Big Science is not Great Science*†

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If the advent of computers generated a digital philosophy, the Manhattan project for the construction of the atomic bomb, produced a radical transformation of the way of doing science. After the Second World War, on one side there were scientists asking for bigger and expensive laboratories; on the other side, there were Governments, which were inclined to invest according to the belief that the evident success of the atomic bomb would have continued to happen also in other fields, both civilian and military. The so-called *Big Science* was born: large government grants, huge laboratories, powerful instruments, lots of researchers.

As noted by Shapin [12], already before the Second World War, communist countries pointed the attention on the worker also in the scientific research world: gradually, the term scientist was replaced by either science worker or research worker[1]. This concept rooted on the belief that, contrary to literature, science has a social side: it is common viewpoint that the artist's work is unique and unrepeatable, expression of an individual, while the results of scientific research are something collective and independent on the individual scientist. Therefore, if one scientist does not reach a certain

*Joke of words by S. Shapin [12] about modern science based on large collaborations.

†This is the translation of the Section 3.6 of my book *Scienza e linguaggio* (Aracne, Roma, 2015). I decided to translate this part following an exchange of *tweets* with Sabine Hossenfelder about her blog post `http://backreaction.blogspot.com/2019/03/merchants-of-hype.html`. There is also a little adaptation, because in the Italian version I had to explain the translation from some English ways of saying. Obviously, this is no more necessary here.

[1]From which it derives the term *researcher*.

conclusion today, then, sooner or later, another will reach that conclusion. It is just a matter of time[2]. The reliability of science would then derive from the community and not from the individual, which in turn would be affected by biases weakening his/her conclusions.

It is not understood that science is not a business company, but it is the result of spontaneous and chaotic contributions of individuals freely interacting among themselves. Scientific institutions, the so-called scientific community, are instead organised, because of obvious social reasons. Problems show up when one wants to organise something that cannot be organised, such as science. If one thinks that the latter is the result of a large collaboration, that one individual is just an elementary gear in an assembly line, then there is also a radical change in the way of doing science. First of all, by removing the individual, the vocation as a basis of the scientist profession is missing. The researcher is then essentially a technician doing a work like any other. Therefore, it is desirable that he/she does not waste valuable production time by thinking either at great questions about the meaning of the Universe or at what and how to study or to boldly go beyond the known. Really, the modern researcher is often a valuable worker, with specific abilities, requiring a long and expensive training, but he/she is not different from any other metalworker or employee. According to this logic, teamwork is more important than any personal ability. If scientific research is a work like any other, this implies that it can be planned and managed. One could expect results, evaluate performances, decide to cut investments or to focus on specific topics. Curiosity and exploration are absolutely banned, because of the waste of time. As Steven Shapin wrote, "big science is not necessarily great science" [12].

The availability of enormous quantities of money favoured the problem solving by means of brute force at the expense of creativity. Just think about the role of particle accelerators in subnuclear physics: people have always thought to build bigger and more powerful accelerators, while there was never any possibility for alternatives (for example, plasma accelerators). Today, the biggest accelerator is the Large Hadron Collider (LHC) at CERN in Geneva, with a circumference of 27 km. Its greatest success was to find the Higgs boson[3]. But, what is there beyond LHC? The only answer is to

[2]Even if one admits as true such a hypothesis, it is worth reminding the time span of about 20 centuries between Alexandrian and Galilean sciences.

[3]Irony of fate, the idea and the theory of the boson was due just to the creativity of a few individuals, Peter Higgs and François Englert among them, who received the Nobel

continue doing the same type of accelerator, but simply much bigger, with a circumference of 100 km [11]. A similar case in another research field is the recent request by climatologists of huge public funding, in order to build a supercomputer able to run more detailed simulations of the terrestrial climate [9]. Also in this case, no new ideas at the horizon, just a bigger computer.

There is no place for alternative hypotheses, there is no place for creativity. Scientists are disappearing, while science politicians and managers burst into institutions [1]. What is important is to gather funds to organise and to manage larger and larger groups. There is no more need to study or to improve personal abilities. If necessary, it is sufficient to hire someone with the required knowledge and to add one more name to the endless author lists in publications. In addition, working always on the same topic, from the graduation to the retirement, increases the possibility to receive funds, recognitions, prizes, and career promotions. As it is more and more difficult to recognise the effective merit of the individuals in hordes of authors, the only clue becomes the research seniority. People think that being always present on a certain research topic is the guarantee of some credit. However, one does not think at what Robert Merton called the St. Matthew's effect: those who have, will have more; those who have not, will have even less [7, 8]. In other words, by doing always the same thing, one will obtain recognitions anyway, just because of seniority. People moved from pioneer scientists to stabilising and polishing up researchers, not to say simple custodians of what is known.

Governments find easier and simpler to give funds to a few large groups (the so-called *critical mass*), in place of expand on many scientists. There is the implicit belief that teamwork favour the best research, and therefore one invests on big labs and institutions to share data and materials [14]. This system is very convenient for politicians, who can show to their voters that they have done something evident during their mandate. A big lab is surely much more visible than the ideas of some isolated scientist.

This way of organising the scientific research has already showed its weakness, although it continues going ahead because of inertia, rather than effective value. Already in 1985, Pickering and Trower [10] depicted the noxious effects of such a kind of research organisation. The main problems observed in large collaborations of particle physicists were:

- frustration and inhibition of individual creativity, with the immediate

prize for physics in 2013 just for this reason.

consequence of making it more difficult to change the present paradigm;

- the hyper-specialisation, that is the fragmentation of the project in many micro work packages assigned to young postdocs or to phd students, which hamper the development of a global view of the project and the possibility to give contributions to science outside the personal micro research field;

- the transformation of senior researchers into managers, who spend their time to search for funds.

The main danger, as noted by Pickering and Trower, is that this system is self-reproducing. The hyper-specialisation makes it easier the career, but only if one always remains inside his/her own micro research field. The experiment itself must be a success, because it drags a significant part of the life and the career of thousands of persons. One cannot surely spend 10 years or more on a project and then to face a failure. Therefore, the experiment *must* be a success, and this can obviously be obtained only by studying known problems. As Luis Alvarez, Nobel prize for physics in 1968, wrote, "our present scheduling procedures almost guarantee that nothing unexpected can be found" (cited in [10]).

This type of research, flattened toward a conservative structure, is already having reverberations on daily lifetime, although a few seem to realise it, while others are stunned by a relentless flux of press releases promising extraordinary discoveries. *Eppur ristagna...* one could say by paraphrasing the well known saying of Galileo.[4] Recently, Michael Hanlon [4] noted that all the current technology is based on the research developed in the period $1945 - 1971$. After that period, called the Golden Quarter, there was just a stabilisation and finishing touch of the postwar technology. Even science fiction seems to be stagnant, and sequels or remakes of old movies are now crowding theatres. It seems that mankind had lost the wish to dream [2].

Although I have taken as an example the large collaborations of particle physics, this way to organise scientific research is by now percolated in many other research fields, and radically changed their activity. Even a research field with a strong tradition of individuals, such as mathematics, is now slowly moving toward the teamwork [3].

[4]Yet is stagnant. Galileo's saying was "eppur si muove..." (yet is moving).

I don't want to be overly critical toward Big Science: it is obvious that certain scientific problems cannot be solved in other ways. The experimental verification of the Higgs boson is not possible without LHC. The real problem happens when Big Science devours everything and reshapes the role of scientists, by causing *de facto* its disappearance [5, 6]. As it will be shown in the next Chapter[5], the invention is an exquisitely individual act. Both direct and indirect[6] relationships with other persons are surely important. However, as it will be shown in the Chapter IV, creativity is a quality of the individual, because it comes from the unconscious, which is the most individual and personal trait of a human being. As Alvin Weinberg wrote, "The act of scientific creation, no less than any intellectual creation, is largely an individual act... I simply cannot imagine the theory of relativity, or Dirac's equation, coming out of the teams that nowadays are so characteristic of Big Science" (cited in [12])[7].

Teamwork is good for existent ideas, just like the Higgs boson, but not to generate new ones. Discussion among scientists is important, one climbs up the shoulders of giants, according to the well-known aphorism by Newton. However, as already written, science is a complex structure, spontaneous, not organised, emerging from the chaotic interaction of individuals. Science cannot be organised, because it cannot be planned. As for any other self-organised structure, as soon as one tries to control its development, it ends with the irreversible alteration or even the destruction of the structure[8]. When I speak about imposition of organisation, I do not refer just to large collaborations with an organisational chart and the corresponding chain of command (although mild and somehow different from military or political hierarchies). I also mean the linguistic effect that could derive. Inside these large scientific collaborations, there is a generation of procedures to follow. In order to have the consensus of the majority of involved persons, it is necessary to rest on well-known and accepted concepts. There will not be place for

[5]I remind that this is the translation of a part of a book.

[6]I mean, reading and writing essays are indirect ways to relate with others.

[7]I prefer using the term invention, rather than creation, because any intellectual activity is always linked to what is existent before, as I will show in the Chapter IV. On the contrary, creation implies something from nothing.

[8]As noted by Stark [13], the main cause of the Western world success is the freedom. Freedom to hope, to do, to invest, and to enjoy the fruits of personal privations. This freedom has its roots in the free will of Christian religion. Each time some kind of "empire" limited or crushed such freedom, it also destroyed the culture, thus – irony of fate – set up the basis of its own self-destruction.

uncertain, exploratory procedures, on the border of knowledge. Scientific papers does not escape from this framework: it is possible to write only by following the imposed rules. Who does not follow the rules is sanctioned with the rejection of publication.

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