p. 31). Or, as another great thinker, Paulo Freire, would say it was about finding consciousness of the possible.

Finding consciousness of the possible

Social equality can be a motivation to develop learning environments. At the northeast of Brazil in the end of the twentieth century one could find poverty, dehumanization, oppression, and economic exploitation. Paulo Freire, a lawyer, was moved by this scenario. He began a personal quest as a pedagogue, that took him to become an agent of social emancipation.

Paulo Freire had his first interventions in Pernambuco, the Brazilian state which he is a native to, teaching others to read and write. The success of his approach was later on recognized by the Brazilian Government and the United Nations. Learners can go from the “consciousness of the real” to the “consciousness of the possible”, tells us Freire, as they perceive the “viable new alternatives” beyond the “limiting-situations” (Freire, 1974). In other words, one path to Freirian emancipation is to perceive oneself as an active agent of change and the world as a mutable entity – in Freire’s poetic prose, “History is the time of possibility and not of determinism [...] The future is not inexorable, the future is problematic” (Freire 1992, p. 21).

The Freirian approach instigated a radical pedagogy inspiring numerous interventions. How do these relate to scientific culture? Many approaches are based upon community science, with the involved communities developing their own research projects. Of another singular interest are the research protocols built with the involvement of the *Royal Science*, or, in other words, with the active involvement of researchers working within institutions, cooperating with peers, that are part of this “main land” of science research. As I was doing this research on public participation in science research, I came to meet by chance on the streets of Lisbon Leïla Perié and Livio Riboli-Sasco. We took a walk through the Botanical Garden of Lisbon, as were discussing passionately community-based approaches to science research. From that critical reflection we came to talk of a project, *The New Sciences Stakeholders*.

As Freirian methodology was aimed at empowering individuals through alphabetization, the New Sciences Stakeholders aims at empowerment through scientific research practices and values. Livio and Leïla's work are based on these premises, to bring

“consciousnesses of the possible” to conflict areas, as Palestine (Peri L, Riboli-Sasco L, Ribrault C 2014; Perié L, Riboli-Sasco L, Ribrault C, Zlotek-Zlotkiewicz E 2014).

Community work within Science Research

The New Sciences Stakeholders is made of local-specific programs, sponsored by the *Fondation de France*. This private foundation acts linking patrons and other private donors and actors on the field since 1969. It aims to aid vulnerable people, in the development of knowledge and the environment and in the the development of philanthropy itself (Foundation de France 2015). Livio and Leïla belong to a collective called *Atelier des Jours à Venir* that brings passionately this framework to Science Research.

Nowadays, this crossing between community work and science research, involves five different European groups, three of those based in France. The project, better seen as a network, is mostly francophone, being this endeavour best known as *Nouveaux Commanditaires Sciences* (NCS). In its process, participants start questioning certainties, engage in constructive criticism, and collaborate with a variety of people. These practices are central, as characteristic of the democratic praxis of the scientific community. The bigger aim, the transformative potential of being part of such collective process, is to bring it to the interests of the participants and their own community, to address social and political issues they face (Nouveaux Commanditaires Sciences 2015). More than making the scientific research practice reachable, this process is claimed as a methodological tool for social inclusion, contributing to make the Freirian emancipation possible. As other praxis focused before, this approach is transversal to science research and communication, but with its aims and methods is claimed as a tool with “untapped potential” (Peri L, Riboli-Sasco L, Ribrault C 2014, p. 1).

Community work within science communication isn't a novelty. As an example, the so-called *Science Shops* exist for more than 10 years to give access to science research. Science Shops concept began with the student movement and counter-culture of the early 1970s when a group of Dutch chemistry students decided to build a cardboard box for posting questions. Coming from this experience, years after, in the 1990's, Dutch

Science Shops were created out of student associations across the country, trying to reply to the requests coming from civil society. Nowadays they are present in more than 12 European countries as local organizations supporting cooperation between citizens, community organizations, Non-Governmental Organizations and Universities. Institutionally, Science Shops are formalized as an European Network since 2003, as the *international Living Knowledge Network* (LK) (European Commission Research Directorate-General - Science and Society Directorate - Public understanding of science– young people and science Unit 2003; Living Knowledge 2015).

Comparing with the NCS approach, Science Shops have a wider distribution. Both do the connection between civil society and science research, but Science Shops have a more expanded institutionalized network that looks within the scientific research communities for questions and needs coming from Society. NCS represents a smaller scale organization that does something similar but clearly more inclusive.

Many young academic students have been taking part in the search for knowledge demanded at the Science Shops, which is, by itself, a factor for renewal of the academic learning environment. Although the question boxes, where inquiries are delivered, sets the limits of the cooperation established. On the other hand, NCS wants to involve researchers with non-scientists in the making of their practice and have this recognized at the institutional level, within Science Research Institutes. What might be perceived as a slight difference, has a great effect on the societal views at hand. NCS aims to produce a novel research question, through the cooperation of science researchers with each of the new stakeholders group. The co-work is stimulated through stages, raising an immersive environment, transformative of scientific practice.

The emancipation route of the NCS, the sprouting of these “consciousnesses of the possible” can even be understood as including the researchers themselves, actively involved with the stakeholders in the design of novel science research. Besides the science researchers and members of communities directly participating, also mediators and facilitators are involved, triggering and supporting the process. These transformative spaces are established in different settings, besides the usual inside-the-school borders.

Science Research within school borders

The implementation of pedagogical approaches that have an empirical approach to science research, as the *Inquiry Based Science Research* (IBSE) movement, have a long history that can be traced back to John Dewey's vision of educational practice in the beginning of the twentieth century' United States of America (Barrow 2006). Both in Europe and USA, IBSE tools are envisioned to reinvigorate school curriculum and foster the motivation of young students to learn (Osborne, Dillon 2008; Anderson 2002). Also many Citizen Science' projects developed in the last years are complementing more formal approaches inside the school settings. Although, altogether these measures implemented in tight hierarchical settings, as most public schools, can be appreciated as a constraint to the practice of democratic science (Gray Nicosia Jordan 2012).

The first of the *Nouveaux Commanditaires Sciences* (NCS) groups was also developed inside a school. It was envisioned with distance given to learners, so that they could develop their own research practice. A group of volunteers from Lluís de Requesens High School in Molins de Rei, nearby Barcelona, Spain, co-created a research project in Neuroscience (ICIL 2015). In spite of being developed inside a school, there's a marked difference with the IBSE approach. The work developed of the new stakeholders has as a major aim the empowerment of the individuals involved. Enhanced learning can be apprehended as an outcome, but not as an aim, in the route of this research practice developed inside the school.

ICIL stands for *Investigating colors for improved learning*. The research question came from a group of 14 year old students, that produced a video in 2013 for a local science culture contest. In it, they formulated their question: How do colors influence learning? Their formulation was aiming at the colors of the school walls: Was there a color that could better enhance the learning environment? Their query came to fuel the NCS project, a cooperation was set with researchers to find together answers for this question.

Two neuroscientists, Mathilde Bonnefond and Guillaume Sescousse from the Donders Institute of Radbout University in Nijmegen, Netherlands joined the eight volunteers from Molins de Rei High School. At first, the youngsters engaged in science research replicating a protocol, a normative practice of *normal* science research, that relates to the research interests of the group (Doerksen Shimamura 2001). Furthermore, the group developed individual approaches on particular questions inside the same research topic, reflecting their personal interests. In the border of Neuropsychology and Neurobiology they have been focusing on attention and memory, connected to colors and learning (ICIL 2015).

As an outcome of the work of the ICIL group, the students have submitted their work to publish to their peers. Assembling 20 tips for young scientists, the students shared their viewpoints on the relevance and impact of their joint venture (Andújar Campderrós García et al. 2015). *Frontiers for Young Minds* is a peer-reviewed journal, in which the peers are young students themselves, from eight to fifteen years old, engaged in citizen science or other inside-the-school research practices, as with an IBSE setting. Still, within the NCS network there are projects being implemented outside the school and having other starting points, relying more on communitarian work for social inclusion of research practices.

Science Research in the Ghetto

As I found the community-based approach of *Nouveaux Commanditaires Sciences* (NCS), I felt the urge to bring it to my vicinity. 2.º Torrão is a shanty-town in the south margin of Tagus River, in the meeting with the Atlantic Ocean, just 15 Km from my home in Lisbon, Portugal. With about 1'100 inhabitants, it's composed mostly of imigrants from Angola and Mozambique (Censos 2011), which proudly refer to the place as their own ghetto.

The implementation of NCS in 2.º Torrão started in February 2014, in close cooperation with local associations and a popular assembly from Lisbon. A pool of facilitators was formed, people like myself which identify themselves with 2.º Torrão and NCS. To

design our approach we used some Freirian-inspired approaches, with a special emphasis on Paulo Blikstein, researcher in new technologies for education, and his field work in the shanty town of Heliopólis, in São Paulo, Brasil (Blikstein 2009). Together we've been designing the activities' proposals and do all the logistics involved in cooperation with different local leaders. We are now in the first step of the project, the co-construction of a research project, that can take between further two to three years. Unlike forms of popular science that take uniquely into account the people as sovereign in applying scientific methods, NCS includes formal science research.

With the NCS, scientific methods are de-constructed with researchers to include non-scientists into the process. Either if considering social or natural sciences, the scientists involved include, as much as possible, participants into the decision making and, also afterwards, in the implementation of the research and its communication. The first NCS group, the ICIL, had conceived a research question before meeting the NCS community. In 2.º Torrão, although, we've been in this process, implementing different methods (ANNEX I) to develop curiosity and discover one question that matters the most to the ones involved. This initial phase, the one of conceiving a research question, is first developed by the community and co-built with the researcher(s).

From the application of our methods with this community we have found plenty of queries, that puzzled the participants. Those questions all allude back to the life within the community. Some of those can be build up into scientific demands. Mitterrand's choice pinpointed at the beginning of this chapter is enlightening. Will 2.º Torrão be swallowed by the sea?

Can we all be experts?

The problems sciences deal with can have more or less direct impact in our lives. For Mitterrand and the other inhabitants of 2.º Torrão the climate change can mean more risk for the community built there, by the coast. As Miterrand recalled, such information could mean a political standpoint for himself and others living there.

The ascension of a political intervention based on the knowledge produced by studies on climate change, soil erosion or seismic activity is such that it obliges the society to deal with that uncertainty. The participation of communities as 2.º Torrão in the decision making process can be acknowledged, having their experience recognized by research. For Silvio Funtowicz and Jerome Ravetz, movements as the one drafted here are a sign of a “new age”, of “post-normal science” (Funtowicz Ravetz 2000, p. 54). The legitimacy of such interventions, according to the authors, increase the quality of the scientific input (idem, pp. 52-53).

As to the left of Figure 6.1 is shown, Funtowicz and Ravetz show an array of positions of scientific culture according to the social decision stakes and the uncertainty at hand. Applied science appears as the one with least risk, more certain, while professional consultancy involves scientific know-how, just as part of a decision-making process that can rely on other factors. Higher stakes and uncertainty of facts sheds light into other values under dispute. Either if we're talking about health issues or climate change, there's also an urgency in the response. The authors coin this situations as *post-normal science* and reflect a need of the peer communities to extend.

For Harry Collins, sociologist of science, there is a clear conflict upon the adoption of such a view point. Such controversies can represent not more than a counterfeit case of scientific culture. The demarcation of what is and what isn't science-based information needs to be based on clear criteria. As believed by Collins, we need to ascertain “the equivalent of a watergate investigation”, rather than “the felt certainties” of other participants (Collins 2014, p. 108).

Can we all be experts? Harry Collins recognizes a zeitgeist of our contemporary era as one of participation and access to information (idem, p. 120). With it, Collins identifies a social tendency for a 'we-know-it-all' kind of attitude, that he relates to emancipation and defines as a *ubiquitous default expertise* (idem, p. 132). While Funtowicz and Ravetz defined more than a decade before such participation in public life as a matter of appraisal, Collins is, on the contrary, reluctant to find value in it. The author recognizes several other kinds of expertise. Whistle-blowers, committed groups of citizens to the denouncement of a illegal, incorrect or dishonest situation acquire a certain kind of

knowledge. As do the people engaged into investigative journalism. These knowledges have legitimacy for their inside information, or *local discrimination* as Collins calls it (ibid, p. 120). Still, in these movement, to acquire primary source knowledge can be dangerous. The impression that we possess a technical knowledge can be false (ibid, p. 118). With Collins, the subject matter under discussion is, first of all, a matter of Scientific practice. To go deeper in our subject, we need a "long immersion" in the scientific community (ibid, p. 73). We can even come to contribute to scientific research, but those borders need to be solid. Science is in a "special social position" that requires such *distance* (ibid, p. 132).

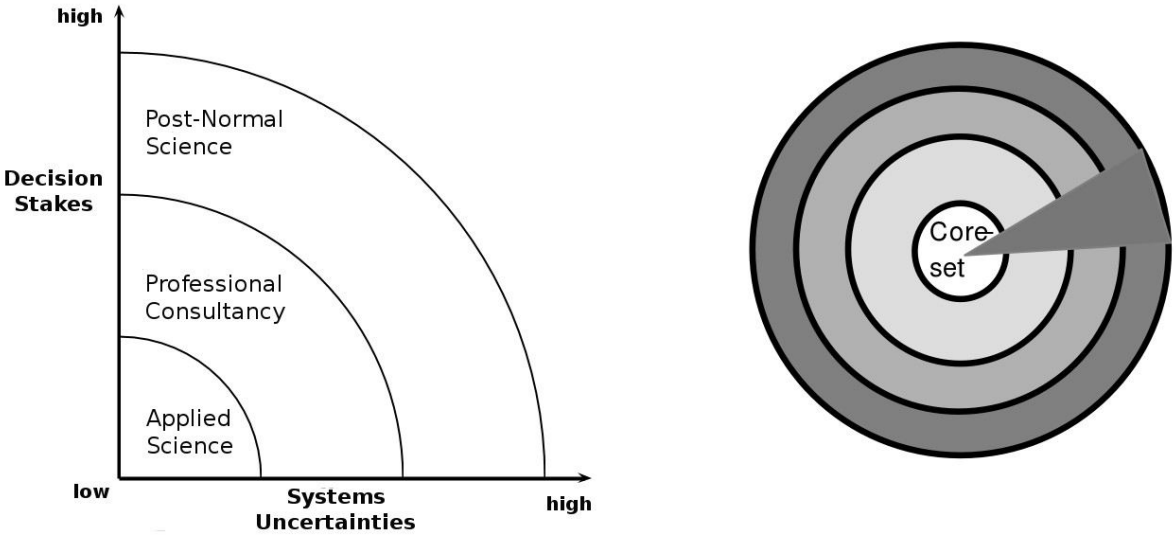

Figure 6.1. The emergence of post-Normal science vs. "distance lends enchantment" models. To the left, a graphic presented by Funtowicz and Ravetz shows how different decision stakes, of more or less societal relevance, are dependent on the uncertainty of the system (Funtowicz Ravetz 2000). From the safer applied science, at the bottom of the graphic, a more risky position is taken by Professional Consultancy, that is more uncertain. Decisions that involve more uncertainty are the ones that take more risk, with higher decision stakes. Therefore, other actors are involved and legitimized, specially when talking about the emergence of the new post normal science. In opposition, to the right side of the figure, we have the bullseye model developed by Collins (Collins 2014). It relies on the special social position taken by scientific practice. On the bullseye are the scientists and all their practical and theoretical work, while outer rings represent other societal actors impacted by the scientific activity. Such distance is needed because "distance lends enchantment".

To the right of Figure 6.1 is shown Collins' target diagram. On the bullseye are the scientists, the ones that do the work; on the outer rings are represented the other people that discuss, evaluate and report it from increasing distances. Such representation is also a fair representation of the problem that Harry Collins recognizes. This distance from the scientific activity represented at core of the diagram, is needed because *distance lends enchantment* (ibid. p. 83).

Harry Collins, when reflecting upon the value of the sciences, aligns himself with Robert King Merton, sociologist that founded the sociology of science and is referred as one of the major stakeholders of the first wave of science studies. Science has a special ethos, “maybe the most valuable contribution of science to society”, adds Collins (ibid, p. 132). He believes that such scientific attitude is distinguished by certain traits as: honesty; universalism; ability to be exposed to expert criticism; and disinterestedness. According to Collins, 'science' is in need of being indulged into its rightful social position. From the 1990's to the 2000's, frauds, scandals and failures in scientific enterprises have come to daylight. From the mad cow disease, to the discussion of the measles, mumps and rubella vaccination, to the so-called *Climategate* controversy, examples abound. To recover 'science''s special status means, for Collins, to keep those borders steady between the different rings of the target diagram. Debates coming from the academy can be used, in this sense, just as indicators for “changes in the public understanding of what science means in our lives” (ibid. p. 48).

Education vs. Emancipation

Collins identifies a contemporary issue of the lack of confidence in science. That such a 'default' expertise coming from the civil society should, still, be guided by scientific knowledge and reasoning. The call out for a *Post Normal Science*, by Funtowicz and Ravetz, goes exactly in the opposite direction, in the affirmation of these civil initiatives as equal stakeholders in the decision-making process. Why would they need to be following the sciences under discussion?

The touchstone of Harry Collins argument is one of pedagogical value. The citizens engaged in complex topics need to learn what these sciences say on the subject and how do they got there. Through this know-how of science research resides the “superior moral qualities” that Collins praises. Under this discussion, Collins focus how this learning process should be privileged, while Funtowicz and Ravetz direct our attention entirely for something else.

Citizens might be enrolled in a public discussion related to science research, but having a know-how on the subject that is unique. Funtowicz and Ravetz aren't worried that these people don't know enough to be recognized stakeholders, quite the opposite! The authors believe that we live at a time that the society needs to appraise these different knowledges to properly deal on complex issues and decide. The touchstone of their argument is one of emancipation.

Therefore, we need to recognize here two different relations. Not taking into account the scientific knowledge of the subject, to assume the role of the ignorant, can be hazardous, as Collins shows. But also taking for granted a certain viewpoint, so that we take ourselves and the others as passive bystanders of a greater order, becoming unable to reflect, is dangerous. Jacques Rancière used a specific concept for this later movement of becoming passive to the World, *abrutir*, that Kristin Ross translates to *stultify*. In a work written in the end of the 1980's, Rancière shows with clarity how these two concepts relate to each other. From the pedagogical relation of *ignorance* to *science*, another sprouts. The writer merges with a french historical character unknown to the History books, to recognize the philosophical relation of *stultification* to *emancipation* (Rancière 1987, p. 14).

I must teach you that I have nothing to teach you

“I’ve learned many things without explanations, I think that you can too. . .” (Jacotot 1836 in Rancière 1987 p. 16). This simple insight of Jean-Joseph Jacotot, changed his life. He was a lecturer in French literature at the University of Louvain. After a long career, he escaped the Bourbons and ended up at this position given to him by the King

of the Netherlands. He didn't get the Flemish words and was teaching to people that didn't understand his native french. So, to classes, he brought a bilingual edition of Fénelon's *Les aventures de Télémaque* and asked his students to use the translation to learn the French text. How surprised he was! Unexpectedly, after some time, most of the class was really good dealing with the french language! (Rancière 1987, pp. 1-3, 18).

Jacques Rancière exposed the impact of such reasoning in the life of this nineteenth century man in 1987's *Le maître ignorant : cinq leçons sur l'émancipation intellectuelle*. Jacotot worked as professor of rhetoric and ancient languages (among other subjects), as artillery captain and as chemistry instructor. After a professional path of thirty years he believed that the major task of the master was to *explicate*. Suddenly, his students flew away from his hands. His pedagogical try-out, compared by Rancière to the Enlightment's philosophical experiments, was apprehended by him basically as a method of *chance* (ibid. pp. 1-3).

Unlike the preceptor of Emile, Jacotot didn't mislead his students for a better guidance or built obstacles for the students to negotiate themselves. To his eyes, he had just left them with classical text and their will to learn the french language (ibid., p. 9). Rancière's depiction of the facts mingles with that of Jacotot. The master was always in the room, but left "his intelligence out of the picture". The other faculty considered during the act of learning, the will, was established in such way, that permitted "an entirely liberated relationship between the intelligence of the student and that of the book" (ibid. p. 13).

Convinced of the existence of these routes of learning paved by chance, and not by the master's knowledge, Joseph Jacotot continued to explore his new-found method. He decided to start teaching at Louvain two subjects he didn't knew nothing about: painting and piano. In his own words, "I must teach you that I have nothing to teach you" (Weyer 1882 in Rancière 1987, p. 15).

Later on, Jacotot came to recognize, his method wouldn't fit inside an University. The traditional pedagogical cause-effect between the explication of the master and the

learning of the class was dissociated by emancipation (Rancière 2008, p. 23). Calling it the Universal Teaching, it wasn't possible to be institutionalized, this method could only be announced (Rancière 1987, pp. 106-107). Nowadays appropriation of public spaces and life itself can be related to this play. According to Rancière, it's our everyday performances that makes each and everyone equal to all other in an unpredictable game of associations and dissociations (Rancière 2008, pp. 25, 27).

From Jacotot to Rancière

The continuity between Rancière and Jacotot is easy to find. An historical paralelism is drafted. Jacotot was prolonguing the french revolutionary energies of 1789 into the 1820's and 1830's. Rancière, with *Le Maître ignorant* / *The Ignorant Schoolmaster*, was emphasizing the dynamics of the students upheavals of May 1968 to the 1980's French socio-political situation (Ross 1991, p. xxii). This book was written also to get out of a polarization on viewpoints on education. As already mentioned before, we could find on one side Bordieu, the sociology of education, the transformation of school from the social conditions and on the other side Milner, with the republican teaching and equality by the diffusion of knowledge. The message of Rancière on equality is another path to follow, one that is fueled by revolutionary forces. Jacotot also lived a revolutionary period and its aftermath and displaced such hope to education and transmission of knowledge.

Jacques Rancière in the 1970's was working with archives, dealing with the worker's movement during the XIX century, when he found the name of Jean-Joseph Jacotot. Several references were in these texts to intellectual learning inspired by Jacotot, as narratives of workers that were sending their children to this man, certain that among themselves some would become improvised jacotist professors (Lamalle Dreux 2005).

The work of the *Ignorant Schoolmaster* accomplishes this merging between Rancière and Jacotot also on a narrative level. As one critique pointed out, it becomes difficult to distinguish in the book where do Jacotot’s adventures stop and Rancière’s reflections start (Pelletier 2009, p. 7).

Intellectual Emancipation vs. Progress

Through Rancière's reading, Jacotot emerges as a solitary madman, the only egalitarian of that age to perceive the representation and institutionalization of progress as a renouncing of the moral and intellectual adventure of equality, public instruction as the grief-work of emancipation (Rancière 1987, p. 18). Throughout the Ignorant Schoolmaster, with Jacotot, Rancière puts in scrutiny his own knowledge and status as a learned man. As Kristin Ross stated, it was emancipation— not education— that has drawn Rancière to Jacotot (Ross 1991, p. xxii).

Emile de Girardin, the “most modern of the progressives” was coeval to Jacotot. Emile was the grandson of Marquis de Girardin, the one who had protected Jean-Jacques Rousseau. As a journalist, he launched the *Journal des connaissances utiles* with the edition of a hundred thousand copies for the masses. With it he founded the *National Society for Intellectual Emancipation*, “that sheds light onto the dark souls of the masses, that replaces all arbitrary demarcations, that assigns each class to its rank, each man to its place” (Girardin 1833 in Rancière 1987 p. 125).

Men of progress are men who move forward. Uninterested in social ranking, they just want to check the trueness of the thing by themselves, be dedicated to the utility of new inventions and discoveries (ibidem, pp. 109-110). Progress comes as point of departure for these men' order of thought, erecting the opinion on progress “to the level of the dominant explication of the social order” (ibid., p. 117). Some, as Emile de Girardin, appropriated the Universal Teaching to create new institutional learning settings.

Although, for Jacotot, as for Rancière, institutions cannot be in themselves emancipatory. The gauge is to multiply for the individual the possibility of revealing their own capabilities. “The essential is to help the people to toggle from a recognized state of incapacity to another, where they recognize themselves capable of everything because they'll consider the others also capable of everything” (Rancière in Lamalle Dreux 2005). The ground-floor to Jacotot's Universal Teaching is then this: *all men have*

equal intelligence. Emancipation is being equal in an unequal society. Progress “has inextricably confused equality with its opposite” (Rancière 1987, p. 133).

Opening up intellectual spaces

The fundamental problem of progress, according to Rancière, is that it sprouts as an opinion high up in the social hierarchy. The dominant explanation that tells this tale of progress becomes a weapon. This way, the pedagogical aim of making things understood is the art of someone who is enlightened, who has more knowledge on a certain subject. To Understand is, in that dimension, a work of grieving to attain that knowledge (ibidem pp. 7-8).

Still, stultification isn't a dead end. To awaken the reason, how Jacotot accomplished it on the eyes of Rancière, is the overall climax of *Le maître ignorant*. Whoever teaches without emancipation stultifies. And whoever emancipates doesn't have to worry about what the emancipated person learns. Intellectual spaces are opened at the learner's will (pp. 18, 59).

Emancipation forges a community of listeners and tellers, the identification by itself of how conventional the social hierarchy is (p. 109). Rancière wants to remember how we can always stand for a reason that isn't the dominant one. Likewise, Joseph Jacotot was in such a way transformed by his experience of seeing his students learning French by their own will, that in the following semester in Leuven he started giving lessons of painting, practice that himself never had tried.

Imagine the excentric professor opening the doors of his Painting small class room at the University. The thing wasn't about making great painters, but a matter of making the emancipated: people capable of saying, “ me too, I’m a painter”. With this meaning: “me too, I have a soul, I have feelings to communicate to my fellow-men” (Rancière 1987, p. 67). Their method of unlocking *chance* and *will* is identical to its morals. In its core we find a poets lesson. Does this lesson have a sense within Science Research?

Discussion

Can we play science? We've seen how this play might have a political dimension. We might even re-state the question, in this case, as: Can we play *a new* science? When the play is about such affirmation of equality, on re-stating what science is, it has been proven fruitful to follow the reasoning of Jacques Rancière.

With Rancière, we've followed two case-studies of contemporary initiatives in these last two chapters, *Do-It-Yourself Biology* and the *Nouveaux Commanditaires Sciences* project. Both have a clear political intent in transforming the scientific practice. In this chapter, I introduced other two approaches in science communication, the *Science Shops* and the *Inquiry Based Science Education*. These were used for better framing the diversity of contemporary approaches to this political issues within science research.

The *Do-It-Yourself Biology movement* (DIYbio) and the *Nouveaux Commanditaires Sciences* (NCS) in two different playgrounds of science culture. DIYbio deals with Biochemistry and Biotechnology in an egalitarian affirmation. These bio-hackers want to reform biotechnology research. NCS works in the inquiry phase of science research. They want to make science research more inclusive, bringing emancipation to the ones involved. Both adopt an inaugural step, an affirmation of equality and emancipation.

To understand what does it mean intellectual emancipation with Jacques Rancière is a delightful voyage. It all breeds out from a moment, a great discovery on the style of the ones of the preceding century. The professor Joseph Jacotot in the beginning of the school year in the XIX century's University of Louvain brought to classes Fénelon's *Les aventures de Télémaque.* Jacotot couldn't understand the Flemish or the students his French. But with that book, they've learned by themselves how to write in French. From that event, Jacotot devoted himself to a method of learning by chance and will. Jacotot and Rancière's paths crossed when the scholar was studying the workers movement of that period. Emancipation brought them together. In the case study of the New Science Stakeholders groups, emancipation, as the social emancipation of Paulo Freire, is an aim.

Science Shops constitute an effective mechanism of communication between research being done and the civil society. The identity borders are clear. The same we can't say about Citizen science participatory projects or, as was just explored in particular, with the NCS network. The NCS' groups being formed can use the knowledge produced from academic research, similarly to people that have posed a question to a science shop. But it is the long process that they embark on that is believed to be transformative. Researchers, mediators and the local community members, the stakeholders, develop joint work looking for a novel research question. That process recognizes Jacotot's equality of intelligences. Moreover, it states an intellectual emancipation.

The poet's lesson at the core of Jacotot's method is made to unlock the will, to be an active participant. Of one of the NCS moments presented, Mitterrand made a political statement. He asked for knowledge that might be useful for himself and others to negotiate, to use.

For Funtowicz and Ravetz this scenario of Mitterrand's demand would be interpreted as a case of post-normal science, in favor of legitimizing the expertise of other actors in political decisions. In opposition, Collins has doubts about recognizing local expertises in the same level than scientific research. He would prefer to create settings in which the focus is to recognize and comprehend the scientific attitude, as watching scientific debates.

Relating to Jacotot's findings, the educated is in relation to the un-educated, as the emancipated is to the stultified. NCS and Jacotot are first-of-all focused on the dimension of emancipation, while Collins, and much more initiatives, are focused on the pedagogy.

Inquiry-Based Scientific Education being adopted into school curriculum focus the pedagogical value of the “learning by doing” science research. John Dewey's philosophical and pedagogical dimensions of experience are here very much present.

But European schools nowadays are still very different from Dewey's vision. The directive pedagogy still takes control of Western education.

Jumping out of school fences makes sense for the setting of the NCS, DIYbio and other projects that aim emancipation. But these and other on-line citizen science games incorporate pedagogical challenges. The question is: Can we play science? What can this 'play' imply for science education?

CONCLUSION

Can we play science? My question irradiated into different philosophical reflections, that were nurtured by different levels of participation in science research. Starting from the immediate experience focused on the second and third chapter we've dealt with Charles Sanders Peirce and the concept of abduction and with John Dewey's concept of experience. Chapter four brought a social dimension of an on-line citizen science community that gave some deepness to the transformation of the Public Sphere, as conceptualized by Jürgen Habermas. Chapter five brought another level of participation, political, from the statements of other participative actions into science research. The work of Jacques Rancière was pivotal to pinpoint this political dimension through the concepts of equality and intellectual emancipation.

Altogether these different forms of participatory science research were intertwined with philosophical perspectives. For the sake of clarity, I present the overall total of citizen science initiatives which were explored in Table 1.

Distributed computing (using the computing power of private computers)		On-line Citizen Science using distributed thinking (depending on the human cognition)		Other participative approaches to science research (that take part totally or partially without Internet-mediated communication)	
SETI@home	Chp. 4	Foldit	Chp. 2	Cornell Lab	Chp. 3
Rosetta@home	Chp. 4	Polymath	Chp. 2	Do-it-Yourself biology	Chp. 5
		Galaxy Zoo	Chp. 4	Nouveaux Commanditaires Sciences	Chp. 6
		Planet Hunters	Chp. 4	Inquiry Based Science Research	Chp. 6
		Stardust@home	Chp. 4	Science Shops	Chp. 6
		CosmoQuest	Chp. 4		

Table 1 – Classification of Citizen Science initiatives approached in this research. A reference to the chapter where the given project was explored is given in brackets. The classification frame was adapted by the one given by Vicky Curtis (Curtis 2015). More details about Curtis work is given in chapter four.

Altogether, we've found some interesting conclusions relating these practices. The first focus on experience and collaborative tools gives emphasis to a Pragmatic view on on-line Science Research.

Charles Sanders Peirce research on abduction, or the process of building hypothesis is explored through the second chapter. Abduction started in a propositional Aristotelian fashion and evolved to the set up of, what Ahti-Veikko Pietarinen's calls a Logic of images (Pietarinen 2006, p. 22). From such evolution of the concept of abduction in Peirce's Philosophy, it is interesting how it can be considered as a *perceptual judgment* in Peirce's 1859' *The fixation of Belief* and *The order of Nature*. This consideration is in contrast with the more typical logical character in Peirce's approach to the concept. From that insight, I identified the concept of Symmetry of Abduction. Abduction

continues to take a role in Philosophy and Epistemology of Science. The consideration of it as a percept mines the logical study, but taken as a process, it contributed to much discussed in Epistemology and Logic studies. We've followed the problem of the *Inference to the Best Explanation* and the problem of justification of the synthetic inferences. As we've seen the context of justification has a strong tradition in the epistemology of science. But different proposals try to unveil a logic of discovery, in a tradition coming from Imre Lakatos, to Atocha Aliseda, Xavier de Donato Rodríguez and others.

Synthetic inferences are given emphasis in the scientific process by shared cognition projects. I used this link to substantiate a view on abduction, from Peirce. Moreover, considering his later phase, of the emergence of *diagrammatic reasoning*, *tinkering* processes are incited. is one that incites or, as Lorenzo Magnani calls it, *manipulative abduction* (Magnani 2004). The great Faraday was “drawing ideas straight out of his experiments”, as Peirce described (idem, p. 272), just like participants in some contemporary on-line interfaces of science research. The organization of knowledge in these platforms is also related to Peirce's iconicity. As we've seen on chapter four, heavyweight models of peer production rely on a threshold to be able to participate. The citizen science games that use this community-building, as *Foldit*, have a strong pedagogical character. But this education isn't based on books, but on dynamic manipulation and reasoning in a step-by-step manner, getting increasing access to more dense concepts. This tinkering seems more dense, corroborating the possibility of a transformative practice.

In opposition to Peirce, John Dewey's philosophy explored on chapter three, doesn't have the logical soundness of Peirce, but seems more systematic. By exploring his 1929 work *Experience and Nature* some principles are enlightening. From the physical, to the psycho-physical to the mental levels, Dewey relates an increasing complexity and intimacy of interactions (EN, p.261), being set in three correspondent plateaus. The third plateau is where the intellect fabrics response to meanings by association, participation and communication (EN, p. 272). In the interaction between subject and

nature, knowledge becomes instrumental. Specific “things in experience” serve as guide, as the features that are signs, indices of something prevail in experience (EN p. 128).

For Dewey, inferences also take center stage in the relation to reality. The inferences make the connection between the kinds of knowledge, the sensible and the rational. The empirical naturalism of Dewey is such that the objects of knowledge are in the orders of relation, diverse from the sensible world (EN 159, 138-139). The thing that guides the inferences, is part of the experience to the subject and involves a connection between the consciousness and nature (EN p. 352-3), that substantiates a connection to the “complete universe” (EN p. 159-60). Peirce was also at odds between idealism and realism through his path, but logic took a central place. Dewey's *empirical naturalism*, gives an interesting contrast to Peirce's *diagrammatic reasoning*. For Dewey, any hope for a logic of discovery is lost. Also Peirce's Pragmaticism isn't concerned with practical consequences, as the classical Pragmatism. In common, without any doubt, is the important role taken by experience.

On-line citizen science engaged players, as in *Foldit*, come to the point of creating their own research questions. The inclusion of 'others' into the scientific practice isn't a novelty. When William Whewell created the term ‘Scientist’, rooting the modern professional role (Vetter 2011, p. 129), he personally in his research, took advantage of “subordinate labourers”, as he used to call them. But how come the engagement of these gamers got them to this deeper collaboration in scientific practice? On chapter four by considering the emergence of Habermasian public spheres, we get a finner understanding on how on-line tools as forums contribute to this joint intellectual effort.

As the study of Vicky Curtis shown us on chapter four, after a first phase of suspicion on on-line citizen science accuracy of results, these bonafide players are considered valuable assets. One of the theoretical frameworks she used, the one that contrasts a heavyweight to a lightweight model of peer production is of interest. To participate to a public use of reason, one needs to be able to do it. The heavyweight model of peer

production sets high thresholds to participation. Moreover, the role of the *gatekeeper* is crafted, that can be recognized when opening the gates of scientific practice in on-line citizen science games, just as in the French salons.

Other games of science research, as *CosmoQuest* and *Zoo Universe*, have lower thresholds of participation. Whoever registers, gets immediately a chance to start 'doing science', by using their cognition towards the objects on the screen. What is taken into account is a majority vote, as many players receive the same images (Curtis 2015, p. 18).

Still, the games that have a community-based approach seem to have a closer collaboration taking place. One of the most complex games, *Foldit*, even offers a window to a curious circumstance. Different players and teams develop different strategies and mental representations while playing. The recognition of these diverse winning strategies bring about further questions. Modern Science recognizes the value of precision and accuracy, but what place can have these idiosyncratic paths? Can they have logical and heuristic value?

Science 2.0 or on-line citizen science is in the front-line of inclusive massive participation, where anyone can come to contribute to the research programs developed. As we've seen on chapter four there's a certain *zeitgeist* very much imprinted here. An enthusiastic take into participation that gives a character of open sharing and incremental exploitation of ideas and data. In terms of publishing it's interesting to see how this movement contributes to other ways of sharing results, as citizen scientists tend to share openly on-line through public blogs or other tools. Also, in terms of professional science, it has an impact. Citizen scientists are signing professional science peer-review papers on top-notch publications. Such is the case of *Foldit*, *Polymath* and *Galaxy Zoo*. Interestingly, many are signed under a collective name, that relates to this more collaborative frame.

Still, as we've seen on chapter four, there's an *agonal* dimension very much present in the *gamifications* of science research. There's a relevance given to the pact of

competition, as equivalent to the *contract of Agon* (Duclos 1997, p. 226). In its etymology, the agonal games (*jeux agonaux*) can make reference to fighting games or celebrations Romans would make in honor of the double-nature of the God Janus. Colan Duclos stresses the elements of tension, stress, chance and uncertainty that make the agonal play (ibidem). This Science 2.0 focus into competition seems like a well-planed strategy, that might circumscribe a putative revolt of “subordinate labourers” and insure the investment into game design to tackle Big Science questions.

Science 2.0 deals with specific challenges presented to scientific research. The astronomy-based approaches explored on chapter four, as well our protein folding game of the second chapter, are posing new scientific questions, relying on the cognitive contribution of citizens. There's a huge amount of data produced and it keeps increasing. The heuristics and epistemology of the diverse “logics of justification” we've tackled on chapter two, seem out of date with these transformations, says the sociologist Hermínio Martins (Martins 2011, p. 121). In agreement with what we've explored before on chapter two, this “data-intensive knowledge”, according to the author, brings forward the synthetic Peircean inferences (idem, p. 120).

Michael Kerns, researcher on distributed thinking, can be seen as one of the *gatekeepers* for participation in on-line citizen science. He finds that the mixed computation between computer algorithms and human cognition to be at “the dawn of a new era” (Hand 2010, p. 685). Kerns was obviously expressing his trans-humanist belief. Martins also coined this current of thought as singularism, as the people believing in it usually identify one singularity where to the world is accelerating into, a liberating new mode of existence, a new civilization, an *escathon* (Martins 2011, pp. 334, 341).

Following Jean-Joseph Jacotot through Jacques Rancière on chapter six, we can see how the master emancipator had to face the men of progress of his time. And nowadays, the same schism lives. Isabelle Stengers hope for a new science regarded in the introduction chapter is delineated in contrast with the capitalist progress in an inaugural lecture she gave in 2011 (Stengers 2011). Just one year before, a slow

science manifesto was made public by the Slow Science Academy of Berlin (Slow Science Manifesto 2010). The need to *decelerate* is something I also face in my practice with *Nouveaux Commanditaires Sciences* (NCS), as we see the deconstruction of science research to make it more social inclusive needs time. Inspired by Freirian emancipation, NCS uses science research to do community work. We believe that to participate in science can bring empowerment.

The adventure of Intellectual emancipation was the one that joined Rancière and Jacotot in 1987's *Le maître ignorant : cinq leçons sur l'émancipation intellectuelle.* The poet's lesson at the core of Jacotot's method is made to unlock the will, to be an active participant, in the same manner than the NCS participants. The substance that Rancière gave to Jacotot's pursuit is one that was used in chapter six to get a finner understanding of a dispute taking place at Social Studies of Science.

Miterrand, one of the NCS participants, made a demand. Will the Ocean eat up his community built by the shore? For Funtowicz and Ravetz a demand coming from a stakeholder would be interpreted as a case of *post-normal science*, in favor of legitimizing the expertise of other actors in political decisions (Funtowicz Ravetz 2000). In opposition, Collins has doubts about recognizing local expertises in the same level than scientific research. He would prefer to create settings in which the focus is to recognize and comprehend the scientific attitude, as watching scientific debates (Collins 2014).

Relating to Jacotot's findings, education is in such relation to un-education, as *intellectual emancipation* is to *stultification*. NCS and Jacotot are first-of-all focused on the dimension of emancipation, while Collins, and much more initiatives, are focused on the pedagogy.

The other political statement approached in this work is the one of *Do-It-Yourself biology.* Appreciating the identity of the biohackers of the *Do-It-Yourself biology* (DIYbio) movement explored on chapter five, we find the affirmation of *justice globalism*. Their identity is rooted with other lines of identity, the occupy movement, the cyberhackers and the open-source culture.

DIYbio takes place outside of normal science institutions, it makes of science research a political statement of equality. Following the reasoning of the *re-enactement of a community of equals* with Rancière see that the (re-)invention of the *community of equals*: (i) is part of the random interplay between what is there and what forces change; (ii) is fundamentally part of a process of sharing; (iii) refers to an earlier coming together of egalitarian event and egalitarian text (Rancière 1995, p. 90). As it is presented in chapter five, the egalitarian text of DIYbio corresponds to the *Biocommons white paper* (Trojok 2012). There is devised an inclusive way to approach the commons, to include not only “natural goods”, as air, water, earth, but also entire organisms, biochemical processes and other discoveries and man-made biological and biochemical concepts. Biotechnology has, then, with DIYbio, a new political and economical vision based on equality.

Still, following Rancière's reasoning, we can see how this movement will have to deal with the inequality of social organization, just like the founders of Icaria did in the past. But this doesn't forcefully means that such an enterprise is made to fail. Just that the “egalitarian signifier” that is now a fundamental part of its identity might fade away, as the old greek *apeiron*, the unbound desire might get dimmer.

At the end, returning to the whole picture of this study, can we play science? Do these citizen science initiatives offer “new” ways of making science? On-line citizen science has been growing in numbers of participants, projects and scale. These solutions deal with concrete new challenges to science research that seem bound to be further developed. It might be more than a trend or an escaping line. We might be facing a *reterritorialization* of this massive approaches to science research.

On the other side of the coin, the counter movements of progress also deals with a *resingularisation* of science research. This play seems feasible, but the scale and efficiency of this *heterogenesis* process remains unaccounted.

ANNEX I

METHODS & DESCRIPTIVE MEMORY

NOUVEAUX COMMANDITAIRES SCIENCES 2.º TORRÃO

Interactive Planning

Our praxis integrates a shared decision making, implemented with interactive planning. All activities that the facilitator's team develops comes from participants needs expressed during fieldwork or as proposals that are negotiated by all involved. This axis of action relates to the first forms of action anthropology, as with 1948' Project Fox of University of Chicago Field School (Willigen 1993). This approach was first inspired in John Dewey's groundbreaking work for western pedagogics. As with the denotative method presented by Dewey, the concept of experience can shift our attention from the 'What' of its objective concern, to the 'How' of method (Dewey 1925). In other words, our concerns in the field are shared between general aims and forms of participation and dialogue.

Generative Themes

The methods we apply, come as in search for an immersive contact between the different actors. Paulo Freire's generative themes are well known concepts coming from his pedagogical practice (Freire 1974). Freire explains his way for coding/decoding elements of local cultures, creating generative themes together with members of these cultures. Our work is based on his writings and another related case study, the one of Paulo Blikstein, that used technology as a tool for freirian emancipation in Heliópolis, the biggest shantytown in São Paulo , Brasil (Blikstein 2009) .

Non-Formal Educational Tools & Questioning Activities

The questioning activities, triggering curiosity among participants are a precious tool for L'Atelier des Jours à Venir. Moreover, facilitators in 2.º Torrão proposed non-formal education tools, as the ones used by SALTO YOUTH to engage participants. The diverse pool of games, as energizers, discussion games, group building activities can be used to engage in meaningful work in an open and critical atmosphere (SALTO YOUTH 2015). In accordance to our practice, we now give relevance to specific dynamics created and the descriptive memory of our joint venture.

Formulating questions February 16th. & March 16th. 2014

We started the NCS group with enthusiasm. We were a mixed group of locals and 'outsiders', people interested in the NCS project or in 2.º Torrão. Livio, mediator of the project, came to support the kick-off session. The guys standing in the field of the central square, just next to Associação de Moradores do 2.º Torrão played along the questioning activity, mostly a mix between the Angola and the Cape Verde gangs of young males. The proposed game dynamic to raise questions and foster curiosity was well received! We made it twice, in separate days, to

come up with a diverse pull of questions and discussions. Altogether, the participants were curious and we were amazed by the deepness of the reflection raised in some of the small groups.

Materials:	papers and pens/ pencils; totem to give right to speak
Duration:	1h30-2h
Place:	Football court

Dynamic:

After a short introduction, that included proposals for group building and energizer activities, participants were divided in groups of three to four elements and were challenged to create questions meaningful to their surroundings, to themselves or just funny formulations. This approach has been before applied in the Nouveaux Commanditaires Sciences settings and was inspired by previous related experiences (Rothstein Santana 2011). The game included a 'joker' in case the questioning got blocked, that could allow also reformulations of the participants' questions. The use of different pronouns represented such strategy. Any given formulation could be brought forward or reformulated using different pronouns: How? What ? When? Where? Why? Who? All the questions raised in these small groups should be noted down.

Reunited back in the big group, participants shared the process and questions raised. A first approach to the classification of questions was approached. Topics under discussion included: the relevance and frontiers of existing knowledge; diversity in the arts, sciences and philosophy research approaches; diversity in sciences and in research methods; roles and practices in science research. In the first session we also used a totem to give the right to speak to give some order to the discussion.

Presentation of project, Organizing and Classifying Questions April 12th. 2014

Activities were implemented inside the Associação de Moradores this time, as we prepared a presentation for the group and also aimed at having more focus inside a closed space. The next step for our process to go on would be grouping the questions previously raised and start a discussion about what could be the research questions under focus and which would matter the most. We made it, but many of the participants that took part before didn't return. Altogether, we, the 'foreigners' started more and more realizing the cultural shock, as the time 'stretches' more in 2.º Torrão and the inhabitants are fairly more easygoing and relaxed about their appointments. Still, when we are cooperating at some given task, its amazing! The group concentration and level of analysis is very deep and accurate.

Materials:

pieces of paper with the questions raised in the previous sessions, duct tape, butcher paper

Duration: 2h - 2h30

Place: Associação de Moradores do 2.º Torrão

Dynamic:

The previous activities raised plenty of questions that were written down. This time, with all the questions printed in small pieces of paper, the challenge was to organize them according to some decided logic. Before getting to work on that, we prepared a presentation about Nouveaux Commanditaires Sciences. These dynamics were in accordance with the group wishes about the project, as these were agreed upon previously.

The presentation was made with the projection of pictures. First, the work initiated by Paulo Blikstein in the shanty town of Heliopólis, São Paulo, Brasil (Blikstein 2009). Then about our perception of the work done by the first NCS group, ICIL - Investigating colors for improved learning-. The facilitators João Cão and Coline Salzmann had visited the ICIL group in early April 2014 and took some pictures to share. The presentation was lively with plenty of questions about the actions and people involved. Afterwards, the group easily worked on the questions raised before, selecting the ones they've seen as the more interesting and grouping them on topics they agreed upon. At the same time a younger participant, a child, that came inside the association did some illustrations of some questions, as proposed by the facilitators.

Decision on the most important research questions,

Question your peers and answer with questions

& Invitation Letter to Science Researchers April 24th-26th 2014

The mediators Livio and Leila came to join our activities these days and we had the most challenging moments. During three days we were able to involve participants that were absent during our last activity, come to a selection of research questions and sketch invitation letters to researchers. Children were involved as well, playing a curiosity game. With this process we realized of two major challenges that we tried to solve: 1) Participation and engagement; 2) Uses of the Associação de Moradores Space.

Decision on the most important research questions

Materials: previous selection of questions

Duration: open space (afternoons, April 24th-26th)

Place: Associação de Moradores do 2.º Torrão

Dynamic:

We had in the previous session made a selection and grouping of the most interesting questions that we could work on. Still, not all the participants took part in this decision making. As we returned April 24th at the agreed time, 14h, to the Associação de Moradores do 2.º Torrão, the group that had made the appointment with us wasn't after all available to take part of it. We then decided to run the activities as in an open space, inviting members of the community to see the selection done and have a critical view point over it. As such, other youngsters, that took part of the first activities, were involved, as well as other members of 2.º Torrão that didn't manage before to participate. After three afternoons the facilitators involved were important to establish the communication between different critical viewpoints and, altogether, we were able to come to a podium selection of three research questions.

In this process we had to deal with the first conflicts, as one participant got aggressive towards one of the facilitators, as he was inviting him to take part in this process. The misunderstanding was handled and resolved. During the same period we had to tackle with another issue. We ran NCS activities at the same space that 'Ciência a Todo Vapor' children communitarian activities took place. As the schedules were increasingly difficult to keep, the environment got messier, as some young adults didn't feel interested in working in the same space than children. As we were faced with this problem, we decided to define the dynamics in ways that different groups working wouldn't get on the way of each other.

Question your peers and answer with questions

Materials: none

Duration: 20m (afternoon of April 26th)

Place: Associação de Moradores do 2.º Torrão

Dynamic:

Some children were receptive to play a game outside of the Inhabitants Association' quarters. In this game you shall only speak with questions. You can only answer a question with a further question. The participants form 2 columns facing each other. The person at the front of the column, discusses with the person at the front of the other column. If (s)he fails, gets back to the end of the column and cue. The next person at the top of the column continues the game. Once again, this game dynamic is part of the Nouveaux Commanditaires Sciences games' tool box, inspired by the experience of Rothstein and Santana, 2011.

Invitation Letters to Science Researchers

Materials:	pens and pencils
Duration:	open space (afternoon of April 26th.)
Place:	Associação de Moradores do 2.º Torrão

Dynamic:

During the last afternoon of the three days, one of the young group leaders, Mitterrand, was engaged in a critical and meaningful conversation about the selection of the three questions raised. Then, Livio, Leila and João proposed the writing of three invitation letters to researchers involved in these topics. As such, we got more deepness into the motivation and possible impacts of having results for these inquiries. The outlines of these letters were later transformed into formal letters and checked back by Mitterrand and others before being used to invite science researchers to take part.

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