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COMMENTARY

Is Bauman's "liquid modernity" influencing the way we are doing science?

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This commentary analyzes the possible effects of lightness—a typical attribute of modern (liquid) society, according to Bauman—on the way we are doing science. We share our opinion in an attempt to discern whether some unwanted practices that may affect our scientific results (such as technology misuse, bonus rewards, publishing under pressure, or indolence for getting accurate results) can be attributed, at least partially, to the liquid characteristic of modern society. We also examine whether the different systems that support science favor these actions, conspiring against what should be the primary goal of science: the search for truth. We finally consider several aspects that should be taken into account to rescue science from the intrusion of weightless actions.

> "According to Bauman (Bauman, 1996), we have moved from a period where we understood ourselves as 'pilgrims' in search of deeper meaning to one where we act as 'tourists' in search of multiple but fleeting social experiences."
> –Barry Knight (Knight, 2017)

The concept of liquid modernity was coined by the sociologist and philosopher Zygmunt Bauman as a metaphor to describe the condition of constant mobility and change he sees in relationships, identities, and global economics within contemporary society. Instead of referring to modernity and postmodernity, Bauman visualized a transition from a solid modernity to a more liquid form of social life (i.e., "unable to keep any shape or any course for long..." and "...prone to change..."; Bauman, 2000), and discussed how liquid modernity influences all aspects of human life (Bauman, 2000, 2005). In Bauman's own words: "We associate 'lightness' or 'weightlessness' with mobility and inconstancy: we know from practice that the lighter we travel the easier and faster we move." Several other philosophers and writers also refer to this concept with different names (Lipovetsky, 2015; Royo, 2017).

Can the concept of liquid modernity be applied to our present way of working in science? Has liquid life influenced the way we are doing science? We are neither sociologists nor philosophers; however, our impression is that the way we are doing science suffers a similar pattern in many more instances than we would like to admit. Interestingly, in his book *Galileo's Revenge: Junk Science in the Courtroom*, Hüber (1991) used the term solid science as opposed to junk science.

Technology and information

Progress in science arises in great part from technological achievements. More than that, technology is essential. It provides the necessary tools to explore in depth different phenomena and rapidly process huge amounts of data, unraveling otherwise unsolvable problems. Today, in routine laboratory work, one can calculate statistics and produce beautiful graphics without the need for doing tedious calculations or using special graph paper. Everything is now much easier and faster than was the case a few decades ago, when one had to read raw data one by one and do all calculations by hand. However, in our opinion, all this super-digested information may conspire against the personalized and useful data analysis and assimilation process. In many cases, science is now driven by machines rather than the scientists who have studied the experiments and raw data. Obviously, the villain is not the technology which provides all these technical improvements, but, rather, the way we often use technology. This sort of light behavior that some researchers may adopt, possibly unconsciously, might in part be a collateral consequence of living immersed in the liquid society or even of the systems that support science (see below).

Digital technology facilitates scientific communication. In the past, scientists usually found articles of interest in *Current Contents, Life Sciences* (a database journal; https://www.ovid.com/product-details.926.html) or some other printed database,

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and asked the authors for reprints (by posting cards) or read in their university libraries the different journals' issues, often with a considerable delay after the journal was printed. In contrast, today it is possible, at the click of a button, to access a manuscript immediately after its acceptance and even before printing. It is even possible to receive alerts on your cellular phone about recently appeared manuscripts related to the subjects of your interest, in real-time. All the knowledge is there at your fingertips. This is a huge advance! Indeed, new and rapid ways of communication facilitate international collaboration and publication, providing the opportunity to do better science. However, this vast amount of information, received in multiple channels and formats, unfortunately has a "dark side," which can be harmful (Bawden and Robinson, 2009). There are various explanations for this paradox including the impossibility to "keep up with the amount of information available" (Bawden, 2001), leading to so-called information-avoidance behavior (Golman et al., 2017; Guo et al., 2020) or reduced decision quality (Speier et al., 1999). Possibly more important for science, information overload does not only affect working behavior but also leads to less time devoted to "contemplative activities" (Misra and Stokols, 2012). Thus, as a double-edged sword, the amount of information received may conspire against deep, conscious, and careful reading of the data. We are not saying that deep thinking is absent in our scientific laboratories. However, in our view, the avalanche of new information may favor a tendency to merely glance at the new articles on our computer or cell phone, promoting superficiality, which is indeed a characteristic of liquid modernity. In Bauman's own words: "The art of surfing has taken over from the art of fathoming the best in the hierarchy of useful and desirable skills" (Bauman, 2012). Possibly much worse, the fact that so much information can be so easily obtained may encourage the false belief that there is no need to remember or study anything because "it is all there." The idea that humans only need creativity to solve unexpected problems and that memory is virtually unnecessary is misleading and without a scientific basis. To give two examples, studies by the British psychologist Alan Baddeley, indicated that "People think with their working memory…" (Baddeley, 1992, 2000), and the neuroscientist William Klemm, concluded "The more one knows (remembers), the more intellectual competencies one has to draw upon for thinking, problem solving, and even creativity" (Klemm, 2007).[1] Certainly, scientists need to have the information in their minds to be able to make the necessary associations and processing to produce new knowledge and in-depth insights. Creativity does not arise from nothingness nor does it spontaneously occur from the massive amount of information that can be so easily obtained. Information must be selected, analyzed, processed, and transformed into deep and true knowledge in our brains. Unfortunately, the effort required for this process may be much less appealing than reading a paper on our cell phone.

The systems that support science

The different systems that support science around the world are also immersed in, and possibly influenced by, the new paradigms of liquid modernity. Thus, are they contributing to favor lightness when doing science?

We will consider two extreme examples. In one, an intensely competitive system urges scientists to publish. One of the main reasons for this arises from the fact that they have to get grants not only as a means to support the cost of experimental work, but in some cases, and possibly more importantly, to maintain their salaries and to survive as a group. There are several other reasons of similar importance in these competitive systems, like promotion or prestige. As Grimes et al. (2018) pointed out, "the phrase 'publish or perish' is more than a pithy witticism—it reflects the reality that researchers are under immense pressure to continuously produce outputs, with career advancement dependent upon them." Using Bauman's concepts, Roman Batko referred to the phrase "publish or perish" as the new slogan of the "liquid university," in which he suggested that the importance of publishing stems more from the credit that the authors and faculty received than from the wisdom of the article (Batko, 2014).

Nevertheless, publishing has to be done and, indeed, is a duty for researchers. According to the physicist and philosopher Mario Bunge, a major characteristic of scientific knowledge is that it lends itself to and requires communication (Bunge, 1998). This attribute allows confirmation or refutation of results and, therefore, the progress of science. However, publishing under pressure for survival or any other motivation conspires against quality, profound thinking, deep discussion, mentoring, and training, and distracts scientists from their main (we should say unique) goal: to pursue the truth. In a recent article, Ioannidis et al. (2018) identified several researchers that had published (sometimes for several consecutive years) >72 papers/yr, equivalent to 1 paper every 5 d. It is difficult to comprehend how these amazing figures could have been reached. Although this is an extreme scenario, it is a wake-up call for scientists' own attitudes regarding the number of publications. In an already famous (and rather shocking) article, Ioannidis (2005) emphasized the fact that many of the findings described in scientific articles prove to be false. According to the author, different factors, neglected by the researchers, may be the cause of this stunning finding (Ioannidis, 2005). We don't want to suggest that pressure to publish is a major driver of misconduct (see, for instance, Fanelli et al., 2015; Fanelli, 2018). However, some of the factors listed above, like the use of poor or incorrect statistical approaches (Eisner, 2021), deficient and/or flexible experimental designs, and small sample size, may well have been triggered by the rush for publication (see also Berger and Ioannidis, 2004). In addition, lack of thoughtful experimental design due to pressure of time, poor methods, and inadequate analyses are important factors for the increasing waste of funding in biomedical research (Lawrence, 2003; Ioannidis et al., 2014).

Other reasons for irreproducible results include conflicts of interest, prejudice (due, for instance, to the belief in a scientific theory), and financial factors (Ioannidis, 2005). Financial interest merits further comment. In several countries, scientists receive extra money for their international publications. The higher the journal impact factor, the higher the bonus. Such

[1]Working memory may be defined as the system for the temporary maintenance and manipulation of information, necessary for the performance of such complex cognitive activities as comprehension, learning, and reasoning (Baddeley, 1992).

policies may corrupt. This is a tremendous scourge for science. Indeed, it is generally recognized that an additional consequence of performing science under pressure may result in fraud, and the use of financial rewards probably favor this terrible and fearsome enemy of science (Eisner, 2018). Fraud is not new (see, for instance, Mentor, 1973); however, the financial bonus for publishing in high-impact factor journals, although possibly not new, has spread globally in recent years (Abritis and McCook, 2017), promoting high and frequently ruthless competition instead of encouraging good science (Qiu, 2010; Franzoni et al., 2011). We do not mean that grants or awards to finance good projects or in recognition of an outstanding career, for example, are dangerous. On the contrary, these should be very welcome and even necessary when promoting or rewarding good science. However, the benefits offered to increase the number of publications in prestigious journals may be dangerous for several reasons. First, because these practices may promote quantity over quality. For instance, a study performed by Franzoni et al. (2011) indicated that cash incentives appear to encourage submission of research regardless of quality. In the words of Osterloh and Frey (2015) "taste for science" may be replaced by "taste for publication." Besides, it is known that some universities may pay even for publications in low-impact factor journals (Abritis and McCook, 2017). Second, because the primary tool used to evaluate quality is the journal impact factor, which is well known as a very doubtful measure of the actual scientific value of the paper (DORA, 2012; Callaway, 2016). Third, because, as we said above, it may favor unwanted behaviors among scientists. One of the best-known examples for this (although not unique; see for instance Franzoni et al., 2011; Abritis and McCook, 2017) is provided by Chinese universities, known to award cash prizes or other benefits for publishing in high-impact factor journals. This procedure was unfortunately associated with a wide range of dubious publishing activities, according to a survey commissioned by China's science ministry in six top institutions. A main reason alleged for this misconduct was the culture of *jigong jinli* (seeking quick success and short-term gain), revealed by one of the people involved in the survey (Qiu, 2010). This is reminiscent of Bauman's words: "The liquid modern society degrades long term ideals…These ideals are replaced by instantaneous gratification and individual happiness" (Bauman, 2005). Under this scenario, liquidity could also be evidenced by the growth of the retraction rate observed in the last few years (Cokol, et al., 2008).

On the other extreme of the spectrum, pressure for publishing is not so high and the requirements to belong to and remain in the scientific system are not very demanding. In many countries, scientists receive their salaries from the state or universities, and grants are mainly used to support the cost of research. In this type of organization, it is difficult to support large research efforts and to recognize exceptional scientists, although they can support a large number of scientists (possibly doing low-cost research; Ioannidis, 2011). Despite the great advantage of not having a high pressure for publishing, the influence of liquid life on science is probably also present in these systems. In the first place, they are not relieved of bad actions generated by competition or excessive ambition. In addition, the behavior of many researchers, whose only worry is fulfilling the minimum requisites to continue in the system, can be very clearly seen; Bauman (2005) uses the term "indolence" when referring to this type of behavior. In many cases, the genuine enthusiasm required for doing science is lost, being the unique motivation the persistence in the system. These people erroneously believe that research work is an ordinary employment opportunity that must be handled as such. They may be clever and have good academic training; however, they lack the necessary motivation to do research. Unfortunately, this attitude is harmful for themselves, because they might have better performance and more satisfaction by doing a different job, and for the laboratory. It contaminates the whole system, breeding the idea of "the lesser the effort, the better" and strongly conspires against making progress. In this context, hard work and strong dedication tend to become antonyms of enjoying life. Words like those pronounced by the Nobel laureate B. Houssay, "Work is the cheapest fun" (Jaim Etcheverry, 2017), may sound like obsolete concepts. In this scenario, the enthusiastic laboratory atmosphere, necessary for creation and innovation, vanishes.

Let's not lose the spirit of science

Is there any approach to avoid the intrusion of lightness in the way we are doing science?

In recent years, the concept of "grit" (defined as perseverance and passion for long-term goals; Duckworth et al., 2007), has emerged as an attribute that drives success. Although some initial controversy arose around this idea (Credé et al., 2017; Ivcevic and Brackett, 2014), more recent analysis indicates that grit is a good predictor of success and performance (Duckworth, 2016; Jachimowicz et al., 2018). As discussed above, we believe that success in science does not refer to the achievement of prestige, positions, economic rewards, or excessive productivity. A scientist is successful when he/she performs good science, looking for the correct result. Prestige, honors, money, recognition, and high productivity may all arrive as a result of doing good science, but they cannot be the goal. In this sense, success and performance might not have the same exact meaning that the authors who coined the term grit envisioned. However, the concepts that they display about grittiness can be perfectly extrapolated to the scenario of science. According to Duckworth (2016), five personality traits seem the most predictive for success, and we believe that they also apply to doing good science: courage, conscientiousness, perseverance, resilience, and passion. We can examine these traits individually and easily see why they can be essential skills for successful scientists (and how the easy route offered by liquid modernity sends us in the wrong direction). Courage is the triumph over fear (but not the absence of fear, as is sometimes thought). Courage includes taking a chance when others will not, following your vision, standing up for what you believe in, following through in a project when progress is slow, and overcoming any difficulties that may arise. Conscientiousness is defined as being thorough, careful, or vigilant. It implies a desire to do a task well and not resting until the job is done and done right. The conscientious have strong moral principles and values and will not take shortcuts to further their careers. Perseverance is synonymous with pain and suffering, but those with true grit can view this as a path to pleasure. Essentially, to persevere means to start and continue steadfastly on the path toward any goal you set; frequently, this factor alone is the difference between failure and success. Resilience is the capacity to recover quickly from difficulties. Resilient people tend to have a strong moral compass or a set of beliefs that cannot be shattered. They also see difficulties and frustration as stepping-stones to transformation. The capacity to overcome and learn from failure and seeing this as a stepping-stone to success is an important quality to have in a young scientist. Resilience is eroded by liquid modernity where frustration and failure are triggers to change directions. Finally, passion is what creates excellence. Passionate people have a deep sense of purpose and are often selfless in their actions. They are driven by goals and are result oriented. They do not let anything stop them—they have an attitude of not accepting "no" for an answer. Passionate people, as well as passionate scientists, recognize themselves in the driver's seat as they travel on their journey of life or research, whereas liquid modernity seems to encourage taking the passenger seat and simply enjoying the view.

Similar concepts can be found in memoirs, published interviews, and essays of prominent researchers and Nobel laureates of different areas. *Drive and Curiosity, What Fuels the Passion for Science* (Hargittai, 2011) is the title of a book inspired in the chronical of 15 discoveries, most of them based on personal interviews, that reflects the essence and the spirit of a scientific journey. Imagination, intelligence, dedication, and perseverance are especially important attributes, but possibly the most important factors are motivation, enthusiasm, and drive: to be involved, even obsessed, by the question to be answered, to think about solving the problem all the time. The solution will eventually show up. In the classic words of Walter Cannon, the man who crystalized the concept of homeostasis (Cannon, 1932), "...The real devotee of research is driven by an impelling desire to learn to satisfy his burning curiosity to know whether his surmise is true or not..." (Cannon, 1945).

Part of the solution to the presence of lightness and weightlessness in science is to keep intact the spirit of science, represented in Cannon's words and in the main traits that characterize grittiness. Senior investigators should be aware of all the nuisances caused by the new liquid modernity in the way we are doing science. They should establish a friendly mysticism, a contagious enthusiasm for science in the laboratory; they have to encourage perseverance and inspire passion. They have to talk and discuss seriously with people who are not enjoying what they are doing each day, clarifying their thoughts. They should set examples of true love for experimental work, analysis, study, reflection, dogma challenge, and deep knowledge, all of them essential for creation and innovation. Certainly, they should also take advantage of some characteristics of liquid modernity that may be beneficial for science. To give just one example, in liquid modernity individuals must (and are able to) quickly adapt to the constant changes and new challenges they must deal with in modern times. These attributes may allow them to rapidly empower new technologies that are necessary for the progress of science.

Moreover, and looking at the problem from the other side, promotion of mechanisms to improve transparency not only in the research process but also in the published results are powerful tools to attain excellence in science. Initiatives like that of the Transparency and Openness Promotion (TOP) Committee, which develops standards as a guide for journals to incentivize transparency, openness, and reproducibility (Nosek et al., 2015) or the San Francisco Declaration on Research Assessment (DORA, 2012), that develop a set of recommendations for the accurate evaluation of scientific papers, reports, or grants, are key proposals for improving transparency and science quality. Interestingly, Chinese institutions have been told to stop paying bonuses for publishing, as part of a new national policy to prevent researchers' misconduct produced by incentives that resulted in being harmful instead of beneficial for science, as initially thought (Mallapaty, 2020).

In summary, we believe that we must be aware of the possible inconveniences that the new modernity may produce in our laboratories to prevent or avoid them, as well as to perceive and enable its possible beneficial consequences. By facing these challenges, we think that we may succeed in surmounting some tendencies of the new modernity that prioritize, according to Bauman's concepts, the transitory rather than the permanent, the immediate rather than long term, and utility over any other value (Bauman, 2000).

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