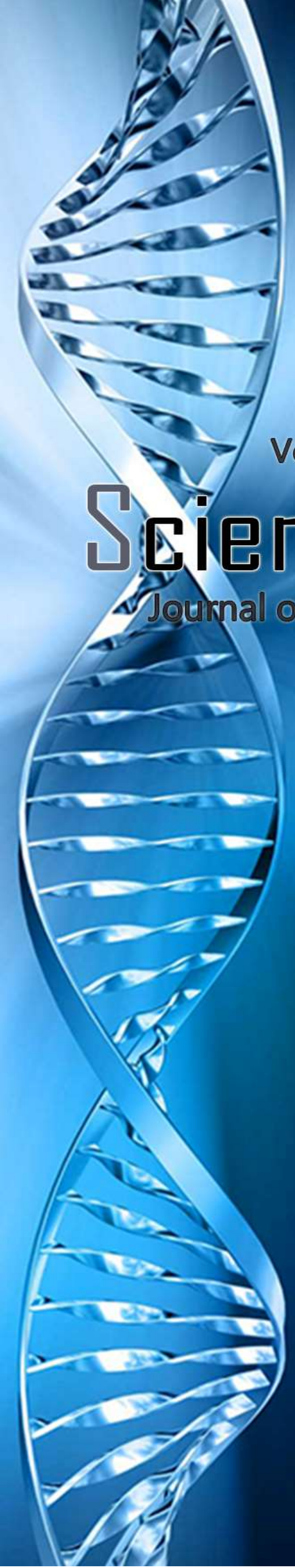


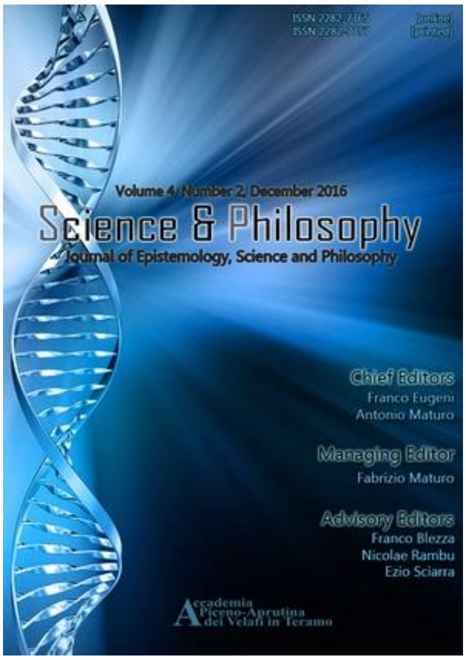
ISSN 2282-7765 [online]
ISSN 2282-7757 [printed]

Volume 7, Number 2, December 2019

Science & Philosophy

Journal of Epistemology, Science and Philosophy

Accademia Piceno-Aprutina dei Velati in Teramo



Publisher
Accademia Piceno - Aprutina dei Velati in Teramo (A.P.A.V.)

Note
All manuscripts are subjected to a blind review process. The reviewers are mainly selected from the huge scientific board. The journal's policies are described at:
http://eiris.it/ojs/index.php/scienceandphilosophy/about/submissions#authorGuidelines

Science & Philosophy is an **International**, **peer-reviewed**, open access journal, published every six months (June-December). Science & Philosophy aims to publish original research articles but also short communication and review papers of general significance that are written clearly and well organized.

The journal is a source of information for professionals in a wide range of scientific discipline. Indeed, Science & Philosophy is a multi-disciplinary journal that covers fundamental and applied research in various areas related to **Science, Epistemology and Philosophy**, including **Mathematics, Statistics, and Social Science.**

Both **English** and **Italian** languages are accepted for publications. In the case of an article in Italian, it is necessary to provide the title, the abstract, and the keywords also in English.

The journal is oriented on the scientific analysis of social phenomena, both by developing research with quantitative and qualitative methods and by interpreting with philosophical criticism. Science & Philosophy has its focus in the study of social phenomena both macro and micro, using the interdisciplinary approach of the social sciences, from economics to law, from politics to sociology, from history to social statistics.

The journal focuses on the analysis of both phenomena and trends, for designing local developments and systems ecology. Scientific analysis is supported by an ethic of sociability.

Science & Philosophy Volume 7(2), 2019, pp. 3-14

How to handle risky experiments producing uncertain phenomenon like cold fusion?

Robert W.P. Luk[1]

Abstract

Some experiments are risky in that they cannot repeatedly produce certain phenomenon at will for study because the scientific knowledge of the process generating the uncertain phenomenon is poorly understood or may directly contradict with existing scientific knowledge. These experiments may have a great impact not just to the scientific community but to mankind in general. Banning them from the study may incur societies a great opportunity cost but accepting them runs the risk that scientists are doing junk science. How to make an informed decision to accept/reject such study scientifically for the mainstream scientific community is of great importance to mankind. Here, we propose a statistical methodology to handle the situation. Specifically, we consider the likelihood of not observing the phenomenon after n trails so that it is statistically significant to have nil result. Consequently, we reject the hypothesis that there is some probability that we observe the phenomenon.

Keywords: risky experiments; cold fusion; statistical methodology; random model.[2]

[1] Department of Computing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong; csrluk@comp.polyu.edu.hk.

[2] Received on September 24th, 2019. Accepted on December 28th, 2019. Published on December 31th, 2019. doi: 10.23756/sp.v7i2.478. ISSN 2282-7757; eISSN 2282-7765.

1 Introduction

From time to time, experiments (e.g., by Meissner and Ochsenfeld [28], Mössbauer [35] and Bednorz and Müller [5]) have produced controversial, important phenomena from unknown processes (e.g., [24]). However, such experiments may not be welcomed by the scientific community. A good example is the cold fusion experiment in which Profs Fleischmann and Pons [13] claimed excess heat release from their experiment, which was thought to be due to some unknown nuclear process. This claim has been thought to be debunked [23] by some scientists as some expressed doubts (e.g., Horanyi [18]; Keddam [20]; Schultze et al., [39]) because many claimed that they were unable to replicate the experiment at least in some way (e.g., by Armstrong et al. [2], Bennington et al. [6] and Astakov et al., [3]). After the Department of Energy (DOE) warmed to cold fusion [10] as well as the American Chemical Society [38], 60 Minutes in 2009 reignited interests of both scientists and the public in cold fusion research (see [42] for a review). Recently, Google scientists [15] have been trying to achieve cold fusion. Despite their failure, they are still hopeful that they can achieve cold fusion in the future. However, some scientists are still skeptical about cold fusion as a legitimate subject of scientific inquiry, and some are concerned that it was publicized in some academic society's press conference. Debates over whether cold fusion should be treated as a scientific inquiry can be observed, for example, from blogs in Physics Buzz [8]. This raises an interesting question as to whether funding agencies and academic societies should accept such research as legitimate scientific inquiry as some regard cold fusion as undead science [41].

An accepted way to deal with such a situation is to wait for the paper on the experiment to be published, and then replicate the experiment. However, some experiments are hard to replicate due to their delicate and unknown nature. If the academic society had banned the research of such experiments, the paper would not be published at all. Publishing a scientific paper takes time, and there are possibilities of (omission) errors. These errors may be omitted unintentionally as the process generating the phenomenon is poorly understood. Even if a paper on a risky experiment (e.g., [19]) is published, there is no guarantee that other scientists can replicate the experiments with high reliability. In this case, the scientific community may fall into yet another debate (e.g., [1]) with the controversial experiment.

One way is to ask a committee of experts to judge whether the concerned phenomenon exists by reviewing a set of papers about the phenomenon and ask them to vote for or against the concerned phenomenon. While experts can comment on the problems with the experiments, the judgments are usually subjective based on just reading the papers (as in the DOE meeting). Experts can voice out their own subjective opinions about the experiment or phenomenon, which can damage/enhance the reputation of the experiment/phenomenon. Instead, what we need is an objective way to decide whether the concerned phenomenon exists. As it is usually hard to gain widespread acceptance/rejection, reviewing papers based on a committee of experts is not very conclusive to decide the acceptance/rejection of experiment/phenomenon. Therefore, this subjective way to make decisions is not preferred. Similarly, we should not rely on the process of reviewing papers by journals as this is also subjective and some journal may have a hidden embargo of papers on certain topics. Therefore, we need to seek a more objective way to make a decision than (pure) subjective judgment.

Another way to deal with such a situation is to send a group of experts (e.g., representatives from funding/government agencies like DOE, representatives of academic society like the American Physics Society and representatives from scientific journals/magazines like Nature) to the laboratory that claims certain phenomenon exists, and let the experts inquire. The laboratory can then demonstrate the phenomenon by carrying out the experiment. If it cannot be done once, the experts can wait for another attempt. However, how many attempts should the experts wait for a successful demonstration? Similarly, as in a reproducibility crisis [4], when replicating other researchers' work, how many times does the experiment need to be repeated before one declares that the experiment results cannot be reproduced?

2 Our Approach

To decide, we need to find a scientifically accepted way to deal with risky situations. The common, accepted method used in science is to use statistical tests as they are commonly used to accept or reject the hypothesis in science. The common idea is to accept the risk that the decision is wrong with a certain amount of percentage. For example, to accept a hypothesis with 95% confidence means that the decision to accept the hypothesis is wrong for less than 5% of the time. In using this statistical method, we accept that we cannot have absolute certainty about accepting or rejecting a hypothesis since there is risk [27]. Therefore, we should use statistical tests to handle how many times we should allow the experiments to be repeated in order to accept the hypothesis that the phenomenon exists or not.

Before we formulate the statistical test, one important observation should be made. According to falsification [36], only one case is needed to refute that a theory is true. To show that a theory is true with absolute certainty, we need to confirm the theory with infinite repetitions of the experiment, which is practically not possible and that is why we need to use statistics to accept or reject the hypothesis (testing the theory with a finite number of times).

For risky experiments with an uncertain phenomenon, the situation is different or the opposite. If an experiment showed that the uncertain phenomenon existed once or it is shown to produce the target result once, then the existence of the phenomenon (like excess heat in cold fusion) should be accepted, because the logical argument is that if the phenomenon once existed, then it implies that the phenomenon exists. Therefore, one only needs to know something existed once to determine its existence. Put this in another way, if we have shown that the phenomenon existed once, then we cannot say that the phenomenon never existed. Now, if we cannot repeat the experiment mechanically, it is due to our ignorance of the process to produce the phenomenon instead of the non-existence of the phenomenon. The demand of requiring mechanical repetition [11] of the phenomenon is over stringent because we do not understand the underlying mechanism that generates the phenomenon, so it is hard to repeat the results at will. If we know the underlying mechanism, then probably we can generate the phenomenon mechanically (although this depends on how controllable the process is). Such over-stringent requirement will prevent the discovery of many phenomena because they are poorly understood at the time of the experiments, so they demand to be studied. However, the over stringent requirement prevents such study by banning them as unscientific. Such over stringent requirement would be doing a disservice to the scientific community or even mankind. Therefore, to show that an uncertain phenomenon exists, only one successful demonstration is needed. Note that to demonstrate a theory or a model works, repeatability in experiments is still needed, so repeatability is not abandoned at all because in this particular case, we have knowledge of the underlying process of how the phenomenon is generated assuming that we can control the process. By comparison, we do not have the knowledge about the risky experiment nor are we capable of controlling it to reproduce at will. However, we need to study it because it is important. That is why we relax the repeatability criterion.

Before any demonstration to the experts, the experimental set up must be checked and validated by the experts and the proponent because there should not be any dispute about the experimental set up after the experiments start. Also, these experts should have the same degree of belief and disbelief that the phenomenon (e.g., excess heat for cold fusion) exist, so we can ascribe a subjective probability of 0.5 as the degree of belief of the experts, which is higher than the proportion of success (i.e., 0.3) in some cold fusion experiments [19]. After n independent trials, if none of the experiments is successful, then the probability that n trials failed in succession is 0.5^n. This probability should be less than the probability, p, that we incorrectly reject the hypothesis that the phenomenon exists (i.e., a Type I error) with probability a half occurring. Typically, p is 0.05, so $n > 4$ in this case for a one-tail test. However, most of the demonstrations of cold fusion are required to be repeated with just one or two trials which are too few to give the cold fusion proponent a "fair" chance to demonstrate. As a result, the proponents may feel that it is unfair to them to reproduce the results mechanically at will as they know their experiments can only be repeated with a certain probability. Therefore, they may be reluctant to demonstrate. By allowing a fair number of trials, they may be enticed to the demonstration as they have a fair chance of success.

In summary, we used a random model to help us to decide how many trials the laboratory has to yield a successful demonstration. The advantage of this is that no prior knowledge can influence this decision as such prior knowledge (or existing theory) may be contradictory to the concerned phenomenon (that is why scientists or theorists want to ban such study). It should be noted that scientific knowledge is provisional (as discussed in Luk [27]) so it can be wrong even if it is accepted. Although theories can be falsified by experiments, experiments may not be falsified by a theory which can be wrong if the experiment after checking for its validity can repeat the (falsifying) results for reliability. Having said that, experiments can be wrong, for example, measurement errors or making wrong wired connections. So, experiments are not immune to errors but they can be checked and double-checked for validity (before the demonstration).

If the experts inquire about the success rate, α, of replicating the experiments, then α can be used to decide how many trials they need to wait for a successful demonstration. In this way, if α is too low, the experts may not need to visit the laboratory because they have to wait for too many trials for a successful demonstration. Acceptable success rate can be worked out by assuming that experts can tolerate at most n trials, so that $\alpha > 1 - p^{1/n}$. The laboratory takes the risk of failure to demonstrate the phenomenon with the probability of $(1-\alpha)^n$. In this way, the laboratory has been given a "fair" chance to demonstrate, and the experts can conclude in a scientifically accepted way, acknowledging there is risk in their decision.

Instead of assuming the trials are independent, we can use the Laplace law of succession [12] to estimate the probability of having n successions of failure, which is $1/(n+1)$. For the probability of incorrectly rejecting the null hypothesis to be less than p, we need $p < 1/(n+1)$. If $p = 0.05$, then $n > 19$. So, the experts have to wait for the laboratory to do at least 20 experiments to decide whether the phenomenon exists. This is a more relaxed requirement as the experiments are not necessarily independent, so they may systematically fail for some reason.

Which number of trials, n, to use would depend on the experts who decide whether they should treat each experiment as independent or not. If the experts ask the laboratory to repeat the experiment differently every time the demonstration of the phenomenon fails, for example, changing the way the alloys are cut or prepared for the experiment in cold fusion (because of fracture in the alloy), then each experiment should be considered independent. On the other hand, if the experts request the laboratory to repeat the experiments intentionally without any change, then the experiments are not independent any more so that the use of Laplace law of succession to determine the maximum number of trials *n* for a successful demonstration is appropriate.

Determining the maximum number of trails to wait for the successful demonstration is obviously one important aspect of the determination to accept or reject the existence of the uncertain phenomenon. However, there are other important aspects too, like the experts checking the experimental set up for fraud and deciding whether the signal of the uncertain phenomenon is sufficiently clear (e.g. the amount of excess heat in cold fusion). Therefore, a checklist of items for checking the experiments should be documented and verified by the experts to ensure the credibility of the demonstration. Such a checklist should be publicized along with the demonstration results in order to provide a “fair” chance for the demonstration and to make as informed as possible about the decision to accept or reject the existence of the uncertain phenomenon in the risky experiments. It should be noted that accepting or rejecting the existence of the phenomenon is not final as scientific knowledge is fallible. However, we have used an accepted procedure to make a temporary risky decision about accepting or rejecting phenomenon so that we can temporarily rest with this decision until another challenge arises as new evidence mounts and as the funding for testing the phenomenon permits.

Some scientists may regard it is a fluke or experimental hiccup that appeared to produce the phenomenon and they may want a more stringent test before accepting the phenomenon is real. Then, this can be considered as the problem of scaling the sample size. If no probability is supplied, then we use the probability of 0.5 as the degree of belief that the phenomenon existed compared with the probability of 0.5 as the degree of belief that the phenomenon does not exist for the null hypothesis. Based on the binomial distribution (or approximated to the normal distribution if the number trials is large), we can work out the 95% confidence level (or other agreed confidence level) of the lowest probability that we would reject the null hypothesis. In turn, this lowest probability can translate into the least number of repetitions that we should observe in at most *n* trials that the scientists are willing to check. For instance, if we are willing to repeat ten trials (instead of at most five), then according to the binomial distribution two or more successful demonstrations out of ten indicate that the null hypothesis that the probability of successful experiment is a half is accepted (based on a one-tail test). However, the number of trials may be too large for people to invest the resources to check the phenomenon. Then, we may need to use a more efficient test like the sequential analysis (e.g., Gottman and Roy, 2004), the details of which I let the reader to explore (since it does not affect my argument as it only improves the efficiency of the test). Yet, another alternative is to restart the demonstration forgetting the successful demonstration and allow *n* (e.g., 5 for the 95% confidence level) trials for yet another successful demonstration. In general, the experts and the proponent can agree with the number of restarts to reach the final decision between them before the demonstration starts instead of limiting the number of restart to just one. In this way, the proponent avoids the situation that the experts keep demanding more repetitions to answer more queries or inspections (similar to moving the goal posts), and the experts can limit the number of trials before declaring their judgment of the demonstration. Introducing the restart allows the experts to look for fraud as the experts have knowledge of the experiment after it is completed. Instead of restart, the proponent can run a mock experiment (with or without successful demonstration of the phenomenon) to let the experts to inquire afterwards. In this way, there is no need to restart for the experts to gain confidence in checking the experiment. Therefore, this can reduce the time needed to demonstrate, and this is a harder test for the proponent than scaling the sample size as every restart requires a successful demonstration after n trials. In summary, there is an accepted way to deal with accepting risky phenomena but yet does not require mechanical repetitions (at will).

Apart from speeding up the decision making by statistical tests, experimental set up can also speed up the decision-making process. Instead of waiting for one experiment to complete before starting another experiment, n experiments are carried out in parallel. This may become important for cold fusion as it may take over a week to boil the water in order to observe the phenomenon. The advantage of parallel experiments is that the time is shortened. The disadvantage is that more resources are required to perform such experiments. In addition, the demonstrator cannot learn from the experiment as to why the experiment failed before starting another experiment to avoid such pitfall although there is no guarantee what is learnt can make any impact on the success of the demonstration as the risky experiments are due to some unknown process. Instead of setting a confidence level of 95% for parallel experiments, one can increase the confidence level a little so that the number of experiments to try in parallel is larger if resources permit, in order to offset the missing learning effect. Yet another approach is to combine both sequential and parallel experiments to carry out experiments in batches. In this case, we may carry out experiment with say a batch of five in parallel and sequentially we carry out two batches to execute a total of ten runs of experiments. In this way, we can save time and can try to learn why the experiments failed.

3 Is cold fusion science?

Coming back to the cold fusion issue, is cold fusion science? First, cold fusion is an experiment rather than a theory. The theory put forward by Pons and Fleischmann was only tentative, so it should be treated as a hypothesis. The focus of the experiment should be on whether excess heat (i.e., the phenomenon) is produced rather than nuclear products as predicted by the tentative theory are observed because the tentative theory can be wrong but there may still be some kind of nuclear process taking place other than fusion. If cold fusion is just an experiment, then it belongs to the working scientific knowledge according to Luk [26] rather than scientific theory or scientific model because to be called a scientific discipline a scientific theory or a scientific model is required according to Luk [25]. However, cold fusion has a nuclear reaction model [13,14], the by-products of which, helium-4, are found to correlate with the excess heat (e.g. [29,30]). Miles [30] got the odds in favor of the correlation of 750,000 to 1 which is well above the ability of the random model of correlation. However, the nuclear reaction model was not initially completely substantiated as the model predicts gamma ray productions with helium-4 but no gamma ray (e.g., [3]) was detected or as the model predicted neutron emission but only a weak rate was reported (e.g., [40]), even though sometimes tritium is detected (e.g., [7,21,44]). Relatively recently, Chubb [9] explained another nuclear pathway where two deuterons fuse to produce helium-4 without energetic particles or gamma rays based on conventional physics. Therefore, the excess amount of helium-4 produced in the experiment is an indication that some nuclear process is taking place even though some [22] may argue that there are other types of nuclear processes (like electron capture [44]) as these are on-going research (e.g., [17,43]). Relatively recently, more evidence of nuclear reaction was found based on identifying or measuring energetic particle (like neutron or tritium) tracks created on CR-39 material (e.g., by Mosier-Boss et al. [32,33,34]) further supporting the existence of nuclear processes in cold fusion experiments. Therefore, it seems certain some kind of nuclear process is taking place in cold fusion but exactly what this nuclear process involves is on-going research as the nuclear process may involve multiple pathways rather than a single pathway. Coupled with the application of the principle of prudence [37] to cold fusion for climate change, it is perhaps apt now to visit the laboratory that claims cold fusion is possible and to decide whether the cold fusion phenomenon exists using our proposed methodology to warrant inclusion in mainstream science (mainly in physics) as this is a catch-22 situation [31] and as some reactor is demonstrated for commercial interests rather than scientific verification (by-passing the scientific enterprise).

Regarding cold fusion as an example of scientific inquiry, we should caution not to dismiss experiments too early as unscientific because it may be possible that in the future respectable scientific theory or model may be able to explain the experiments, so that the experiments may eventually be classified as a scientific experiment. For an experiment to be called scientific, mechanical repeatability is not a mandatory requirement because otherwise many subjects cannot be called science because the experiments cannot be controlled for repeatability or may not be repeated literally like the big bang theory. Instead of repeatability, we believe an assessment of the reliability (using statistics and probability) is more important because there is no guarantee that future experiments can be repeated even if they were repeated mechanically in the past (as in the problem of induction). Therefore, using statistics to assess the reliability of our experiment is more important than demanding mechanical repeatability (to show the phenomenon exists) because the statistics help us to appreciate the risky decision that we are making (about future events).

4 Conclusion

We have shown that there is a statistical methodology that can help to decide how many times an experiment should be repeated before a replication is judged to fail or before the uncertain phenomenon is judged not to exist. This statistical method tells us the risk of our decision in making the incorrect judgment. If the decision is to reject that the phenomenon exists or to reject the experiment can be replicated, this methodology only makes a provisional rejection decision since there is risk in the decision similar to common (scientific) hypothesis testing. As there is more evidence mounting towards the existence of the uncertain phenomenon or the replication can be done, another round of statistical tests can be carried out if resources permit. Therefore, we have a methodology to handle such a situation in a scientifically accepted way.

References

[1] Armstrong, R.D. (1989) "The cold fusion debate" *Electrochimica Acta* 34(9): 1287.

[2] Armstrong, R.D., Charles, E.A., Fells, I., Molyneux, L. and Todd, M. (1989) "Some aspects of thermal energy generation during the electrolysis of D_2O using a palladium cathode" *Electrochimica Acta* 34(9): 1319-1322.

[3] Astakhov, I.I., Davudov, A.D., Katarin, N.V., Kazarinov, V.E., Kiseleva, I.G., Kriksunov, L.B., Yu Kudryavtsev, D., Lebedev, I.A., Myasoedov, B.F., Shcheglov, O.P., Teplitskaya, G.L. and Tsionskii, V.M. (1991) "An attempt to detect neutron and gamma radiations in heavy water electrolysis with a palladium cathode" *Electrochimica Acta* 36(7): 1127-1128.

[4] Baker, M. (2016) "1,500 scientists lift the lid on reproducibility", *Nature* 533(7604): 452-454.

[5] Bednorz, J.G. and Müller, K.A. (1986) "Possible high T_c superconductivity in the Ba-La-Cu-O system", *Zeitschrift für Physik B Condensed Matter* 64(2): 189-193.

[6] Bennington S.M., Sokhi, R.S., Stonadge, P.R., Ross, D.K., Benham, M.J., Beynon, T.D., Whithey, P., Harris, I.R., and Farr, J.P.G. (1989) "A search for the emission of X-rays from electrolytically charged palladium-deuterium" *Electrochimica Acta* 34(9): 1323-1326.

[7] Brillas, E., Esteve, J., Sardin, G., Casado, J., Domènech, X. and Sánchez-Cabeza, J.A. (1992) "Product analysis from D_2O electrolysis with Pd and Ti cathodes" *Electrochimica Acta* 37(2): 215-219.

[8] Buzz Skyline (2010) "Chemists taken in by cold fusion again!", http://physicsbuzz.physicscentral.com/2010/03/chemists-taken-in-by-cold-fusion-again.html.

[9] Chubb, S.R. (2011) "Conventional physics can explain cold fusion excess heat" *Physics Procedia* 20: 404-419.

[10] Feder, T. (2004) "DOE warms to cold fusion", *Physics Today* 57(4): 27-28.

[11] Feldman, B.J. (2010) "Cold fusion and reproducibility" *Physics Today* 63(11): 12.

[12] Feller, W. (1968) *An Introduction to Probability Theory and Its Application*, Vol. 1, Wiley, New York.

[13] Fleischmann, M. and Pons, S. (1989) Electrochemically induced nuclear fusion of deuterium. *Journal of Electroanalytical Chemistry and Interfacial Electrochemistry* 261(2) Part 1: 301-308.

[14] Fleischmann, M., Pons, S., Anderson, M.W., Li, L.J., Hawkins, M. (1990) Calorimetry of the palladium-deuterium-heavy water system. *Journal of Electroanalytical Chemistry and Interfacial Electrochemistry* 287(2): 293-348.

[15] Gibney, E. (2019) Google revives controversial cold-fusion experiments. *Nature* 569: 611 (doi: 10.1038/d41586-019-01683-9).

[16] Gottman, J.M. and Roy, A.K. (2004) *Sequential Analysis: A Guide for Behavioral Researchers*. Cambridge, England: Cambridge University Press.

[17] Hagelstein, P.L. (2010) "Constraints on energetic particles in the Fleischmann-Pons experiment" *Naturwissenschaften* 97(4): 345-352.

[18] Horanyi, G. (1989) "Some doubts about the occurrence of electrochemically induced nuclear fusion of deuterium" *Electrochimica Acta* 34(6): 889-890.

[19] Kainthla, R.C., Velev, O., Kaba, L., Lin, G.H., Packham, N.J.C., Szklarczyk, M., Wass, J. and Bockris, J.O'M. (1989) "Sporadic observation of the Fleischmann-Pons heat effect" *Electrochimica Acta* 34(9): 1315-1318.

[20] Keddam, M. (1989) “Some comments on the calorimetric aspects of the electrochemical cold fusion by M. Fleischmann and S. Pons” *Electrochimica Acta* 34(7): 995-997.

[21] Kozima, H., Watanabe, S., Hiroe, K., Nomura, M. and Ohta, M. (1997) Analysis of cold fusion experiments generating excess heat, tritium and helium. *Journal of Electroanalytical Chemistry* 425(1-2): 173-178.

[22] Krivit, S.B. (2013) “Nuclear phenomena in low-energy nuclear reaction research” *Naturwissenschaften* 100(9): 899-900.

[23] Lindley, D. (1989) “Official thumbs down”, *Nature* 342(6247): 215.

[24] London, F. (1935) “Macroscopical interpretation of superconductivity”, *Proceedings of the Royal Society* (London) A152: 24-34.

[25] Luk, R.W.P. (2010) “Understanding scientific study via process modeling”, *Foundations of Science* 15(1): 49-78.

[26] Luk, R.W.P. (2017) “A theory of scientific study”, *Foundations of Science* 22(1): 11-38.

[27] Luk, R.W.P. (2018) “The implications and extensions of Luk’s theory and model of scientific study”, *Foundations of Science* 23(1): 103-118.

[28] Meissner, W. and Ochsenfeld, R. (1933) “Ein neuer effekt bei eintritt der supraleitfähigkeit”, *Die Naturwissenschaften* 21(44): 787-788.

[29] Miles, M.H., Hollins, R.A., Bush, B.F., Lagowski, J.J. and Miles, R.E. (1993) “Correlation of excess power and helium production during D2O and H2O electrolysis using palladium cathodes”, *Journal of Electroanalytical Chemistry* 346(1-2): 99-117.

[30] Miles, M.H. (2005) “Correlation of excess enthalpy and helium-4 production: a review”, *Condensed Matter Nuclear Science*, Edited by P.L. Hagelstein and S.R. Chubb, pp. 123-131.

[31] Mosier-Boss, P.A., Forsley, L.P. and Gordon, F.E. (2013) “How the flawed review process impedes paradigm shifting discoveries” *Journal of Condensed Matter Nuclear Science* 12: 1-12.

[32] Mosier-Boss, P.A., Gordon, F.E., Forsley, L.P. and Zhou, D. (2017) “Detection of high energy particles using CR-39 detectors part 1: results of microscopic examination, scanning, and LET analysis” *International Journal of Hydrogen Energy* 42(1): 416-428.

[33] Mosier-Boss, P.A., Szpak, S., Gordon, F.E. and Forsley L.P.G. (2007) “Use of CR-39 in Pd/D co-deposition experiments” *European Physical Journal - Applied Physics* 40(3): 293-303.

[34] Mosier-Boss, P.A., Szpak, S., Gordon, F.E. and Forsley L.P.G. (2009) “Triple tracks in CR-39 as the result of Pd-D co-deposition: evidence of energetic neutrons. *Naturwissenschaften* 96(1): 135-142.

[35] Mössbauer, R.P. (1958) “Kernresonanzflureszenz von gammastrahlung in Ir”, *Zeitschrift fur Physik A* 151(2): 124-143.

[36] Popper, K.R. (1959) *The Logic of Scientific Discovery*. London: Hutchinson.

[37] Price, H. (2019) “Icebergs in the room? Cold fusion at thirty” *3 Quarks Daily*, March issue, (https://www.3quarksdaily.com/3quarksdaily/2019/03/icebergs-in-the-room-cold-fusion-at-thirty.html).

[38] Sanderson, K. (2007) Cold fusion is back at the American Chemical Society. *Nature* (March 2007) doi:10.1038/news070326-12.

[39] Schultze, J.W., König, U., Hochfeld, A., Van Calker, C. and Kies, W. (1989) “Prospects and problems of electrochemically induced cold nuclear fusion” *Electrochimica Acta* 34(9): 1289-1313.

[40] Seeliger, D., Wiesener, K., Meister, A., Marten, H., Ohms, D., Rahner, D., Schwierz, R. and Wustner, F. (1989) “Search for DD-fusion neutrons during heavy water electrolysis” *Electrochimica Acta* 34(7): 991-993.

[41] Simon, B. (1999) “Making sense of the cold fusion after the (arti)fact” *Social Studies of Science* 29(1): 61-85.[42] Storms, E.K. (2010) “Status of cold fusion (2010)” *Naturwissenschaften* 97(10): 861-881.

[43] Storms, E.K. (2013) “Efforts to explain low-energy nuclear reactions” *Naturwissenschaften* 100(11): 1103.

[44] Szpak, S., Mosier-Boss, P.A. and Gordon, F.E. (2007) “Further evidence of nuclear reactions in Pd/D lattice: emission of charged particles” *Naturwissenschaften* 94(6): 511-514.

Science & Philosophy Volume 7(2), 2019, pp. 15-26

Solar Cycles, Light, Sex Hormones and the Life Cycles of Civilization: Toward Integrated Chronobiology

Roy Barzilai[1]

Abstract

The emerging discipline of complexity science, applied to the social sciences, seeks to study the rise of human civilization as a part of a natural, evolving biological system that exploits energy resources to fuel its growth into a complex social system. In order to understand the whole system, the reductionist approach, typical to Western science, must be supplanted. The atomistic study of various scientific fields as separate mechanical parts of the system must be broadened, creating a more holistic view of human culture as an integral part of larger universal process of evolution and creation. In this article I wish to integrate the various scientific fields, including physics, chronobiology (studying the effect of solar cycles on biological growth), biology, evolutionary psychology, and the social sciences, to achieve a unified understanding of our cultural evolution.

Keywords: sex hormones, cultural evolution, evolutionary psychology.[2]

---

[1] Independent scholar, Tel Aviv, Israel. roybarzilai@gmail.com.
[2] Received on December 17th, 2019. Accepted on December 28, 2019. Published on December 30th, 2019. doi: 10.23756/sp.v7i2.483. ISSN 2282-7757; eISSN 2282-7765.

1. Introduction

In his book, *Consilience: The Unity of Knowledge* (1998), biologist E. O. Wilson, the father of sociobiology, suggests a new synthesis of knowledge from different specialized fields of human endeavor to reach a greater understanding. Hormones—a word meaning *impetus*—are actually the drivers of biological processes as well as forces that structure the sexual organization of human societies. The primary human sex hormone is testosterone. Not only does testosterone fuel the passion for reproduction and play a critical role in the length of our lives, but it is also an integral component to the mechanism of human civilization—its triumphs and its tragedies. In order to understand the forces that drive the life cycles of human cultures and that form the engine of history, I propose that the profound transformations in social mood that bring the rise and fall of civilizations is caused by biological cycles and directed by hormones. Hormones regulate and control the way the human mind perceives the world, understands the nature of the good, and forms social organizations and political orders accordingly.

Our body is a complex biological system composed of various specialized cells working in social cohesion and harmony, synchronized according to hormonal cycles that regulate our sexual reproductive life cycles: from birth to puberty and adolescence, when humans reach sexual maturity, to the years of mating, raising offspring, and aging, until death. Individual humans bond to form complex social groups, such as the family unit, nations, and entire civilizations, which coordinate our organization through cultural norms. Humans develop intricate social institutions, such as religion and politics, in order to divide resources and labor to facilitate growth.

2. Energy and Human Evolution

In order to grow, biological organisms require energy, which we consume from our environment. Our evolution is a process of adaptation, directed to adapt us to environmental change. Hence, to understand the physical and biological underpinnings of our sexual and social organizational patterns, repeated throughout evolution and history, it is necessary to understand how energy is available and how it is utilized for the growth of the human superorganism. In his article "Energy and Human Evolution" (1995), David Price writes:

Life on Earth is driven by energy. Autotrophs take it from solar radiation and heterotrophs take it from autotrophs. Energy captured slowly by photosynthesis is stored up, and as denser reservoirs of energy have come into being over the course of Earth's history, heterotrophs that could use more energy evolved to exploit them, Homo sapiens is such a heterotroph; indeed, the ability to use energy extrasomatically (outside the body) enables human beings to use far more energy than any other heterotroph that has ever evolved. The control of fire and the exploitation of fossil fuels have made it possible for Homo sapiens to release, in a short time, vast amounts of energy that accumulated long before the species appeared. (p. 301)

This writing will begin by exploring the role of solar cycles in driving the biological and social growth processes of human civilization.

3. Integrated Chronobiology

The two primary hormones that, along with solar activity, are involved in the co-regulation of human growth, social mood, social status, sexual behavior, and dominance are serotonin and testosterone. In the daily circadian rhythm, both serotonin and testosterone rise in the morning and fall at night, when serotonin is being converted to the sleep hormone, melatonin. The levels of these hormones are regulated by the master hormone regulator, the hypothalamus, and are synchronized with solar cycles.

Serotonin is the most ancient hormone, involved in photosynthesis in plants, oxygen utilization, and growth cycles. Evolutionary psychiatrist Emily Deans (2011) describes some of this process:

Tryptophan hydroxylase may be the oldest enzyme to attach oxygen to other molecules. Since oxygen is generally quite reactive and toxic biochemically, this was an early way to safely get rid of excess oxygen created by photosynthesis in primitive organisms. The light receptors in the human (and other animals) retina are very similar to serotonin receptors and were first thought to evolve a billion years ago. Serotonin is the oldest neurotransmitter, and the original antioxidant. There are 20 different serotonin receptors in the human brain, and serotonin receptors are found in all animals, even sea urchins.

In other animals, serotonin is involved in swimming, stinging, feeding modulation, maturation, and social interaction. In general, it is thought of as a growth factor for animal brains. In humans, deficiency of serotonin is implicated in autism, Down syndrome, anorexia, anxiety, depression, aggression, alcoholism, and seasonal affective disorder.

In the opening lines of the Torah, Moses recorded the creation of the world, attributing to our benevolent Creator the first command of creation: “Let there be light.” The scripture continues, “…and there was light. And God saw the light, that it was good: and God divided the light from the darkness.” (Genesis 1:3, 4) Light is primal to life and to its very creation. It is no surprise, therefore, that light, and specifically bright light (more than 2,500 *lux*) has a direct effect on our ability to create life. Beginning in the 1980s, studies have confirmed that bright light exposure directly affects sex hormones. A 2003 study showed that when young men were exposed to 1 hour of bright light in the blue spectrum (BL), early in the morning for 5 days, the luteinizing hormone, a precursor to testosterone, increased by almost 70% (Yoon, Kripke, Elliott, & Youngstedt, 2003). Improving testosterone production has many positive effects, including a decrease in depression and low sexual desire and function (Bossini et al., 2009). It is also possible that BL exposure in the early morning could stimulate ovulation in women (Konstantin, Danilenko, & Samoilova, 2007). Notably, the color of light makes a significant difference in these and other studies. Light in the blue part of the spectrum is most effective when assessing testosterone production. Faryadyan et al. (2014) found that blue light has been shown to significantly increase the serum testosterone levels in rat babies when the mother was housed where predominantly blue rays affected her. The male rats in the study were born with statistically significant higher levels of testosterone than those that had lived in white or black boxes. Green light also created higher testosterone levels in new-born rats, but not as high as the blue.

Light therapy and serotonin-increasing medications are both effective treatments for depression that occurs with low levels of sunlight. Light exposure increases serotonin in humans. Serotonin levels are lowest in midwinter and higher on bright days no matter what time of year. 10,000 *lux* light therapy decreases suicidal ideation in some people that can occur from low serotonin levels (Means, 2011). In a meta-analysis of research on serotonin and depression, Young (2007) reports that such bright light treatment is effective in treating year-round depression and premenstrual and pregnancy depressions.

Furthermore, ultraviolet-B sunlight rays trigger the production of vitamin D, which is a catalyst for testosterone and serotonin production. Vitamin D—a steroid hormone—is correlated with conception rates, both peaking in the same months in respective hemispheres. Peak sun exposure in the northern hemisphere in June and July leads to peak vitamin D levels in September and October, given the six to eight weeks it takes for the body to convert sunlight to hormone. Those are the months when testosterone levels are highest and when conception rates are highest. An interesting exception to this pattern can be found in Scandinavia where sunlight is so pervasive in the early summer—twenty hours a day in June and July—that there is more of a bright-light effect, which causes the peak of conception rates to correlate with light exposure (Brody, 1981).

Like testosterone and serotonin, melatonin has also been shown to play a role in reproductive capability in both humans and animals. And like those hormones, melatonin production is light-dependent. Studies suggest that BL treatment can diminish activity in the human pineal gland, which in turn supports greater melatonin secretion as well as positively influencing sexual function (Bossini et al, 2013). In a placebo-blind study, the group treated with BL reported up to 3 times greater sexual satisfaction than those treated with a placebo, compared to their reporting prior to the treatment (Bossini et al, 2013).

In addition to specific light sensitivity, it seems that life on earth is sensitized to other facets of our sun's activities. The strength of the earth's magnetic field, for example, or the actual position of the sun in the galaxy, or the occurrence of sunspots all play roles in creating and sustaining life. The earth's magnetic field, which is created by its core, protects the earth from solar particle storms by deflecting them into loops called the Van Allen belts. When solar radiation is particularly strong and the magnetic field is more highly activated, a section of the brain's hippocampus senses these changes and signals the pineal gland to produce melatonin and the hypothalamus to produce growth hormones. Scientist Maurice Cotterell (2017) argues for the *solar hormone theory* that asserts the sun controls fertility in women, coordinating its twenty-eight-day rotation with women's twenty-eight-day fertility cycle.

4. The Impact of Solar Energy on Human Cultures

Given that light energy is essential for biological life to grow, it is not surprising that human culture all over the world associates light with a good and optimistic social mood. In Western Judeo-Christian theology, as depicted in Genesis 1, God is the Creator of light, and creation of this world is associated with the good and the kingdom of light. In contrast, Satan is the ruler of the kingdom of darkness and evil. In Chinese philosophy and in astrology, yin-yang represents the feminine-masculine principles in nature, wherein the feminine is associated with the moon, darkness, less energy, and passivity, and the masculine is more connected to the sun, high-energy, and the active element of creation.

The hormonal mechanisms previously discussed are responsible for translating variations in seasonal solar cycles into behavioral adaptations to the environment. Solar cycles vary not only on a seasonal basis but also on much longer annual cycles, such as the 7-year and 70-year cycles. These are eras of mass social mood driven by recurring waves of testosterone rise and decline. Light causes our master hormone regulator, the hypothalamus, to control the release of growth, sex, and stress hormones throughout our body, the coordinator that synchronizes physical light-energy and the neuro-psychological motives that drive human activity.

Periods of rising solar radiation levels signal our primitive mammalian brain that the environment accommodates a growth cycle, spurring testosterone, serotonin, melatonin, and dopamine levels and propelling us to expand. In this cycle, humans seek dominance in their own societies and over the rest of the natural world in order to acquire resources and reproduce. By contrast, periods of declining solar radiation impel humans, through decline in growth hormones, to shrink into a mode similar to hibernation during winter in order to conserve resources and wait for a better opportunity to grow again. Adaptation to a changing environment is at the core of biological evolution. These hormonal cycles have been influencing human behavior for thousands of years, across the globe, by the great force that synchronizes our hormones: the sun.

In the schema of Western history, the period when Roman civilization collapsed has been referred to as the Dark Ages, whereas the period demarking the rise of modern civilization is called the Enlightenment. As depicted in Figure 1, rising solar activity correlates with the culture of reason and liberty of the Enlightenment, exemplified in the thinking of English Puritans, from the natural philosophy of Newton and John Locke's ideal of liberty (1680s) to the Founders of the United States in 1776 with the Declaration of Independence.

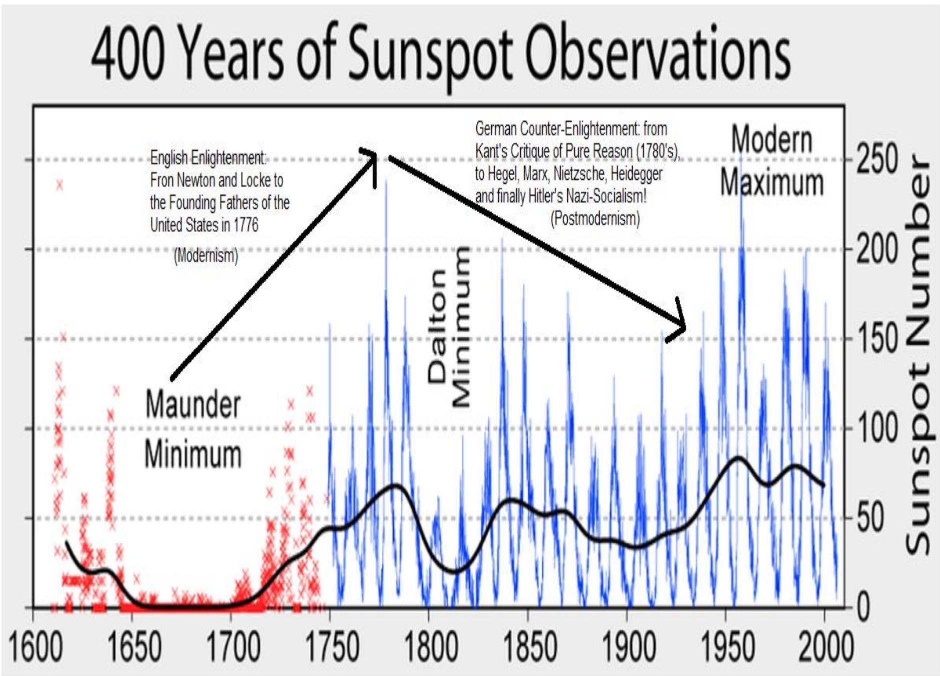


Figure 1: 400 Years of Sunspot Observations

However, as solar radiation peaked and began a long period of decline from the 1780s to 1930s, the period of philosophical modernism gave way to postmodernism. This brought us to the period of the German counter-Enlightenment, the assault on reason and individualism led by Kant's *Critique of Pure Reason* (1780), to Goethe, Hegel, Marx, Nietzsche's existentialist philosophy, Heidegger, and finally culminating in Hitler's Nazi cult. Moreover, when solar activity declined into the 1930s, it led to the economic period of the Great Depression. The concomitant social mood of psychological depression and social conflict is evident with the rise of National Socialism in Germany, and communism and fascism in the USSR and Italy, respectively, leading to WWII.

During the Enlightenment period of the 1680s –1776, the leading English Puritan intellectuals, such as Newton, Locke, and Thomas Jefferson were Unitarians, who identified with the biblical archetype of God the Father, the Creator who commands, "Be fruitful and multiply and have dominion over nature" (Genesis 1:28)—a high-testosterone posture of dominance and fertility. This is evident in the Declaration of Independence of United States, written by Thomas Jefferson, also a Unitarian, who wrote, "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable rights, that among these are Life, Liberty and the pursuit of Happiness." As high testosterone and serotonin levels are associated with positive mood trends, this explains the culture in pursuit of happiness. The negative social mood during the Counter-Enlightenment period of German philosophy led to Goethe's character Faust, who makes a pact with Satan to enslave humanity. This stood in contrast to the Enlightenment philosophy of God-given liberty to mankind. In addition, the existentialist philosophy of Friedrich Nietzsche and Martin Heidegger was nihilistic, proclaimed the death of God, and characterized life as devoid of meaning and purpose, rendering reason impotent to know the reality.

In further contrast to the ideals of the English Puritans during the Enlightenment, Catholicism is more feminine with the exaltation of Mary the Mother of Jesus, a more feminine archetype. The Augustinian doctrine of Original Sin correlated with a cultural fall into the Dark Ages, when sex was considered an evil and there was a rise of the ideal of priests as celibate monks. However, this tradition was radically altered during the Protestant Reformation by Martin Luther, who disavowed his celibacy to marry a nun and have a family of five children. This suggests that a rise of testosterone levels led to a change in social norms and belief systems during this historical period starting from the Renaissance in the mid-fifteenth century, the very meaning of which is a rebirth of civilization, leading to the Protestant Reformation in 1517, and culminating with the Enlightenment during the eighteenth century.

5. Impact of Testosterone on Demographic Trends

Because there is a lack of historical data on hormone levels in human populations dating back more than 40 years or so, other available statistical information can be used as a guiding measure to analyze changing hormones levels. Changing fertility rates through the history of civilization is a reasonable indication that testosterone levels oscillate in up-down cycles, causing the rise and decline cycles in population size. These trends in societal growth and decline offer at least a cursory view of the parallels in fertility rates and the ideas that drove Western civilization.

The graph in Figure 2 depicts 450 years of the demography of England and Wales and stands as an excellent visual of how fertility rates have correlated with social trends. Throughout these years, life expectancy has risen while the total fertility rates have fallen at an intriguingly similar pace. The rhythm and flow of fertility rates can be seen and correlated with solar activity during this period by looking at Figure 1 and Figure 2. In the Enlightenment period of 1680-1800, fertility rates rose sharply, because light raises testosterone levels. However, during the period following, a rapid decline in birth rates is shown, as solar activity declined into the 1930s. In the 1950s a rise in solar activity again led to the Baby Boom. Since testosterone levels declined from their peak in 1957 until today, a commensurate fall in fertility rates has been identified. Moreover, there is also research indicating that men with higher testosterone levels are more likely to marry than men with lower testosterone. Testosterone drives men to create a family, but later it declines as they care for their children with the feminine quality of empathy (Gray, 2011). Thereby testosterone, regulated by light, regulates the entire reproductive life cycle.

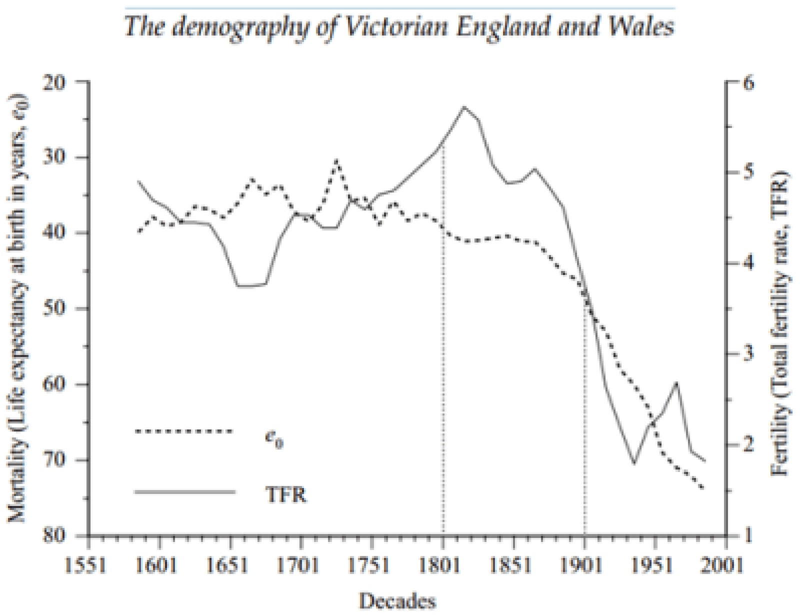


Figure 2: The Demography of Victorian England and Wales. (Used courtesy of Robert Woods and Cambridge University Press, 2000.)

6. How Low Solar Activity causes low Sex Hormones and a global Mental Health Crisis

Falling fertility rates are a signal for collapsing testosterone levels throughout such periods of cultural decline. At the same time, there is an obesity epidemic that is causing a health care crisis due to rapidly rising heart disease, cancer, and diabetes, all caused by high sugar and fat levels. Such indications of an increase in societal stress correlate with an increase in the number of people are taking psychiatric drugs to try and alleviate psychological tension, rising anxiety levels, and depression. In the past 25 years, there has been a four-fold rise in the rate of prescribing antidepressants alone, a statistic that does not even account for those identified with depression yet not using prescribed medication (Szalavitz, 2001) At least one large study of college students that compared them to their counterparts of the 1930s and 40s found that fully 85% of them have worse mental health:

Students today report they feel significantly more isolated, misunderstood, and emotionally sensitive or unstable than in decades past. Teens were also more likely to be narcissistic, have low self-control, and express feelings of worry, sadness, and dissatisfaction with life. (Hutchinson, 2009)

The correlation between depression and obesity rates rising invites the question of whether antidepressant use contributes to obesity. Stress activates the hypothalamic–pituitary–adrenal (HPA) axis, and the HPA axis is also regulated abnormally in obesity. Therefore, this is a common pathophysiological pathway in the conditions of depression and obesity. One study assessed years of relevant research and concluded that animal studies in particular give ample evidence that indeed, “short-term antidepressant treatment and stress, followed by a high-fat diet and long-term follow-up, has an important role in consolidating the role of antidepressant use in weight gain” (Lee, Paz-Filho, Mastronardi, Licinio, & Wong, 2016)

In addition to depression and obesity, the current opioid epidemic is indicative of the rising stress in the current culture. The misuse of and addiction to heroin and prescription opioids in the US alone has become a public health epidemic with a dramatic increase in fatal overdoses impacting the social and economic welfare systems. Between 1999 and 2012, overdose deaths from opioids rose more than fourfold (Substance Abuse and Mental Health Services Administration [SAMHSA], 2012). With depression and suicide rates increase along with opioid addition, life expectancy in the US is decreasing (Xu, Murphy, Kochanek, & Arias, 2016). Xu et al. (2016) highlight that of the 20 categories measured for mortality, the greatest rise in rates was among deaths from “external” causes, such as drug overdoses, alcohol-related liver disease, and obesity-associated conditions like diabetes. Moreover, the suicide rate has increased 24% between 1999 and 2014, with an uptick in the rate increase after 2006 (Tucci and Moukaddam, 2017).

7. Conclusion

Harvard psychologist Steven Pinker's book, *Enlightenment Now: The Case for Reason, Science, Humanism, and Progress* (2018) calls for a return for the spirit of optimism and the culture of reason as in the Enlightenment, as he states in the back cover:

Far from being a naïve hope, the Enlightenment, we now know, has worked. But more than ever, it needs a vigorous defense. The Enlightenment project swims against currents of human nature--tribalism, authoritarianism, demonization, magical thinking--which demagogues are all too willing to exploit. Many commentators, committed to political, religious, or romantic ideologies, fight a rearguard action against it. The result is a corrosive fatalism and a willingness to wreck the precious institutions of liberal democracy and global cooperation.

However, with solar activity in decline, lack of light causing low growth hormones and diminished levels of happy chemicals in the brain leading to a negative trend in social mood, we are more likely to the see the re-emergence of the trend Pinker warns about, such as greater social conflict, tribalism, and authoritarianism, which have been characteristic of Counter-Enlightenment trends over the past two centuries.

To overcome natural cycles that have synchronized and coordinated our sociocultural evolution through the epochs of history, rooted in our chronobiology, we shall have to engage in a more holistic approach to the study the body of our civilization as a complex social system that evolves according to incoming solar energy cycles. Hormonal factors determine the sexual organization of our society, and we shall have to better understand the yin-yang, feminine-masculine dynamics, which shape both our bodies and minds. Pinker's prescient call at this precarious time of history, may be similar to Sigmund Freud's warning in his 1929 book *Civilization and Its Discontents*, harkening the tension between the individual and civilization, immediately before the onset of the Great Depression that led to global conflict and WWII.

References

Bossini, L., Caterini, C., Koukouna, D., Casolaro, I., Roggi M., Di Volo, S.,…& Fagiolini, A . (2009). Light therapy as a treatment for sexual dysfunctions. *Psychotherapy and Psychosomatics, 78*(2). doi: 10.1159/000203119

Bossini, L., Caterini, C., Koukouna, D., Casolaro, I., Roggi M., Di Volo, S.,… & Fagiolini, A. (2013). Light therapy as a treatment for sexual dysfunctions--beyond a pilot study. *Psychiatria Polska 47*(6), 1113-11122. Retrieved from https://pdfs.semanticscholar.org/344c/fe727638deed5eac9ccade5c7e5901633bb7.pdf

Brody, Jane E. (1981). From fertility to mood, sunlight found to affect human biology. *The New York Times*. Retrieved from http://www.nytimes.com/1981/06/23/science/from-fertility-to-mood-sunlight-found-to-affect-human-biology.html?pagewanted=all&mcubz=0

Cotterell, Maurice. (2017). How our 28-day spinning sun regulates fertility in females. Retrieved from https://www.mauricecotterell.com/downloads/fertility.pdf.

Deans, Emily. (2011). Sunlight, sugar, and serotonin: The evolution of serotonin, and why we crave carbs. Psychology Today online. Retrieved from https://www.psychologytoday.com/us/blog/evolutionary-psychiatry/201105/sunlight-sugar-and-serotonin

Faryadyan, P., Khosravi, A., Kashiri, M., & Valizadeh, R. (2014). Prenatal exposure to blue and green colors increases serum testosterone levels in male offspring rats. *Biomedical & Pharmacy Journal, 7*(1), 129-135. Retrieved from http://www.biomedpharmajournal.org/dnload//BPJV07I01P129-135.pdf

Gray, Peter B. (2011). The descent of a man's testosterone. *Proceedings of the National Academy of Sciences of the United States of America, 108*(39), 16141–16142 doi:10.1073/pnas.1113323108

Hutchinson, Courtney. (2009, December 10). Today's teens more anxious, depressed and paranoid than ever. *ABC News*. Retrieved from http://abcnews.go.com/Health/MindMoodNews/todays-teens-anxious-depressed-paranoid/story?id=9281013

Konstantin, K., Danilenko, V., & Samoilova, Elena A. (2007). Stimulatory effect of morning bright light on reproductive hormones and ovulation: Results of a controlled crossover trial. *PLoS Clinical Trials, 2*(2), e7, doi: 10.1371/journal.pctr.0020007

Lee, S. H., Paz-Filho, G., Mastronardi, C., Licinio, L., & Wong, M-L. (2016). Is increased antidepressant exposure a contributory factor to the obesity pandemic? *Translational Psychiatry, 6*(3), e759, doi: 10.1038/tp.2016.25

Pinker, Steven. (2018). *Enlightenment now: The case for reason, science, humanism, and progress.* New York, NY: Viking.

Price, David. (1995). Energy and human evolution. *Population and Environment: A Journal of Interdisciplinary Studies, 16*(4), 301-19.

Substance Abuse and Mental Health Services Administration. (2015). Results from the 2012 national survey on drug use and health: Mental Health Findings. NSDUH Series H-51, HHS Publication No. (SMA) 16-4984. Rockville, MD: Substance Abuse and Mental Health Services Administration.

Szalavitz, Maia. (2011, October 20). What does a 400% increase in antidepressant use really mean? *Time.* Retrieved from http://healthland.time.com/2011/10/20/what-does-a-400-increase-in-antidepressant-prescribing-really-mean/

Tucci, V. and Moukaddam, N. (2017). We are the hollow men: The worldwide epidemic of mental illness, psychiatric and behavioral emergencies, and its impact on patients and providers. *Journal of Emergencies, Trauma, and Shock, 10*(1), 4–6, doi: 10.4103/0974-2700.199517

Woods, Robert. (2000). *The demography of Victorian England and Wales*. Cambridge, UK: Cambridge University Press. Retrieved from http://catdir.loc.gov/catdir/samples/cam031/2001268297.pdf

Yoon, I. Y., Kripke, D. F., Elliott, J. A., & Youngstedt, S. D. (2003). Luteinizing hormone following light exposure in healthy young men. *Neuroscience Letters*, *341*(1), 25-28. doi: 10.1016/S0304-3940(03)00122-8

Young, Simon N. (2007). How to increase serotonin in the human brain without drugs. *Journal of Psychiatry & Neuroscience*, *32*(6). Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2077351/

Xu, J. Q., Murphy, S. L., Kochanek, K. D., Arias, E. (2015). Mortality in the United States. NCHS data brief, no 267. Hyattsville, MD: National Center for Health Statistics. Retrieved from https://stacks.cdc.gov/view/cdc/43013#

Science & Philosophy Volume 7(2), 2019, pp. 27-48

Esoteric philosophy: Leo Strauss and sociolinguistics

Aron B. Bekesi[1]

Abstract

Leo Strauss's controversial theory of esoteric philosophy, as presented in *Persecution and the Art of Writing* (1952), sparked a fierce debate. Opponents and proponents of the theory utilised a wide range of perspectives to support their arguments. By investigating esoteric philosophy from a sociolinguistic perspective, this paper introduces a novel perspective to the Strauss dispute. In *PAW* Strauss is mistaken regarding esotericism and its role in philosophy. On the one hand it is reasonable to endorse Strauss's persuasive account on the origins of esoteric writing. The Straussian account provides a plausible sociological background as to why philosophy, *per se* became an esoteric field. On the other hand, it seems as Strauss ascribed undue significance to possible clandestine messages that may be found within works of philosophy because philosophy is mostly already done in an esoteric linguistic space.

Keywords: Leo Strauss, Persecution and the Art of Writing, sociolinguistics, esoteric philosophy, Minowitz[2]

---

[1] Independent researcher, medical student at the University of Pécs with a background in philosophy (MA, History of Philosophy: KCL): aron.b.bekesi@gmail.com

[2] Received in December 4th, 2019. Accepted in December 30th, 2019. Published in December, 2019. doi:10.23756/sp.v7i2.481. ISSN 2282-7757; eISSN 2282-7765.

1. Introduction

My thesis is that, while Leo Strauss's account regarding the origins of esoteric writing presented in *Persecution and the Art of Writing* (1952)[3] might appear persuasive, Strauss seems to ascribe undue significance to possible clandestine messages that may be found in the already esoteric field of philosophy. Novel linguistic perspectives presented in the current paper challenge the literal interpretation of Strauss's hypothesis on two grounds: (1) The dichotomy of esoteric—exoteric meaning exists in an objectively true and demonstrable sense. Sociolinguists have demonstrated that a dichotomy of esoteric and exoteric meanings routinely appears in language. However, contrary to Strauss's concept presented in *PAW*, sociolinguistics provide substantial evidence that philosophy, in general, is highly exemplary of esoteric language use. The linguistic view that philosophy as a whole occupies an esoteric linguistic niche challenge Strauss's arguments that subversive ideas need to be hidden from the masses by esoteric writing techniques because philosophy is a linguistic niche that is intrinsically hard to access for the majority. (2) The sociolinguistic model of communication and the requirements of the successful spread of information as described by Dawkins (1976) support the view that clandestine messages incorporated into an already esoteric field would have a marginal effect. This model contradicts Strauss, who suggests that hidden esoteric messages may serve to pass on secret teachings and revolutionary, subversive ideas.

2. Esotericism

In *Persecution and the Art of Writing,* political philosopher Leo Strauss presents a unique model of communication that challenges traditional ways in which scholarly texts are read. Strauss's model of communication is based on the thesis that two layers of meaning can coexist within a single text. An external, easier to comprehend exoteric layer serves as a vehicle for transmitting the clandestine message of the author, which comprises the internal, harder to comprehend, esoteric layer. The essence of Strauss's model of communication can be understood as a dichotomy of esoteric and exoteric meaning. To present a concise recapitulation of Strauss's concept of esotericism one has to consider the sociological premises Strauss provides in *PAW* that serve as groundings of the esoteric—exoteric dichotomy.

[3] Published in 1952, *PAW* is a collection of essays. Strauss's original article of the same title appeared earlier (Strauss 1941).

Accordingly, the following section presents the development of the esoteric—exoteric dichotomy in the context of its sociological premises as laid out by Strauss.

Strauss's arguments rest on an underlying tension between the prevailing power structures of society and independent, heterogeneous thought, resulting in persecution by those in power of those promoting subversive ideas. An inherent interest of the prevailing political power is to suppress ideas that conflict with its views, thus maintaining a homogenous intellectual milieu that favours political stability. The political interest of homogenous thought is protected from the heteronomous ideas of 'independent thinkers' by politically motivated prosecution that manifests itself as censorship (Strauss 1952: 23). Censorship may present itself in several forms (*Ibid*.: 33) and act as a source of pressure on individuals wishing to express their independent ideas. As a reaction to political oppression, some authors capable of free thinking develop the ability to 'write between the lines', *i.e.* authors imbue their texts with meaning hidden well enough to pass censorship (*Ibid*.: 24-5). The phenomenon of evading censorship by writing between the lines is the central concept of Strauss's theory of esoteric communication, a method that Strauss calls the 'art of writing'. Thus the art of writing, according to Strauss, denotes the elaborate skills that an author needs to imbue a text with hidden messages.

Esoteric texts, according to Strauss, have an exoteric, more accessible layer open for deliberation to a larger audience, plus an esoteric, less accessible layer, which can be understood only by a minority of readers who have the skills of reading between the lines (*Ibid*.: 17-9). Parts of the text that are easier to comprehend serve to obscure the important messages of the author, which in turn become difficult to uncover even for the 'trained' philosopher (*Ibid*.: 24-5). Therefore a cautious author of exceptional intellect holding heterogeneous views, and wary of prosecution, is likely to produce works that are comprehended only by a minority of his or her readers, who are interested enough in its interpretation and have the intellect necessary to decipher the hidden code of the author (*Ibid*.: 25). The majority of readers remain misguided (*Ibid*.: 35-6).

It is worth noting that Strauss deduces the emergence of esoteric writing as a seemingly inevitable consequence of the coevolution of different strategies that develop from the conflict of public and individual interests. The interests of the prevailing power produce persecution that manifests as censorship, which limits the work of independent thinkers and infringes on free deliberation. As a reaction to censorship, at least some independent thinkers produce esoteric works. Once Strauss's sociological premises are accepted, they initiate seemingly inevitable coevolution that unfolds into Strauss's model of communication. Persecution gives rise to the art of writing; esoteric messages appear within exoteric texts; consequently the exoteric—

esoteric dichotomy is established within the sociological context of Straus's theory of communication.

3. Reception

The ideas put forth by Strauss were highly controversial. Contesting interpretations of the exoteric—esoteric dichotomy stand at the heart of the dispute[4]. This section presents a summary of how Strauss's ideas were received, showing that concerns stemming from the exoteric—esoteric dichotomy remain unresolved (Smith 1997). By unresolved I mean that that the academic debate has so far been unable to develop an interpretation regarding the exoteric—esoteric dichotomy that could warrant credibility amongst the majority interested in Strauss's theory.

Numerous scholars, for instance, hold the view that Strauss himself wrote in an esoteric way (Lampert 2009: 63)[5], but opinions split over whether that is laudable (Frazer 2006) or odious (Drury 1985). Other commentators argue that it is entirely false to assume that Strauss wrote in an esoteric way, as it would be inconsistent with Strauss's own claims (Batnitzky & Leora 2016). Lack of consensus on the interpretation of Strauss's exoteric—esoteric dichotomy produces contradicting interpretations of the ideas, and even the personal character of Strauss, and compete in an on-going dispute. For example, while some argue that Strauss was a fascist, others claim Strauss was a defender of democracy against Nazism (Grant 2016)[6,7].

---

[4] '...no aspect of Strauss's work is as hotly contested as his claims about esotericism. Interpretations of Strauss's view of esotericism include: that Strauss advocates clandestine cabals with secrets imparted from teacher to disciple; that Strauss's writings are themselves esoteric documents; that Strauss thinks that all thinkers write esoterically; that Strauss claims to know a secret; that, Strauss promoted mass deception and perpetual war; and that, in one particularly crude rendering, Strauss used his esoteric methods to hide his fascist sympathies, if not his secret Nazism.' (Batnitzky & Leora 2016).

[5] 'It is reasonable to suspect that a partisan of esoteric philosophy [Strauss] would himself write esoterically' (Lampert 2009: 63). Lamperts' view is shared by, *e.g.* Frazer (2006) and Minowitz (2009).

[6] 'Strauss's critics on the left have charged that he was a right-wing—even fascist—enemy of liberal democracy. His supporters on the right have argued that he was a defender of liberal democracy against the threats coming from communism, Nazism, relativism, and historicism.' (Grant 2016). *Cf*: Frazer (2006) and Smith (1997).

[7] 'The Zuckerts set out to demonstrate two key points, the first of which is also broached by Minowitz: (1) Leo Strauss and his followers are innocent of the charge that the political Left has levelled against them, of being antidemocratic elitists; and (2) the Straussians and neoconservatives, contrary to the customary association, have separate identities. The Zuckerts insist that although the Straussians are tireless advocates of American democracy...' (Gottfried 2012: I)

On one side, Strauss is charged with historical inaccuracy, the vagueness of expression, elitism, and obfuscating the meaning of the works he interprets. Acclaimed scholar of ancient philosophy, Myles Burnyeat, for example, states that Strauss's account of political philosophy is 'a tale' containing 'extraordinary inaccuracies' (Burnyeat 1985). Shadia Drury became one of the most influential opponents of Strauss by devoting much of her work to presenting an extensive criticism of Strauss[8]. In one of her early works, Drury suggests that Strauss's thesis of esoteric writing is based on a tautology (Drury 1985). Drury herself, however, received some negative responses that centred on 'technical difficulties' and 'intellectual short-sidedness', allegedly flawing her arguments (Lora 2000).

On the other side, Strauss's philosophy is seen as a possible counterpoint to the failure of modern rationalism. The failure of modern rationalism is a wider concept in Straussian philosophy that refers to a series of philosophical crises, *e.g.* nihilism, challenging traditional value judgment (Pangle & Nathan 1987), which amount to an intellectual gap between contemporary Western philosophy and its historic roots. Peter Minowitz stands out from amongst the proponents of Strauss by dedicating an entire volume to defending Strauss from contemporary criticism, focusing on Drury's allegations (Minowitz 2009). Minowitz points out Drury's biased approach, unrealistic assumptions, lax—or lack of— references, and inaccurate conclusions, as main weaknesses undermining Drury's work (Schaefer 2010). Underscoring the bitterness of the dispute, in an arresting, somewhat flamboyant passage, Minowitz claims that the situation for followers of Straussian thought compares to that of the members of the 'GLBQT (gay, lesbian, bisexual, queer, and transgender) community'. Both Straussians and GLBQT members are, according to Minowitz, 'routinely excoriated' and 'in the eyes of prominent individuals' act as 'scapegoats' (Minowitz 2009: 5).

Additionally, certain proponents of Strauss offer confusing answers to problems raised by the exoteric—esoteric dichotomy; for example, what seems to be Strauss's esoteric teaching is, in fact, Strauss's exoteric teaching, and therefore is not to be given serious consideration *per se* (Frazer 2006). It seems that the most moderate readings of Strauss, recapitulated in broad terms, interpret the esoteric—exoteric dichotomy in the wider context of Straussian philosophy and view the dichotomy as a somewhat abstract enquiry into the 'nature of truth'(Batnitzky & Leora 2016).

Notwithstanding the many approaches, ideas and argumentations sparked by Strauss, according to my research, as of today, there has been no publication investigating philosophic esotericism from a sociolinguistic perspective. This paper seeks to undertake that task.

---

[8] See, for example Drury's recent book: *Leo Strauss and the American Right* (1997).

4. Impact of Esoteric Writing

Taken literally, one is likely to find the exoteric—esoteric dichotomy highly troubling, as it challenges traditional ways of how great works of philosophy ought to be interpreted. Uncovering possible esoteric messages would call for a thorough revision of philosophic literature. Strauss, however, seems to set the standards of interpretation required by such a revision to almost unattainable heights.

The practical implications of Strauss's dichotomy of exoteric and esoteric writing seem to create an intellectual trap, where the burden of proof to verify the candid or clandestine nature of a text rests on the reader. In the worst cases, the reader is either deceived by the exoteric layer of a text or remains sceptical of the text's true meaning. In a somewhat better scenario, the reader discovers evidence of the dichotomy, becomes sceptical of the misleading exoteric layer, but fails to uncover the esoteric meaning (*Ibid*.: 32). Only the remaining cases are truly favourable, when either the reader can detect a dichotomy and then is able to successfully interpret the esoteric layer, or the reader with absolute certainty can establish that the text is written in a candid way. It follows that precise interpretation of a text depends on the reader's ability to ascertain the existence or the lack of existence of esoteric meaning.

The burden of proof is on the reader to uncover evidence of, or evidence for the absence of an esoteric message. In Strauss's words: 'the burden of proof rests with the censor. It is he, or the public prosecutor who must prove that the author holds or has uttered heterodox views.'(*Ibid*.: 26) Strauss here elaborates the arduous tasks of interpretation with respect to the work of the censors. All readers, however, face the same challenge. Considering that the reader bears the burden of proof to produce a clandestine message or the evidence of absence of a clandestine message, I believe, sets the standards of interpretation to levels that can hardly be met in practice.

Strauss addresses the difficulty of interpretation himself and comes to the conclusion that the arising problems of reading call for new strategies of exegesis (*Ibid*.: 30). Based on the above, it seems unlikely that any strategy can be a reliable tool for establishing the evidence of, or evidence of the absence of ideas that have been concealed so well that, as of now, no one has discovered their existence.

By introducing the dichotomy of esoteric—exoteric writing, Strauss puts forward a novel model of communication that challenges the traditions of reading. Since Strauss's model of communication sets the standards of interpretation to levels that seem difficult to meet in practice, it follows that many traditionally accepted interpretations of philosophy are, and most likely remain, false.

According to the sociological and political premises, Strauss provides in *PAW* as the groundwork for the development of esoteric writing, the extent of misinterpretations may vary between two extreme cases. In the most favourable scenario, the most revolutionary, therefore probably most important, thoughts of some of the greatest thinkers are distorted or omitted from discussion. In the worst scenario, the traditional interpretations of the history of Western philosophy are mostly misguided fictions based on recapitulations of the exoteric teachings of great authors. In any case, the implications of esotericism seem far-reaching and subverting in relation to our understanding of philosophy.

5. Sociolinguistics and Strauss

The two most important questions pertaining to Strauss's model of communication: (1) whether esoteric texts exist, and if esoteric texts exist, (2) what is the impact they have on philosophy. The following section compares Strauss's account of esotericism with the sociolinguistic model. The impact of esotericism on philosophy is estimated based on sociolinguistics and Dawkins' stipulations on the conditions required for the successful spread of information.

From a linguistic perspective, the model of communication presented by Strauss is hierarchical. By hierarchical I mean that different interpretations subordinate one another. Strauss presents a model of communication that divides readers into two categories: the 'thoughtless', who are 'careless readers', and the 'thoughtful', who are 'careful readers' (Strauss, 1952: 25). Due to their superior intellect and longer attention span, 'thoughtful' readers can decipher the concealed ideas of a text. The 'thoughtless' readers are barred from the esoteric messages and can only access the exoteric layer of esoteric work. As the abilities to think clearly and directing one's attention are part of what is termed 'general intelligence' (McGrew 2005), the two factors of attention span and thoughtfulness referred to as separate capacities by Strauss can be safely merged and referred to as intelligence[9]. Therefore, Strauss's model suggests that intelligence is the key to uncover and distinguish the esoteric truth from the exoteric layer camouflaging it.

Six different types of contradictions are listed in *PAW* that serves as clues for the reader to uncover esoteric messages (*Ibid*.: 71). The contradictions pose a gradually increasing intellectual demand for the interpreter. Compare, for example, a simple contradiction ($a = b;\ \ a \neq b$) to

[9] For a complete list of abilities that make up of what is defined as general intelligence see Spearman's account (Spearman, 1904) *cf. Cattell–Horn–Carroll theory of cognitive abilities* (McGrew, 2005).

($a = b;\ a \neq \beta; [b = \beta + \varepsilon]; a \neq b$). ($a = b;\ a \neq \beta; [b = \beta + \varepsilon]; a \neq b$) denotes, in Strauss's words:

> '[the] method… to introduce between… two contradictory statements an intermediary assertion, which, by itself not contradictory to the first statement, becomes contradictory to it by the addition, or the omission, of an apparently negligible expression; the contradictory statement creeps in as a repetition of the intermediary statement' (*Ibid.*:71).

That Strauss's model of esotericism allocates a decisive role to intellect in deciphering the esoteric layer raises doubts about the credibility of the model. Granting intelligence the prominent role, as Strauss did, allows for infinitely regressing streams of interpretations. If, for example, an interpreter has reconstructed an esoteric message "A" from a text, a more intelligent reader might find a deeper esoteric meaning "B" in the same work. The following, even more eminent interpreter can, according to Strauss's theory, come up with a third hidden message "C" found within the previously exposed esoteric layer "B", and so on. It seems theoretically possible that different readings of work based primarily on the intelligence of the interpreters can regress *ad infinitum*. One could argue that a definite reading can be accomplished, but Strauss himself implied the contrary: '…reading between the lines will not lead to a complete agreement among all scholars.' (Strauss 1952: 30). Additionally, according to the logic of *PAW*, increasingly elaborate readings will falsify the less complex interpretations by demonstrating that the previously uncovered esoteric messages were part of the exoteric layer of the text. Therefore, allowing for the possibility of finding a reader who is by some degree more intelligent than the previous reader may result in continuous production of new interpretations without ever providing definite assurance that the final and true esoteric message of a text has been understood. It seems that this shortcoming is a result of oversimplification and the centrality attributed to intelligence in Strauss's model of esotericism.

Strauss constructed a hierarchical model based on simple dichotomies of conflicting concepts. Besides the exoteric—esoteric dichotomy, the thoughtful—thoughtless, careful—careless, truth—lie, etc. dichotomies also appear in *PAW*. Strauss's system is notably hierarchical since these dichotomies subordinate each other and are value charged. By value charged I mean that opposing concepts of *PAW* are linked to either the domains of freedom or repression (*Ibid.*: 32), therefore the dichotomies, in essence, represent value judgments of right and wrong (*Ibid.*: 29-30), good and evil.

Since a correct reading depends on the intellectual capacity of the interpreter, the reader also becomes a subject of the above-mentioned binary splitting, automatically suffering a value judgment. According to *PAW* (*Ibid*.: 59), intelligent readers are good and worthy (*Ibid*.: 25), while their less intelligent colleagues are second rate (*Ibid*.: 29), worthless at understanding the real intent of esoteric work. It is noteworthy how the subjective variable represented by the reader is first reduced to an objective quantity, intelligence, then further simplified by qualifying his or her performance as apt or inapt. Due to the exclusive centrality Strauss attributes to intelligence in the interpretation process, the Straussian model, in a linguistic sense, can be considered simple. Furthermore, the value judgments associated with an assortment of dichotomic traits describing the reader's ability and the quality of philosophic texts, makes Strauss's model hierarchical.

I hold that Strauss failed to consider the simple fact that people have different personalities. By way of their different personalities, people think, speak, and write in different ways, resulting in a complex heterarchical linguistic environment that allows the coexistence of a multitude of esoteric linguistic spaces.

The same text, for example, might be read by three readers of the exact same intelligence. One of these readers might have an exceedingly sophisticated knowledge of poetry, the other an interest in history, while the third could be an expert in deductive logic. It can be expected that the three readers will produce three different subjective interpretations of the objective reality represented by the text. The different interpretations could be difficult to achieve by others lacking particular knowledge of a specific field. Moreover, a reader of particular expertise may uncover a hidden aspect, in other words, an esoteric meaning, of a text.

It seems biased to single out one such esoteric interpretation and to claim all others worthless. One could object, claiming that the correct reading includes all perspectives and a reader of proper intelligence could produce that interpretation. I object based on the ground that it would seem foolish to expect that, for example, every philosopher should analyse technical texts of their particular discipline with equal and detailed respect to their aesthetic, historical, logical, etc. merits. On the contrary, a professional is rightly expected to interpret a text within the bounds of his or her own discipline.

It seems arbitrary to hold that the role of intelligence should be prioritised in the interpretation process since other factors also play a role in producing different, often equally correct readings of a text. Not only might one find it condescending to use intelligence as a basis of value judgments to qualify readers, but it also seems to be logically incorrect. There is no good reason to support the thesis that a certain reading of objective reality is more or less correct than another, because mutually correct interpretations of a text may exist without subordinating each other, thereby allowing for several correct esoteric meanings to exist in a mutually inclusive, heterarchical way.

The numerous subjective differences between people lead to three important effects: (1) Several interpretations of objective reality may coexist without challenging each other, thereby creating a heterarchical system. (2) Subjective differences provide the basis of esoteric communication because individual subjective differences enable one to comprehend a type of information that is difficult to access by someone else. (3) By virtue of subjective differences, it is possible for several layers of esoteric meaning to coexist within the same text. Consequently, I propose that esotericism exists in an objectively true sense but contrary to Strauss's suggestion esotericism exists in a heterarchical model of communication. This line of thought is supported by sociolinguistics.

The notion that subjective factors are decisive in the interpretation of objective reality was not a novel idea at the time of *PAW's* publication. Philosopher Edmund Husserl pioneered the thought that objective reality is construed in a subjective way. Husserl published what is often considered his most important book, *Logical Investigations,* at the turn of the 20th century (Husserl 1900). The school of phenomenology developed along with the ideas of Husserl (Zahavi 2003) and had a decisive influence on psychology. Phenomenology eventually became a distinct subfield of psychology. From the beginning of the1940s, psychologist Carl Rogers, considered the most influential promoter of phenomenological psychology, started developing person-centred psychotherapy, which is, in broad terms, the practical application of phenomenology in psychology (Rogers 1942). These developments unfolded before *PAW's* publication. In the 1960s, subjective factors of interpretation gained scientific recognition in linguistics and led to the development of sociolinguistics, a subfield of linguistics.

The origins of sociolinguistics can be traced to linguistic research dating back to the 19th century, which culminated in the wake of William Labov's work in the late 1960s (Koerner 1991). Sociolinguistics studies the effects society has on language (Gumperz & Cook-Gumperz 2008), which is what underlies Strauss's theories in *PAW*. Grounded in sociological research, sociolinguistics acknowledges individual differences and delineates a complex, heterarchical linguistic system, which, contrary to the ideas of Strauss, allows for the coexistence of esoteric spheres of language.

In contrast with Strauss's reasoning—that persecution leads to philosophical esotericism, an *a priori* argument independent of experience—sociolinguistics rely on *a posterior* justification to support its results. Sociolinguistics is a descriptive, evidence-based science.

> '…[sociolinguistics is] is the scientific study of the relationships between language and society, which entails practising a different way of doing linguistics that is very much influenced by work in the social sciences. It is empirical research — *i.e.* based on observation —, specifically focusing on how human beings actually use language in social interaction in real, everyday life situations and studies languages exclusively in their naturalistic social context' (Hernández-Campoy 2014)

Objective linguistic observation, a fundamental feature of sociolinguistics, is achieved via fieldwork, meaning that data later analysed by linguistic professionals is collected on the site where the specific language or language variation is used. '[The linguistic data] collected in the field, *i.e.* in natural environments of spoken language, just as people usually and casually meet and interact, rather than in an office.' (*Ibid.*)

> 'Sociolinguistics is therefore in a continuous process of theoretical reformulation and methodological redefinition in consonance with the epistemological evolution and the development of new fieldwork methods, data collection techniques and — in the case of quantitative approaches — statistical analyses.' (*Ibid.*)

The success of the sociolinguistic method is underlined by its widespread, real-world application in a variety of fields, ranging from medicine to business.

> 'In Medicine, Sociolinguistics has been helpful in therapeutic discourse and doctor-patient communication… In Business, for intercultural communication in the world of commerce, the language of advertising and mass media communication; as well as in Education, Government, or Social Justice […]Sociolinguistics has been one the most applied branches of linguistics since its initial conception.' (Hernández-Campoy 2014)

Some of the best established, evidence-based sociolinguistic concepts support that an esoteric—exoteric dichotomy exists in an objectively true and demonstrable sense. According to sociolinguistics, language can consist of several *linguistic communities* of different sizes (Marcyliena, 2014). The broadest category encompassing all linguistic communities within a language is the *national language* (Brann 1994). A national language signifies all written and spoken communication of a language. *Vernacular* is a particular version of the national language that all speakers of the national language understand (Wolfram & Schilling-Estes 1998). Smaller linguistic communities, or in the sociolinguistic term *speech communities*, develop within distinct groups of people who are, in a linguistic sense, in proximity to one another and use language in a unique and mutually accepted way amongst themselves (Yule 2006). A group of friends or members of a family, for instance, are likely to form a speech community. Physical vicinity, however, is not a requirement of a speech community. Two academics of the same field, but who are separated by distance, for example, even if they have never communicated with each other, are likely to share a speech community. A person may be a member of several speech communities. More importantly, speech communities use a variation of language, or *language variations*, characteristic to a particular group of speakers.

Language variations represent unique uses of language (Wardhaugh 2006: 6). There is an inverse relationship between the uniqueness of a language variation and its closeness to the vernacular. The more unique a language variation is, the less it has in common with the vernacular, and consequently, it is more likely to exclude people from its comprehension. To varying extents, language variations mix easily with hard-to-access linguistic elements[10]. Therefore, speech communities produce variations of language that, as described by sociolinguistics, support a dichotomic communicational space of esoteric and exoteric meaning.

Previously, I argued that Strauss was mistaken in prioritising the intellect in the interpretation process and that besides general intelligence, subjective factors also play a decisive role in the interpretation process and provide the bases of a heterarchical model of communication. The sociolinguistic account of language supports the above argument because sociolinguistics studies language based on individual differences of language users. Moreover, according to sociolinguistics, language variations create spheres of esotericism. Language variations are developed by speech communities. Speech communities are in turn formed by individuals, often not out of necessity, but according to their individual affections based on various subjective differences (Kristiansen & Jorgens 2005: 287-330). Language variations coexist without either being subordinated to each other or qualified

[10] That is, with regards to the comprehensive abilities and lexical knowledge of the majority.

as having a lesser or greater value. Therefore, sociolinguistics supports a heterarchical account of esoteric communication.

Linguistic evidence supports that a dichotomy of exoteric and esoteric communication exists as an objectively true phenomenon in language. Sociolinguistics verifies that Strauss was right to propose that esotericism plays an important part in communication, and confirmed that esoteric texts exist. There are, however, contradictions between Strauss's and the sociolinguistic account of esoteric communication.

There are two main differences between how Strauss and sociolinguistics describe esoteric communication. First, according to Strauss's account, exoteric and esoteric language appears in a hierarchical model, whereas sociolinguistics presents a heterarchical model. Second, there is a discrepancy between Strauss's mystic account of esotericism, and the sociolinguistic account that presents esotericism as a mundane phenomenon. Concerning the first discrepancy, I have already argued in favour of a heterarchical view. The second discrepancy has not been addressed so far.

Contrary to Strauss, it seems to be a mistake to assume that hidden meanings play an important role within philosophic texts for the reason that most of philosophy is done in an esoteric way. In effect, philosophy is probably one of the best examples of esoteric language use.

Contrary to how flamboyant the notion of secretive communication seems, a brief sketch of a few common language variations strongly suggests that esotericism is a mundane linguistic phenomenon. Several types of language variations have been categorised according to the history of their development and function. *Dialects*, *sociolects*, *argots*, and *jargons* are amongst the best examples of language variations. Dialects usually develop as a result of geographical isolation and are regional variations of a language (Wolfram & Schilling-Estes 1998). Sociolects occur irrespective of geographical boundaries, developing amongst speakers of similar social standings. Sociolects are often used to express status or solidarity with a group (Wolfram & Schilling-Estes 1998)[11]. An argot is a cryptic language version used by a group, originally criminals, to prevent outsiders from understanding communication within the specific group (Hukill & Jackson 1961: 145-51)[12]. Jargons are used by a speech community that participates in a common profession. Jargons are 'specifically associated with professional and technical circles' (Forsyth 2007: 88) and make use of a 'vocabulary [that] may not be understood by people outside these groups' (Llamas et al. 2006: 218). Jargons tend to feature technical terminology consisting of narrowly defined words of specific meaning. The reason for esoteric communication thus may range from contingent circumstances, *e.g.* in case of dialects, to the explicit need of

[11] *Cf.* Yanchun 2013: 2209-13.
[12] *Cf.* Ruiz 2015: 47-70.

communicating in a secretive way, *e.g.* in case of argots. It follows that people communicate in esoteric ways for all sorts of reasons, probably often without knowing that they do so.

In a linguistic sense, as described by sociolinguistics, philosophy is an example of a jargon, a language variation that typically makes excessive use of technical terms. In addition to excessive technical terminology, a large vocabulary and advanced comprehension requirements make philosophical texts some of the most difficult to access.

According to the *Oxford Dictionary of English*[13], the English language contains approximately 170,000 words[14]. A fraction of this vocabulary is used in practice. Between 100 and 150 words are enough to begin reading simple English texts (Milton *et. al.* 2016). West proposed that a simplified vocabulary of approximately 2000 words is sufficient for a fluent understanding of English (West 1953), while Hirsh and Nation have suggested increasing the threshold to 5000 words (Hirsch & Nation 1992). Upon beginning higher education, UK undergraduates possess an average vocabulary of around 10,000 words (Milton *et. al.* 2016). The vocabulary of the average university graduate peaks around 18,000 words. The vocabulary of non-graduates is significantly smaller, and peaks around 15,000 words (*Ibid*.: 2016). The difference between the vocabulary sizes is likely the result of the special vocabulary requirement of the higher education courses. Formal training in philosophy can be achieved through higher education. Therefore it is reasonable to assume that understanding philosophy requires a vocabulary size equal or greater than the average graduate possesses. According to the Office of National Statistics, ‘In July to September 2017, there were 34 million people aged between 21 and 64 in the UK who were not enrolled on any educational course... Breaking these people down by the highest qualification they held: 14 million, or 42% were graduates’[15]. The Department for Business, Innovation and Skills reports, that in 2014 41% of the working-age population achieved a level 4 diploma or above[16]. Therefore, on average more than half of Britain’s population lacks the vocabulary to understand philosophic texts. It

[13] Lexico, *Oxford Dictionaries*, Oxford University Press. << https://www.lexico.com/en/explore/how-many-words-are-there-in-the-english-language>> accessed 14 August 2019.

[14] Numbers in this section refers to word families. As described by Hirsch and Nation (1992), a word family is a headword and its closely related inflected and derived forms.

[15] Office for National Statistics (2017), *Graduates in the UK labour market*. <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/graduatesintheuklabourmarket/2017> accessed 30 August 2019.

[16] Department for Business, Innovation and Skills (2016) *Further education and skills: statistical first release (SFR) 23 June 2016* <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/556015/SFR_commentary_June_2016_final_JuneOfqual_update.pdf> accessed 30 August 2019.

follows that philosophic texts are hard to access for the majority, approximately 60%, of the UK's population.

In addition to the large vocabulary requirement, complex sentence structures also complicate the understanding of philosophical texts. Specific readability tests are able to indicate the difficulty of comprehending a passage. Readability tests, such as the *Flesch–Kincaid readability* and *Lexile Framework for Reading,* support the claim that philosophy is amongst the most difficult to access areas of language[17]. Some rudimentary works of philosophy, such as Descartes's *Discourse on the Method, Meditations on First Philosophy* and Kant's *The Critique of Judgment*, top the Lexile scale.

Moreover, it is worthy to consider that 'Anaxagoras, Protagoras, Socrates, Plato, Xenophon, Aristotle, Avicenna, Averroes, Maimonides, Grotius, Descartes, Hobbes, Spinoza, Locke, Bayle, Wolff, Montesquieu, Voltaire, Rousseau, Lessing and Kant' (Strauss 1952: 33), authors Strauss have hinted to have included hidden ideas in their texts, lived in ages when even basic literacy was an exceptional skill. The literacy rate in England in the 1640s was around 30 per cent for males, rising to 60 per cent in the mid-18th century. In France, the rate of literacy in 1686-90 was around 29 per cent for men and 14 per cent for women (Melton 2001: 81–2)[18]. Because of lower accessibility to education in the past, it is probable that even the literate few possessed, on average, a vocabulary and comprehension skills markedly lower than our contemporaries. Therefore, we can assume that during the Age of Enlightenment, more so in previous ages, only the smallest proportion of society had the chance of understanding complex works of philosophy, making philosophic texts highly esoteric. Furthermore, one can wonder about the literacy rates of classical antiquity. So did, for example, Descartes, Kant and Anaxagoras have reasons to include hidden ideas in their texts? It seems unlikely they had any reason to do so. That the majority, both today and historically, have had no access to works of philosophy, is in direct contradiction with the groundwork of Strauss's argumentation in *PAW*:

> '…a philosopher… could expound only such opinions as were suitable for the nonphilosophic majority: all of his writings would have to be, strictly speaking, exoteric. These opinions would not be in all respects consonant with truth. Being a philosopher… [he] would leave it to his philosophic readers to disentangle the truth from its poetic or dialectic presentation. But he would defeat his purpose if he indicated clearly which of his statements expressed

---

[17] See the Lexile framework for reading under: <http://cdn.lexile.com/cms_page_media/135/11x17%20Lexile%20Map.pdf> accessed 17 July 2019. On the Flesch–Kincaid readability test see: (Flesch, R. 1948: 221-33).

[18] *Cf.* Mitch 2004.

> a noble lie, and which the still more noble truth.' (Strauss 1952: 35)

The need for a large vocabulary, high comprehension skill levels, and knowledge of a unique technical terminology support the notion of philosophy being an esoteric discipline. In sociolinguistic terms, the jargon of philosophy makes philosophy hard to comprehend for the majority of contemporary English speakers. Lower literacy rates and poorer access to education made philosophy even more exclusive during the life of the authors Strauss refers to in *PAW.* It follows that philosophy, or at least most of it, is and has been done in an esoteric way. The linguistic view that philosophy occupies an esoteric niche contradicts Strauss's argument that subversive philosophic ideas need to be hidden from the masses by esoteric writing techniques because philosophy is a linguistic niche that is *per se* hard to access for the majority. It follows that there is no rationale for philosophers to incorporate clandestine ideas in their works with the intent of concealing them from the majority.

Nevertheless, assuming that, as Strauss claims, esoteric messages exist that are hard for even well-trained scholars to discern, and accepting that these secretive messages have some sort of effect on philosophy, this effect is most likely marginal. Messages that are accessible solely to a community of handful philosophers of the highest ability are simply unsuitable to form the continuous and sustainable discourses characteristically seen throughout the history of philosophy. Evolutionary biologist Richard Dawkins' thesis on cultural evolution supports that esoteric teachings are not suitable to become part of a wider discourse.

Based on evolutionary biology, the thesis formulated in his influential work, *The Selfish Gene* (Dawkins 1976), Dawkins states that in the case of humanity, biological evolution is replaced by cultural evolution (*Ibid*.: 190-2). Dawkins refers to units of human culture as *memes* (*Ibid*.: 192). According to Dawkins, a memes can be '…tunes, ideas, catch-phrases, clothes fashions, ways of making pots or of building arches.' (*Ibid*.: 192)[19]. Concisely stated, a meme denotes an idea that exists in human culture. According to Dawkins, memes spread in culture just as genes do in nature.

> 'Just as genes propagate themselves in the gene pool by leaping from body to body via sperms or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation. If a scientist hears or reads about, a good idea, he passes it on to his

[19] This is a concise recapitulation of Dawkins' thesis, which he later goes on to refine (Dawkins 1976: 195). The refined definition is not in contradiction to the one delineated here, which serves well for the purpose of the unfolding our argument.

> colleagues and students. He mentions it in his articles and his lectures. If the idea catches on, it can be said to propagate itself...' (*Ibid*.: 192)

Dawkins' stipulations describing the successful spread of ideas relates closely to Strauss's theory.

> 'Imitation, in the broad sense, is how memes can replicate. But just as not all genes that can replicate do so successfully, so some memes are more successful in the meme-pool than others. This is the analogue of natural selection. I have mentioned particular examples of qualities that make for high survival value among memes. But in general they must be […] longevity, fecundity, and copying-fidelity.' (*Ibid*.: 194)

While longevity 'is probably relatively unimportant' (*Ibid*.: 194), it is connected to the prolificacy of memes.

> ' As in the case of genes, fecundity is much more important than longevity of particular copies. If the meme is a scientific idea, its spread will depend on how acceptable it is to the population of individual scientists; a rough measure of its survival value could be obtained by counting the number of times it is referred to in successive years...' (*Ibid*.: 194)

Copying-fidelity, Dawkins' third condition, denotes how well a meme can be grasped and spread to the minds of others (*Ibid*.: 194). Esotericism in philosophy, as proposed by Strauss, does not meet any of the conditions Dawkins identifies as requirements for the successful spread of ideas. Strauss claims that esoteric messages are hard to discover and difficult to reliably reconstruct. Therefore, deeply concealed esoteric philosophical ideas can be reasonably assumed to spread with great difficulty.

It seems that if the esoteric teachings, as presented by Strauss, exist, these esoteric ideas are not suitable to enter, nor to initiate, a philosophic discourse. Even provided that esotericism, in the sense of hidden meanings, has some effect on general philosophic discourse, that effect is likely marginal[1]. More likely, if such esoteric teachings exist, they form islands of thought isolated form continuous philosophical thought and are of significance only to historians of philosophy interested in intellectual curiosities[2].

It seems that philosophers had scant, if any, need to write between the lines. Provided they did so, isolation makes any possible esoteric idea within philosophy insignificant. The insignificance of esotericism in philosophy is in stark contrast to the significance Strauss attributes to writing between the lines.

6. Conclusion

I have contended Strauss's theory of esoteric writing on several grounds. Strauss's arguments in *PAW* are problematic in that they can lead to infinite regression, that the burden of proof to uncover evidence of esotericism rests on the reader, and outlined some additional deficiencies that stem from Strauss's ambiguity. I avoided the recapitulation of these shortcomings because most of them have already appeared in the critical literature. There are more profound problems presented in this paper, which to my knowledge have not been addressed, that challenge the literal interpretation of *PAW*.

Because Strauss never provides a single example, the alleged phenomenon, in which hidden meaning supposedly occurs 'between the lines', exactly what he is referring to is never made clear. The ambiguity led to several competing interpretations of Strauss's dichotomy of exoteric and esoteric meaning, ranging from literal to symbolic readings of *PAW*. Because Strauss masterfully based his thesis on sociological premises grounded on hard to contest minimalist claims, the current paper follows a literal interpretation, *i.e.* that Strauss held that esoteric, hidden messages exist as a form of written communication within works of philosophy. The decision is supported by the practical consequences that are entailed by a literal reading.

The dichotomy of esoteric—exoteric meaning exists in an objectively true and demonstrable way. Sociolinguistics provide evidence that esoteric language use routinely appears in communication. Strauss however, uses the term 'esoteric' in an unconventional and arguably confusing way. Esotericism, in a linguistic sense, refers to language that is understood only by a group of speakers, because it makes unique use of language in a way not generally known by the public at large. Strauss uses the term differently, referring to one meaning of a generally accessible text that has been carefully constructed by its author to convey dual levels of meaning: one to the general literate public, the 'exoteric' level, and one only discernible to a small number of specialists, the 'esoteric' level.

There are three main differences between the Straussian and the linguistic model of esotericism. (1) Strauss's account of esotericism is hierarchical. The esoteric layer of a text subordinates the exoteric layer and intelligence plays a central role in uncovering the true meaning of a text. According to sociolinguistics, several hard to access, in this sense, esoteric layers can coexist in a heterogeneous way without subordinating each other. Besides intelligence, various other factors contribute to the understanding of an esoteric layer. (2) In *PAW* Strauss presents esoteric writing as an unusual, mystical feature of philosophy. According to sociolinguistics, philosophy is generally done in an esoteric way. In technical terms a jargon, a type of language variation that is hard-to-access to the majority, philosophy is an esoteric discipline. (3) Strauss suggests that esoteric philosophy serves to pass on certain teachings and ideas veiled from the general public. According to sociolinguistics, there is no need to hide philosophic ideas because philosophy is already mostly done in an esoteric way. Moreover, according to Dawkins esoteric philosophy, as proposed by Strauss, is unsuitable to reliably pass on teachings and ideas.

Following a literal reading, the interpretation of *PAW* can take two mutually exclusive courses.

I. In agreement with evidence provided by the present paper, interpreters of *PAW* may endorse the view that Strauss was mistaken in granting a significant role to hidden esoteric ideas that might appear in the philosophy of great authors. Even provided esotericism as laid out in *PAW* exists, its effect on philosophy is likely marginal. According to the argumentation that supports this scenario, it is likely that hidden esoteric ideas within philosophy, if they exist at all, are rare and isolated phenomena only of interest to historians of philosophy fascinated by oddities.

II. In the second case, one accepts the thesis of *PAW*. Logical consistency requires one taking this stance to (a) refute inferences that can be drawn from objective linguistic evidence, including basic concepts of sociolinguistics, from which it follows that most of philosophy takes place in an esoteric linguistic space, and (b) to challenge Dawkins' thesis on conditions that determine the successful spread of ideas, which would marginalise any effect hidden esoteric ideas within the already esoteric works of philosophy might have on general discourse.

Success of the latter scenario requires a massive defence that seems unlikely to succeed.

According to the novel linguistic perspectives presented in the current paper, it seems that in *PAW* Strauss is mistaken regarding esotericism, and its role in philosophy. It is initially tempting to endorse Strauss's persuasive account on the origins of hidden esoteric writing as a response to persecution. The Straussian account provides a plausible sociological background as to why philosophy *per se* became an esoteric field. Upon further reflection, it seems that Strauss posited, without factual basis, the existence of clandestine messages within works of philosophy, something generally unnecessary because philosophy is mostly already done in an esoteric linguistic space.

References

Batnitzky & Leora (2016) Leo Strauss, The Stanford Encyclopedia of Philosophy. <https://plato.stanford.edu/archives/sum2016/entries/strauss-leo/> accessed 15 July 2019.

Brann, C.M.B. (1994) 'The National Language Question: Concepts and Terminology' Logos , Vol 14: 125–34.

Burnyeat, M.F. (1985) 'Studies in Platonic Political Philosophy by Leo Strauss', Political Theory, 13/2: 292-6.

Dawkins, R. (1976) The selfish gene, Oxford: Oxford University Press.

Department for Business, Innovation and Skills (2016) Further education and skills: statistical first release (SFR) 23 June 2016 <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/556015/SFR_commentary_June_2016_final_JuneOfqual_update.pdf> accessed 30 August 2019.

Drury, S. B. (1985) 'The Esoteric Philosophy of Leo Strauss', Political Theory, 13/3: 315-37.

— (1997) Leo Strauss and the American Right, Basingstoke: Macmillan.

Flesch, R. (1948) 'A new readability yardstick', Journal of Applied Psychology, 32/3: 221-33.

Forsyth, Patrick (2007) Outsmarting Your Competitors: Techniques of Sales Excellence to Build Profitable Business, Marshall Cavendish.

Frazer, M. L. (2006) 'Esotericism Ancient and Modern: Strauss Contra Straussianism on the Art of Political-Philosophical Writing', Political Theory, 34/1: 33-61.

Goldberg, L.R. (1993). 'The structure of phenotypic personality traits' The American Psychologist, 48 /1: 26–34.

Gottfried, P. (2012) Leo Strauss and the conservative movement in America : a critical appraisal, Cambridge; New York: Cambridge University Press.

Grant, N. H. (2015) 'Leo Strauss and Anglo-American Democracy: A Conservative Critique', American Political Thought, 4/3: 513–16.

Gumperz & Cook-Gumperz (2008) 'Studying language, culture, and society: Sociolinguistics or linguistic anthropology', Journal of Sociolinguistics, 12/4: 532–45.

Hernández-Campoy, J. M. (2014). ’Research methods in Sociolinguistics’, Aila Review, 27, 5-29.

Hirsh & Nation (1992) ‘What Vocabulary Size Is Needed to Read Unsimplified Texts for Pleasure?’, Reading in a Foreign Language, 8: 689-96.

Hukill & Jackson (1961) ’The Spoken Language of Medicine: Argot, Slang, Cant’, American Speech, 36/2: 145-51.

Koerner, K. (1991) ‘Toward a History of Modern Sociolinguistics’, American Speech, 66/ 1: 57-70.

Kristiansen & Jorgens (2005) ’Dialect change: convergence and divergence in European languages’ in Auer, Hinskens & Kerswill (ed.) Dialect change: convergence and divergence in European languages, Cambridge: Cambridge University Press, 287-330.

Llamas et al. (2007) The Routledge companion to sociolinguistics, London : Routledge.

Lexico Oxford Dictionaries, Oxford University Press. <https://www.lexico.com/en/explore/how-many-words-are-there-in-the-english-language> accessed 14 August 2019.

Lora, R. (2000) ’Leo Strauss and the American right’, Journal of The History of the Behavioral Sciences, 36/1: 88-9.

Melton, J. (2001) The rise of the public in enlightenment Europe, Cambridge: Cambridge University Press.

MetaMetrics The Lexile Framework for Reading. <http://cdn.lexile.com/cms_page_media/135/11x17%20Lexile%20Map.pdf> accessed 17 July 2019.

Minowitz, P. (2009) Straussophobia : defending Leo Strauss and Straussians against Shadia Drury and other accusers, Plymouth : Lexington Books.

Mitch, D. (2004) ‘Education and Skill of the British Labour Force’, in Floud & Johnson (eds.) The Cambridge Economic History of Modern Britain, Vol. I: Industrialisation, 1700-1860, 345. Cambridge: Cambridge University Press.

Morgan, M. H. (2014) Speech communities / Marcyliena Morgan, Cambridge; New York: Cambridge University Press.

Office for National Statistics (2017) Graduates in the UK labour market. <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/graduatesintheuklabourmarket/2017> accessed 30 August 2019.

Pangle & Nathan (1987) 'Epilogue' in: Strauss & Cropsey, History of Political Philosophy, 3rd ed, Chicago: University of Chicago Press, 907–8.

Rogers, C. R. (1942) Counseling and psychotherapy, Cambridge : Riverside Press.

Ruiz H. (2015) 'At the crossroads between literature, culture, linguistics, and cognition', A Journal of English Studies, 13/8: 47-70.

Schaefer, D. (2010) 'A Review of "Straussophia"', Perspectives on Political Science, 39/2: 121-3.

Smith, G. (1997) 'Leo Strauss and the Straussians: An Anti-Democratic Cult?' PS: Political Science and Politics, 30 /2: 180-89.

Smith, G. (1997). Leo Strauss and the Straussians: An Anti-Democratic Cult? PS: Political Science and Politics, 30/2: 180-189.Strauss, L. (1941) 'Persecution and the Art of Writing' Social Research — Graduate Faculty of Political and Social Science, New School for Social Research —, 82/1: 79-98.

— (1952). Persecution and the Art of Writing, Glencoe, illustrations : Free Press.

Wardhaugh, R. (2006) An introduction to sociolinguistics / Ronald Wardhaugh. Oxford: Blackwell.

West, M (1953) A General Service List of English Words. London: Longman, Green and Co.

Wilson et al. (2016) 'English Vocabulary Size in Adults and the Link with Educational Attainment', Language in Focus, 2.

Wolfram & Schilling-Estes (1998) American English: dialects and variation, Malden, Mass.: Blackwell: 13–6.

Yanchun, Z. C. (2013) 'A Sociolinguistic Study of American Slang', Theory and Practice in Language Studies, 3/12: 2209-13.

Yule, G. (2006) The study of language, 3rd ed. Cambridge: Cambridge University Press.

Zahavi, D. (2003) Husserl's Phenomenology, Stanford: Stanford University Press.

Science & Philosophy Volume 7(2), 2019, pp. 49-58

Cognition and Reality

Aaron Peng Fu[1]

Abstract

My study rebuilds the basic cognitive principle to approach the true form of motion reality. Scientific study and development have always been led by facts but has never been able to reach the basic truth. This is related to our basic sensory and cognitive modes. Our cognition and practices have been developed based on functionally created facts which are at odds with the motion directed natural principle formed in reality. Our basic sensory form is integrated by interactive features formed based on interactions between our senses and environment. We do not sense the true motion features of reality. This cognitive mode successfully meets our survival needs of interacting with the environment. However, for the development of a sustainable civilization it's necessary to break through the ultimate barrier between cognition and reality. We need to realize the functions and limitations of our cognitive mode and how that effects human social practice and development, and most importantly, the natural world. This is the way to fundamentally understand and solve the societal and environmental problems caused by human development.

Keywords: function of integration, integrated society, cognitive forms, Cognitive principle, cognition and motion, interactive mechanism, limitation of cognition, cognitive evolution

[1] Independent Researcher; aaronfu@afvisionary.com. Received on September 24th, 2019. Accepted on December 28th, 2019. Published on December 31th, 2019.
doi: 10.23756/sp.v7i2.475. ISSN 2282-7757; eISSN 2282-7765.

1 Introduction

The diversified development of culture and knowledge shows the great capacity for creativity possessed by human cognition. However, we also have many different understandings about the nature of truth and reality, showing also the limitations of cognition.

The creative capacity allows for growth and development, but the limitations have to lead that development to the many predicaments we now face. The very principle that supports this creativity is the same principle that causes these inherent limitations. A breakthrough requires a point of view which goes beyond our basic cognitive form.

I study the forms of cognition and motion. Through my articles, I will share with you new insights regarding our cognitive forms, the limitations therein, the resulting conflict (explaining how our every developmental advancement inevitably seems to lead us further from harmony with our world) and also the solution; that is, how we can break through these limitations and evolve to the next stage of human civilization, one in which we are in harmony with the natural motion systems that surround us.

2 The form of cognition

To be able to understand a cognitive mode fundamentally requires a point of view which goes beyond the principles of cognition. Our sensory system is interactive and an integrated form of cognition (Fu, 2019). It has been tested and adapted to daily survival needs. Interaction (the mechanism) and integration (the form) are the two key factors of sense. The benefits of cognition based on the interactive information mechanism and integrated information include accurate guidance of the interactive activities and rapid identification of the environment. However, the limitation of this form of cognition is that it can’t cognize the motion form of information. It means we can interact with reality through our senses but we can’t cognize motion truths through sense.

3 The function of integration

The content of integrated information is the relative features. So the integrated information is not limited by the type of units as long as their integration contains relative features, such as negative and positive, black and white, strong and weak, 1 and 0 etc. Here we can call these relative features as negative and positive features (NPFs). The NPFs can represent the features of interactions and be formed, passed, recorded and synchronized during a series of interactions, thus completing the interactive information mechanism.

For example, light undergoes a series of reflections during interactions with the environment, forming light with a relatively weak or strong distribution. When the light of varying intensities excites visual receptors, neural currents are produced with varying intensities proportional to the intensity of illumination. The currents trigger electrochemical reactions within the synapses and form neural-pixels with NPFs which are proportional to the intensity of the currents. The sensory information process is based on an interactive information mechanism.

Our senses gather information from multiple interactions such as sight, sound, and many more. They not only work to detect the environment and direct our interactive activities; they also decode the environment into sensory forms based on interactive features. Senses must take interactive features as basic information as the request of survival needs. It is a functionally directed cognition mode. If we sense the natural motion features of the environment directly instead of recognizing the interactive features, our senses would lose the ability to direct our daily interactive activities with our environment. Without any doubt, the cognitive mode we are born with is the best suited for our survival needs.

Our senses are functional as a practical tool for survival, not as observers of truth. They allow cognition based on integrated forms and interactive features so we can only develop functional cognition based on the integrated principle together with interactive experiences, which do not involve the motion form of reality. When it comes to needs of survival, consider our understanding of the conceptual ‘apple’: red, delicious, cures hunger and thirst, provide energy. Through these dispersed bits of information and experiences, we can integrate an informational structure to form the functional cognition concept that the red apple is a delicious food source.

The process of integrated cognition is: collect dispersed information, piece together the information randomly until a certain structure of information can meet the functional needs, then establish a cognitive mechanism. Our sensory cognition, through the integration of relative features, in a way similar to cards for detecting colorblindness, functionally highlights the relative differences of information to achieve the purpose of decoding and identifying the environment easily and quickly.

In the process of advanced integrated cognition, we choose certain information and organize the information with a functional mechanism to complete cognitive activities such as: describing, identifying, explaining, understanding, assuming, inferring, judging, creating, etc. to meet diverse advanced cognitive needs. This integrated mechanism is based on a creative mechanism which is functionally directed. This functional cognitive mode is what promotes the development of human technology.

The functionally directed cognitive mechanism is commonly referred to as ‘logic’. We judge a statement as logical or not based on whether it builds upon on a recognized functional mechanism or not. If not it will make no sense. However, nature doesn’t run by principles of logic because nature is not functionally directed. Reality is dynamically directed and nature is a motion system. It developed with a continuous and harmonious foundation due to the ductility and self-consistency of motion form. The development of motion is directed by the characters of the motion form itself. A motion system, such as nature, provides a world principle for continuity and harmony. Any motion phenomenon which has formed in nature (including life) automatically blends into this dynamic foundation.

However, human creativity is artificial, a functionally created structure, as it lacks a dynamic foundation. This integrated creation of technology doesn’t blend into but rather ignores and damages the dynamic foundation of reality. The dynamic principle is the enemy of the integrated mechanism. Therefore, natural dynamic development won’t produce an integrated structure (such as machines) and functional directed creations can’t imitate the natural dynamic systems (such as life).

There are interactions between our sensory system and the external world, but our sensory form is virtual (non-dynamic) and integrated. In other words, reality does not exist in the form we sense. I call this cognitive mode the Virtual Interactive Cognitive Mode (VICM). The VICM is a non-motion cognitive mode based on the interactive mechanism and virtual integrated information. Through the VICM we can cognize and control interactions and also create virtual cognitive forms to describe reality.

4 The scientific world view and developmental concept

The scientific world view considers that everything is made of units of matter. This is because our senses are integrated by units of information. This material point of view is an integrated world view decided by the principle of cognition. Material motion based on our senses is only virtually dynamic motion. However, the updating of integrated information doesn’t contain any motion mechanism.

Science is the application of the VICM, based on a virtual but functional cognitive mode. Scientific facts are creations based on interactions. They don't naturally exist, but they happen consistently through scientific experiments and are functionally proven. Scientific cognition considers that as 'fact'. However, scientific practice avoids a very important fact which is that scientific study does not understand the truth behind the facts. We face a lack of understanding of our cognitive form and its relationship with reality and are further misdirected by our current world view and concept of development.

Scientific 'facts' are cognized from an integrated point of view and the dynamic foundation of reality has been removed from consideration, leading the scientific study to methods of deconstruction and integration which promote development based on random innovation and creation. Human technology creates change and takes control of reality by functionally directed interactions which ignore and even damage the dynamic nature of reality. Thus these artificial "facts" are damaging the natural "truth".

It is not difficult to be aware of the limitations and the solution. Even though we have a great capacity for creation, we are unable to learn the motion mechanism all around us that we can clearly sense or observe. The reason is actually quite simple. Before we have made the awareness and breakthrough of our cognitive form, the scientific study of nature and application of technology remains completely blind. The creation of technology based on a functionally directed integrated structure depends on sustained energy consumption. Technology based on this integrated and deconstructionist point of view releases the energy of motion through the destruction of the natural motion mechanism, in order to meet the energy needs of integrated technology. These two factors have led scientific technological development to follow the path of dense integration and high energy consumption.

To be aware of the limitations and the solution is a pressing need for scientific practice and development. Dynamic cognition and its practice are beyond the ambit of interactive science, but this is not a critique or call to end functional scientific advancement. Rather, dynamic cognition can lead us beyond the current misguidedness and chaos by providing an essential base and direction for scientific study and development. Science as a field should be functionally executed but dynamically directed to benefit humanity as well as the natural world.

5 Functionally directed society

Integrated social structure can be considered the application of integrated technology. It is a functionally directed structure that enabled increased productivity and enriched living resources, but the non-dynamic form doesn't provide a foundation upon which to develop a society that has dynamic needs. Without a dynamic mechanism, few people capture the majority of resources while the labor majority has been distributed a small amount.

Rigidity and inhomogeneity are the characteristics of a nondynamic society, which suppress and distort the dynamic nature of humanity and create the eternally false proposition of human nature as inherently good or evil. Centralization and control are basic methods to build up integrated structure which inevitably leads to enslavement and war during the development of integrated society. The bottom of these problems is that they are all caused by the limitations of the integrated form of society. Throughout the history of human society, the functionally directed structure has promoted technological power and ability, but as a world principle it has failed in every way; it's inharmonious, unbalanced, discontinuous, centralized, and based on control, causing human suffering time and again.

From the basic functional point of view, modern social structures are integrated by three parts: resource procurement, production and consumption, excretion of waste. All parts operate towards maximizing social function, but without a dynamic foundation. This creates disorder in addition to inordinate exploitation, overproduction, overconsumption, resource exhaustion, massive waste, environmental pollution and ecological damage. Functional development is random and out of control.

Although there is more awareness of the importance of the dynamic needs for continuity and harmony within social development, due to the limitation of our cognitive form, we can only do damage control. We are unable to solve the problem caused by the inherent faults of the social principle and form. Human society has been kidnapped by a functionally directed principle.

Let's contrast this with a dynamically directed and self-functional system. The human body is a fully functional dynamic system. Functional activities also include resource procurement (eating and drinking), production and consumption, (gaining and expending energy) and excretion of waste. But rather than being built by functional structures, these activities are directed by the dynamic foundation inherent to the human body's system. We can't ignore the existing dynamic foundation with the aim of maximizing functionality. From conception to adulthood, the operation of all functional activities is directed and supported by a continuous and harmonious development within a dynamic living system.

Understanding the different nature of functionally directed and dynamically directed systems could help us to be aware of the misguidedness of a functional social mechanism. This will allow us to set our sights on the real solution to the social problems we are facing.

6 Human society and the natural ecosphere

The earth's ecosphere is a dynamic system, not unlike the human body. All life systems are based on a similar dynamic principle, since they developed within the dynamic system of the ecosphere, automatically copying the dynamic mechanism of growth and development. However, due to the limitations of the non-dynamic cognitive form we have difficulties building connections between dynamic systems.

The Earth's ecosphere is a complete and closed dynamic system. Even without bone and muscle tissue, it is a system founded on the cycles of water and air, just as inside the human body. Within the earth's ecosphere system, there are multiple organisms that function like various cells in the human body. From this point of view, the reproduction of certain organisms in the biosphere is the same biological activity as a cellular division in the human body.

Cellular division is the function of cells that support the operation and development of the biological system, the same function as various organisms in the ecosystem. These biological activities are all regulated by the dynamic mechanism that keeps the ecosphere balanced and self-sustainable. At the time of early hominids, our ancestors also acted as normal "cells" whose reproduction and activities followed a dynamically directed natural principle. At the dawn of agriculture, human's mode of living underwent a mutation of sorts and began to develop a functionally directed society. After a period of low-speed development, humanity stepped into industrial civilization.

The rapid development of technology allowed the utilization of more resources from earth's ecosphere. Human society broke away from the dynamically directed principle of the ecosphere completely and rushed towards a period of rapid proliferation, due to the functionally directed mechanism. Even though the increase of human capacity for growth and development and the abundance of living resources can be considered as a great achievement of humanity, from the dynamically directed point of view of earth's ecosphere, functionally directed modern society conforms to all the features of cancer. The development of cancer starts with cell mutation. It then breaks away from the body's dynamically directed system and starts functionally directed development which is maximizing cell function: infinite cleavage and rapid proliferation.

Since the industrial revolution, human society has been cancer to the earth's ecosystems. The digital information era pushed society into an even faster developmental period. Functionally directed scientific and technological development has allowed human an even stronger and more efficient capacity for rapid proliferation. This combines with the push from our current developmental concept which praises rapid and infinite acceleration of development. In a short time, human's explosive development has caused ecological havoc, rapid depletion of natural resources, massive pollution, the severe compression of the other normal 'cells' (organisms), and the destruction of the overall ecological balance. The functionally directed society has the same developmental trend as cancer in the human body. As it enters the later stages, it develops more rapidly and causes more damage to the system in which it resides.

The natural motion system, which is adjusted and supported by a harmonious and continuous principle, is stable, regular and has low energy consumption. When the principle is damaged, systemic turbulence and internal conflict result. Non-dynamic cognition and the functionally directed practice of mankind have clearly caused interference and even destruction of the natural dynamic system. From a systemic point of view, global warming is a sign of increasing energy consumption within the dynamic mechanism.

The functionally directed growth mechanism is strong, but cuts corners. Without external intervention, like surgery and radiation or chemotherapy, the spread of cancer is unstoppable. However, as tough as cancer is, when it reaches its fastest and strongest period, it is called the 'terminal stage'. The development of cancer is misguided by a functionally directed mechanism and finally destroys the dynamic foundation for its own existence, and everything else as well. We have to be aware that although the functionally directed mechanism shows us unlimited potential, it also limits our vision and causes us to neglect the dynamic foundation that is the reason for all that happens and exists. If we can see through to the essence of the problem, we will see that the solution is to transform our functionally directed blind development into a dynamically directed civilization system. This provides a solution to help ourselves while at the same time repairing and compensating the natural ecosystem. The transformation must be based on the evolution of our cognitive form.

7 Dynamic cognition

The fundamental traits of human consciousness are stability, continuity, harmony and regularity. It is based on a dynamic foundation. I call it dynamic consciousness. It is the foundation for all of our cogitative activities. The cognition humans develop after birth, in order to adapt and interact with the environment for survival needs, is the VICM, which is non-dynamic. Although dynamic consciousness is the prime foundation of cognitive activities, the form and principle of our cognitive mode is still decided by the form and principle of the cognitive subject. For example, our cognition, based on integrated sensory information, is non-dynamic.

Of course, on the other hand, the existence of dynamic consciousness also makes it possible to develop a dynamic cognitive mode. The problem is that for the individual human being, dynamic cognition is not needed for survival, so we lack any pressure to develop it from the beginning. Humans have created a functionally structured society without awareness of the cognitive prerequisite. To build up a sustainable civilization requires a separate cognitive form and mode from that needed to meet an individual's survival needs. We need a complete understanding of the natural motion form and dynamic world principle.

A self-motivated cognitive evolution is the biggest challenge facing humanity. The difficulties not only come from the cognitive development process but also the misguidance and friction against the current mainstream functionally directed cognition and mechanism. It requires great courage to re-examine the principles and limitations of the current cognitive mode and escape from its influence.

The two forms of cognition are based on different principles. The development of dynamic cognition must start from the very bottom and rebuild a separate cognitive principle to approach the true form of motion reality. The active dynamic cognitive mode can cognize motion form, features and mechanism directly, and naturally, develop a knowledge system based on them. My research 'cognition and reality' was not inspired by the scientific point of view and methods of study. Instead, it has a dynamic knowledge system as a background. Building upon dynamic cognition fundamentally requires avoiding the influences of the current cognitive mode and methods of study. My studies include the path for dynamic cognitive development, the dynamic model as relates to social transformation and technology, and the advanced dynamic cognition to understand the principles of motion, including living systems.

8 Conclusions

Stretching out the timeline of Homo Sapiens, human civilization has been around for a relatively short period of time and can be considered as a mere ‘transitional’ period. However, I believe the rapid development of functional societal practice and the resulting environmental issues are signs of a failure of the evolution of civilization. The functionally directed cognition and achievements make us optimistic towards future advancement, but the dynamic systems of earth’s ecosphere will collapse, and do so in a time and way which can’t be predicted or understood from a non-dynamic point of view. This deterioration will be irreversible and completed in a very little time. The chance for success is small, but we need to act while we still can, and do so in the right way.

References

[1] Fu, A. (2019). Sense and Motion: The Barrier Preventing Us from Understanding Motion. *JOURNAL OF ADVANCES IN PHYSICS*, *16*(1), 372-376. https://doi.org/10.24297/jap.v16i1.8468

Science & Philosophy Volume 7(2), 2019, pp. 59-70

A model for the solution of the quantum measurement problem

Biswaranjan Dikshit*

Abstract

The basic idea of quantum mechanics is that the property of any system can be in a state of superposition of various possibilities (or eigen states). This state of superposition is also known as wave function and it evolves linearly with time in a deterministic way in accordance with the Schrodinger equation. However, when a measurement is carried out on the system to determine the value of that property (say position), the system instantaneously transforms to one of the eigen states and thus we get only a single value as an outcome of the measurement. Quantum measurement problem seeks to find the cause and exact mechanism governing this transformation. In an attempt to solve the above problem, in this paper, we will first define what the wave function represents in real-world and will identify the root cause behind the stochastic nature of events. Then, we will develop a model to explain the mechanism of collapse of the quantum mechanical wave function in response to a measurement. In the process of development of model, we will explain Schrodinger cat paradox and will show how Born's rule for probability becomes a natural consequence of the measurement process.

Keywords: Quantum measurement problem, Born's rule, Schrodinger cat paradox, Biased will theory.†

* Laser and Plasma Technology Division, Bhabha Atomic Research Centre, Mumbai-400085, India and Homi Bhabha National Institute, Mumbai, India; e-mail address: bdikshit73@yahoo.co.in

†Received on December 9th, 2019. Accepted on December 21st, 2019. Published on December 31st, 2019. doi:10.23756/sp.v7i2.482. ISSN 2282-7757; eISSN 2282-7765.

1. Introduction

As per modern physics, all processes in nature are governed by laws of quantum mechanics. Till date, no violation of quantum mechanical laws has been observed in experiments. Even for macroscopic bodies, each classical event can be explained as a consequence of a large number of quantum processes happening at the microlevel. The most interesting characteristic of quantum mechanics is that it permits a system to be in the state of superposition of all possible values represented by orthogonal vectors for any physically observable property. The vector space created by these possibilities (eigenvectors) is known as Hilbert space and the state vector of the system lies in this Hilbert space. For example, spin angular momentum of an electron can be in a mixed state of $+\frac{1}{2}\hbar$ (up) and $-\frac{1}{2}\hbar$ (down) spins although the measurement yields only a single value, either up or down. Similarly, the position of a particle in a box can be superposition all possible values although its measurement by an external body gives us only a single value for the position. The generalized superposition state of the quantum mechanical system is also known as a wave function. When we measure a physical property, the probability of finding a specific value is given by Born's rule which states that probability is proportional to the square of the component corresponding to that value in the state vector. Stated simply, the probability is proportional to the square of the wavefunction. Immediately after the measurement, the state of the system is found to be same as the eigen state of the value it exhibited. Thus, although the state vector, in general, evolves deterministically and linearly with time as per the Schrodinger equation, in response to the act of measurement, the state or wave function instantaneously collapses to one of the eigen states. Quantum measurement problem seeks to understand what is it in the measurement process that stimulates the wave function collapse and how does this wave function collapse exactly occur in nature. The

Copenhagen interpretation (by Bohr and others), the oldest interpretation of quantum mechanics believes that certain '*something*' happens during the act of measurement which collapses the wave function. But, it is unable to find out what this "*something*" is. Rather, it takes up an often-quoted stand "shut up and calculate" [1].

Many-worlds theory [2-4] rejects altogether the phenomenon of wave function collapse. It suggests, at the time of measurement, the universe just makes many copies of itself in which all the possibilities happen. The question still remains, why we happen to be in the universe in which a specific value of the physical property was observed. In other words, this theory doesn't explain the mechanism for choosing one out of many possible options. In addition, methods of the derivation of Born's rule for probability by many-worlds theories have been proved to be circular by many researchers [5-10].

Meanwhile, Einstein, Podolskey and Rosen [11] had suggested that some local hidden pre-existing variables in the system (which are not normally considered by quantum mechanics) might be responsible for observation of a particular value instead of other values. By assuming this local hidden variable theory to be the correct, Bell [12] derived an inequality expression for the spin correlation among entangled pairs of particles which was in contradiction with the quantum mechanical prediction. Consequently, a large number of experiments [13-21] have been carried out which demonstrate the violation of Bell's inequality and thus explanations based on local hidden variable theory are ruled out for the solution of the measurement problem.

Recently, non-local (or global) hidden variable theories like deterministic Bohmian mechanics [22-23] for the solution of measurement problem have also been proved to be incompatible with quantum mechanics and relativity by Leggets [24] and Gisin [25]. Groblacher [26-27] has reported experimental results demonstrating the inconsistencies of non-local hidden variable theory. Groblacher stated [26], "Our result suggests that giving up the concept of locality is not sufficient to be consistent with quantum experiments unless certain intuitive features of realism are abandoned".

The GRW theory [28-29] tries to explain only the collapse of the macroscopic measurement system and that too by assuming spontaneous collapse of the microscopic objects. This theory doesn't provide any explanation for the spontaneous collapse of microscopic system. In this approach, an additional stochastic term is postulated in the quantum dynamical equation without the required logical reasoning. So, this approach for the solution of the measurement problem is not convincing.

Decoherence theory [30-31] identifies the environmental monitoring as the cause for the destruction of quantum coherence between classical pointer states and hence for expression of a single value of observable out of many possibilities. However, the quantum mechanical measurement problem is also applicable for a microscopic isolated system for which above theory doesn't have any explanation. In addition, decoherence theory doesn't explain the mechanism for choosing a specific eigenvalue by the system during measurement. That's why even one of the proponents of decoherence theory, Joos [32] has stated "Does decoherence solve the measurement problem? Clearly not. What decoherence tells us is that certain objects appear classical when observed". In another article titled "Why decoherence has not solved the measurement problem: a response to P. W. Anderson", Adler [33] has given a mathematical treatment to justify the fact that decoherence theory doesn't solve the measurement problem.

In this paper, we will propose a theoretical model for the solution of quantum mechanical measurement problem. We will explain the mechanism of collapse of the quantum mechanical wave function during measurement and will also identify the root cause behind the probabilistic nature of events. We will explain the Schrodinger cat paradox and will show how Born's rule for probability becomes a natural consequence of the measurement process. The uniqueness of the present derivation of Born's rule as compared to our purely mathematical approach [34] published earlier is that it identifies the exact mechanism in which Born's rule comes into picture during the process of collapse of the quantum mechanical wave function.

2. Proposed model for the solution of the quantum measurement problem

To explain the stochastic nature of every particle, initially, Schrodinger [35] and then Coway and Kochen [36-37] proposed that every elementary particle in the universe might have *free will* which causes the uncertainty or randomness in events. In our recently published paper [38], we have proposed *biased will* theory which provides a theoretical justification for the form of the quantum mechanical wave function of a free particle so that quantum mechanical operators can be derived on which the whole of quantum mechanics stands. This theory was also able to derive the quantum mechanical probability distribution for the spin of a particle. The biased will theory assumes the existence of *will* in every inanimate object and states that quantum processes proceed in a direction so as to achieve collective goals of the universe or coherent assembly of particles. This explains the recently reported adaptive mutation in the DNA of bacteria [39-40]. In response to a changing environment, mutations in E. Coli bacteria (which are quantum processes) instead of being random were found to be biased in a direction such that the chance of survival of the bacteria is increased.

In the background of the above developments, we will assume that each fundamental particle or any coherent system has consciousness and has its own *thought* which decides its behavior in the physical world. What is known as the wave function or state vector is actually the *thought* of the particle. Because thought can contain mutually exclusive options at the same time, the wave function can also be the superposition of various physical possibilities. For example, suppose you enter a city and you are thinking of which hotel to stay in. You can think of many hotels simultaneously although your actual physical stay can only be in a single hotel. Similarly, an electron can be in a state of superposition of 'up' and 'down' spins until it is required to physically interact with the external world using one of the options. Since the position is just a property expressed by a particle during interaction with another body, it (i.e. position) can also be in a state of superposition which is commonly known as wave function in position space. Just like *thought* resides in our mind, wave function resides in the multidimensional space of possibilities technically known as Hilbert space. So, we can identify the Hilbert space to be same as the mind of particle.

Regarding evolution, the dynamics of our thought depends upon our own present state, environmental conditions and future objectives. For example, our thought to select a hotel in a new city will be guided by considerations such as our financial status, the information we have collected about nearby hotels, which hotel is nearer to our workplace and our goal such as whether we need to save money or have the luxury. Similarly, the position of interference maxima of a particle depends on its properties carried over from past (such as momentum, energy), environment (how many slits are there) and what is the ultimate goal (like conservation of momentum, energy and maintaining symmetry of space that gives rise to wave behavior [38]). So, dynamically, thought and quantum mechanical wave function (or state vector) behave in the same manner.

Since we have identified the state vector or wave function as the *thought* carried by the particle, we will now address the core question of why and how wave function collapses during measurement. Measurement of any observable is a two-step process. The first step is interaction and second is awareness about this interaction by some subject. It is the first step only i.e. *interaction* that causes the collapse of the wave function. Collapse has nothing to do whether this interaction is observed by some living being or not. So, ours is an objective interpretation. We support this idea as even when living beings were not created, this universe did exist and evolved in accordance with the laws of quantum mechanics. The interaction causes collapse of the wave function as in this nature two systems can physically interact with each other only if each of them has a specific value of the observable (not a superposition). Using this line of thought, we can explain the Schrodinger cat paradox as given below.

In Schrodinger cat problem, a cat along with a radioactive nucleus and a bottle filled with poisonous gas is kept in a box. As soon as the radioactive decay occurs, it triggers an electronic circuit which ultimately breaks the bottle and the poisonous gas comes out killing the cat. Conventionally, it is said that if the box is closed for a long time, the nucleus remains in a state of superposition of 'decayed' and 'un-decayed'. So, the cat also remains in a state of superposition of 'alive' and 'dead'. When the observer opens the box, he forces the system to take a stand and so, he is indirectly responsible for death or life of the cat. Of course, the conclusion here is paradoxical or flawed. This is because we have started from an un-decayed nucleus and just by closing the box so that no one observes it, it doesn't go into a state of superposition. An observation can certainly change the quantum state of a system from a superposition state to a specific eigen state as it is also an interaction. But the opposite is not true. *Non-observation of a system cannot bring it from an eigen state to superposition state.* So, Einstein correctly commented, "Isn't moon there in the sky when no one looks at it?". In case of Schrodinger cat problem, since we have started from a live cat and an undecayed nucleus, they remain so *till* the radioactive decay event. Radioactive decay occurs not by personal observation, but by physical interaction between quarks or nucleons. The quarks are in continuous motion inside the nucleus and constantly try to break the nucleus. Within a few minutes, they are subjected to a huge number of trials and they can succeed at any time. As soon as they succeed, the electronic circuit is triggered, the bottle breaks and the cat goes to the state of "dead". The cat doesn't wait for us to open the box (i.e. for our observation) to change its state. So, when we open the box, we only get to know about the state of the cat after possible interactions that have already happened inside the box and the observer opening the window is in no way responsible for the death of the cat.

So, after clarifying that it is only the interaction which causes the collapse of the wave function, let us now understand the mechanism of collapse. At first, we will consider the example of the spin of an electron as it is the simplest case in the sense that it has only two options i.e. +½$\hbar$ (up) and -½ $\hbar$ (down). As explained earlier, spin can be in a state of superposition of ‘up’ and ‘down’ spins until it is required to physically interact with the external world through magnetic moment generated by its one of the options. Using Dirac notation for vectors, let us represent the normalized system state vector by $|\psi\rangle$, ‘up’ spin by eigenvector $|A\rangle$ and ‘down’ spin by eigenvector $|B\rangle$ as shown in Fig. 1. Writing $|\psi\rangle$ as a vector sum of its components along eigenvectors,

$$|\psi\rangle = \overrightarrow{OP} + \overrightarrow{PS} \tag{1}$$

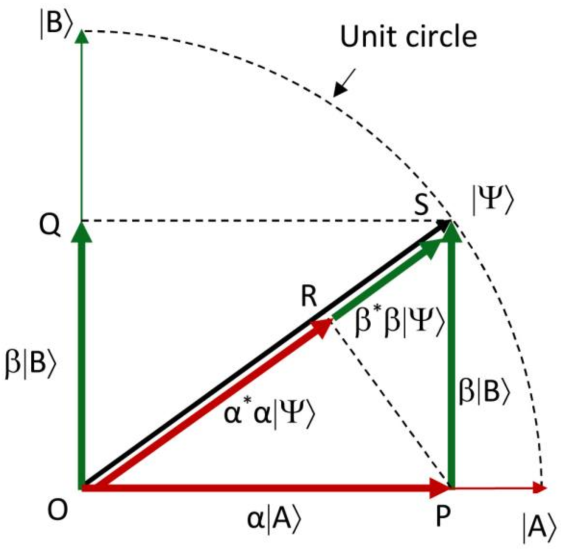


Fig. 1 Vectorial representation of superposition state and eigen states of a quantum system

Using the definition of projection operator and writing

$$\langle A|\psi\rangle = \alpha \quad and \quad \langle B|\psi\rangle = \beta \tag{2}$$

We get, $\overrightarrow{OP}$ = Projection of $|\psi\rangle$ along $|A\rangle = |A\rangle\langle A|\psi\rangle = |A\rangle\alpha$ (3)

And $\overrightarrow{PS}$ = Projection of $|\psi\rangle$ along $|B\rangle = |B\rangle\langle B|\psi\rangle = |B\rangle\beta$ (4)

We know, actions of any human being is generally decided by his or her own thought. Similarly, since state vector $|\psi\rangle$ is considered to be a kind of thought carried by the particle, the physical behavior of the particle is decided by the vector components ***collinear*** with state $|\psi\rangle$. In Fig.1, along $|\psi\rangle$, the collinear components contributed by eigen vectors are given by,

$$\overrightarrow{OR} = \text{Projection of } \overrightarrow{OP} \text{ along } |\psi\rangle$$

$$= |\psi\rangle\langle\psi|A\rangle\alpha = |\psi\rangle\alpha^*\alpha \quad \text{(Using Eq. (2))}$$

$$= |\alpha|^2|\psi\rangle$$

Similarly,

$\overrightarrow{RS}$ =Projection of $\overrightarrow{PS}$ along $|\psi\rangle$

$= |\psi\rangle\langle\psi|B\rangle\beta = |\psi\rangle\beta^*\beta$ (Using Eq. (2))

$$=|\beta|^2|\psi\rangle$$

Thus, we find that the magnitudes of collinear vectors contributed by eigen vectors $|A\rangle$ and $|B\rangle$ are $|\alpha|^2$ and $|\beta|^2$ respectively. When the system (or particle) encounters an external object (say measuring equipment) for possible interaction, it selects any point at random on line OS in Fig. 1. This is the step where the particle makes an acausal selection due to the virtue of its *creativity*. Whichever collinear component the selected point falls on, the system tends to expand that to acquire the full magnitude of unity by instantaneously rotating the state vector to coincide with the corresponding eigen vector (as only a single value for the observable is physically allowed). However, this rotation of state vector occurs only if the interaction of the particle with external body is possible with the help of selected eigen vector. This is how the collapse of the wave function occurs. As the probability of selecting a point on a collinear vector is equal to its magnitude $|\alpha|^2$ or $|\beta|^2$, probability of collapse of the state $|\psi\rangle$ to any eigen vector $|A\rangle$ or $|B\rangle$ is also $|\alpha|^2$ or $|\beta|^2$ respectively. Thus, the Born's rule for probability of interaction come into picture.

The mechanism for collapse of the wave function when there are many possible values for the observable (such as wave function for position) can similarly be explained. Like other properties of a quantum system, the position is just another physical property expressed by the particle. However, since the position is continuous, it has infinite possible values. So, position state vector (in our language, thought that decides the choice of position) lies in an infinite-dimensional Hilbert space. If x_i is any position of the particle in space, $|x_i\rangle$ is the corresponding eigenvector, $|\psi\rangle$ is position state vector and $\psi(x_i)$ is the wave function,

$$|\psi\rangle = \sum \psi(x_i)|x_i\rangle \tag{5}$$

The projection of $|\psi\rangle$ on $|x_i\rangle$ is $\psi(x_i)|x_i\rangle$. As calculated earlier, the magnitude of the projection of $\psi(x_i)|x_i\rangle$ along the state vector $|\psi\rangle$ is given by,

$$M = \langle\psi|\left(\psi(x_i)|x_i\rangle\right) \tag{6}$$

Using Eq. (5) in Eq. (6),

$$M = \left(\sum \psi(x_j)^* \langle x_j|\right)\left(\psi(x_i)|x_i\rangle\right) \qquad 7)$$

As all eigenvectors $\left|x_i\right\rangle$ are orthogonal to each other, the terms in Eq. (7) involving dot product of any two vectors with $i \neq j$ are zero. So, Eq. (7) becomes,

$$M = \psi(x_i)^* \left\langle x_i \,\middle|\, \psi(x_i) \middle| x_i \right\rangle$$

Or $$M = \psi(x_i)^* \psi(x_i) = \left|\psi(x_i)\right|^2 \tag{8}$$

Thus, the magnitude of the collinear component contributed by any eigenvector corresponding to a particular position is equal to the square of the wave function as given in Eq. (8). In response to a stimulus, the system randomly selects any point on the state vector using its own creativity and the collinear component on which this point falls instantaneously expands to become the complete eigenvector and other components die out (of course only if there is a scope of interaction). This is made possible by the state vector rotating instantaneously towards the eigenvector corresponding to the selected collinear component. Since the probability of selection of a collinear component is proportional to its magnitude which ultimately is proportional to the square of the wave function, probability of interaction is given by $\left|\psi(x)\right|^2$. That's why, when a single particle passes through a slit and encounters a detector, either it is detected with a probability of $\left|\psi(x)\right|^2$ or it moves forward unaffected in a superposed state.

3. Conclusions

In this paper, to solve the quantum mechanical measurement problem, we have developed a model to explain the mechanism of the collapse of the wave function in response to a measurement attempt. We have identified that the root cause behind the stochastic nature of events in nature is the thought process (or creativity) present in every inanimate particle or quantum system. The cause of the collapse is the physical interaction between two bodies (not the observation or awareness by conscious human beings). In this light, we have understood the Schrodinger cat paradox. Last but not the least, our analysis correctly reproduces the Born's rule for the probability of quantum interaction for which no convincing proof using other approaches exists.

References

[1] N. David Mermin. Could Feynman Have Said This?. Physics Today, 57 (5), 10. 2004.

[2] David Deutsch. Quantum theory of probability and decisions. Proc. R. Soc. Lond. A, **455**,3129-3137. 1999

[3] Edward Farhi, Jeffrey Goldstone and Sam Gutmann, How Probability Arises in Quantum Mechanics. Annals of Physics, **192**, 368-382. 1989.

[4] J B Hartle. Quantum mechanics of Individual systems. American Journal of Physics, **36**(8), 704-712. 1968

[5] Meir Hemmo and Itamar Pitowsky. Quantum probability and many worlds. Studies in History and Philosophy of Modern Physics, **38,** 333-350. 2007.

[6] David J. Baker. Measurement outcomes and probability in Everettian quantum mechanics. Studies in History and Philosophy of Modern Physics, **38**, 153-169. 2007.

[7] Adrian Kent. Against Many-Worlds Interpretations. Int. J. Mod. Phys. A, **5**, 1745-1762. 1990.

[8] Andres Cassinello and Jose Luis Sanchez-Gomez. On the probabilistic postulate of quantum mechanics. Foundations of Physics, **26** (10), 1357-1374. 1996.

[9] Carlton M. Caves and Rudiger Schack. Properties of the frequency operator do not imply the quantum probability postulate. Annals of Physics, **315**, 123–146. 2005.

[10] Euan J. Squires. On an alleged “proof” of the quantum probability law. Physics Letters A, **145** (2-3), 67-68. 1990.

[11] A Einstein, B Podolsky and N Rosen. Can Quantum-Mechanical Description of Physical reality be considered complete?. Physical Review, **47**, 777-780. 1935.

[12] J S Bell, “On the Einstein Podolsky Rosen paradox”, Physics, **1** (3), 195-200 (1964)

[13] Alain Aspect, Philippe Grangier and Gerard Roger. Experimental realization of Einstein-Podolsky-Rosen-Bohm Gedanken experiment: A new violation of Bell’s inequalities. Physical Review Letters, **49** (2), 91-94. 1982.

[14] Alain Aspect, Jean Dalibard and Gerard Roger. Experimental test of Bell’s inequalities using time varying analyzers. Physical Review Letters, **49** (25), 1804-1807. 1982.

[15] Alain Aspect. Bell's inequality test: more ideal than ever. Nature, **398**, 189-190. 1999.

[16] W Tittel, J Brendel, H Zbinden and N Gisin. Violation of Bell inequalities by photons more than 10 km apart. Physical Review Letters, **81** (17), 3563-3566. 1998.

[17] Z Y Ou and L Mandel. Violation of Bell's inequality and classical probability in a two-photon correlation experiment. Physical Review Letters, **61** (1), 50-53. 1988.

[18] Y H Shih and C O Alley. New type of Einstein-Podolsky-Rosen-Bohm experiment using pairs of light quanta produced by optical parametric down conversion. Physical Review Letters, **61** (26), 2921-2924. 1988.

[19] Gregor Weihs, Thomas Jennewein, Christoph Simon, Harald Weinfurter and Anton Zeilinger. Violation of Bell's inequality under strict Einstein Locality conditions. Physical Review Letters, **81** (23), 5039-5043. 1998.

[20] Roger Colbeck and Renato Renner, "No extension of quantum theory can have improved predictive power", Nature communications, **2**:411, 1-5 (2011)

[21] Zeeya Merali. Quantum Mechanics Braces for the ultimate test. Science, **331**, 1380-1382. 2011.

[22] David Bohm. A Suggested Interpretation of the Quantum theory in terms of "Hidden" variables. I. Physical Review, **85** (2), 166-179. 1952.

[23] Marco Genovese. Research on hidden variable theories: A review of recent progresses. Physics Reports, **413**, 319-396. 2005.

[24] A J Leggett. Nonlocal Hidden-Variable Theories and Quantum mechanics: An incompatibility theorem. Foundations of Physics, **33** (10), 1469-1493. 2003.

[25] Nicolas Gisin. Impossibility of covariant deterministic nonlocal hidden-variable extensions of quantum theory. Physical Review A, **83**, 020102(R). 2011.

[26] Simon Groblacher, Tomasz Paterek, Rainer Kaltenbaek, Caslav Brikner, Marek Zukowski, Markus Aspelmeyer and Anton Zeilinger. An experimental test of non-local realism. Nature, **446**, 871-875. 2007.

[27] Tomasz Paterek, Alessandro Fedrizz, Simon Groblacher, Thomas Jennewein, Marek Zukowski, Markus Aspelmeyer and Anton Zeilinger. Experimental test of Nonlocal Realistic theories without the Rotational Symmetry assumption. Physical Review Letters, **99**, 210406, 1-4. 2007.

[28] G C Ghirardi, A Rimini and T weber. Unified dynamics for microscopic and macroscopic systems. Physical Review D, **34** (2), 470-491. 1986.

[29] Gian Carlo Ghirardi, Philip Pearle and Alberto Rimini. Markov processes in Hilbert space and continuous spontaneous localization of systems of identical particles. Physical Review A, **42** (1), 78-89. 1990.

[30] Wojciech Hubert Zurek. Decoherence, einselection, and the quantum origins of the classical. Reviews of Modern Physics, **75** (3), 715-775. 2003.

[31] Wojciech H. Zurek. Decoherence and the transition from quantum to classical. Physics Today, **44** (10), 36-44. 1991.

[32] E. Joos. Elements of environmental decoherence. In P. Blanchard, D. Giulini, E. Joos, C. Kiefer, I.-O. Stamatescu (Eds.), Decoherence: Theoretical, experimental, and conceptual problems (pp. 1–17). New York: Springer, 1999

[33] Stephen L Adler. Why decoherence has not solved the measurement problem: a response to P. W. Anderson. Studies in history and Philosophy of Modern physics, 34, 135-142. 2003.

[34] Biswaranjan Dikshit. A simple proof of Born's rule for statistical interpretation of quantum mechanics. Journal for Foundations and Applications of Physics, **4** (1), 24-30. 2017.

[35] E Schrodinger. Indeterminism and Free will. Nature, **138**, 13-14. 1936.

[36] John Conway and Simon Kochen. The free will theorem. Foundations of Physics, **36** (10), 1441-1473. 2006.

[37] John H. Conway and Simon Kochen. The strong free will theorem. Notices of the AMS, **56** (2), 226-232. 2009.

[38] Biswaranjan Dikshit. Origin of Quantum Mechanical Results and Life: A Clue from Quantum Biology. NeuroQuantology, **16** (4), 26-33. 2018.

[39] Zeeya Merali. Solving Biology's Mysteries Using Quantum Mechanics. Discover, December 29. 2014 (http://discovermagazine.com/2014/dec/17-this-quantum-life)

[40] Johnjoe McFadden and Jim Al-Khalili. A quantum mechanical model of adaptive mutation. Biosystems, **50**, 203 – 211. 1999.

Science & Philosophy Volume 7(2), 2019, pp. 71-82

Forms of Crossed and Simple Polygons

Luigi Togliani[1]

Abstract

In this paper the author presents a new form of hexagon and the solution of the open problem of classifying plane hexagons. In particular are illustrated the forms of crossed and simple *n*-gons for *n* = 3, 4, 5, 6 and also the forms of simple ones for *n* = 7, 8, 9. A graphic way to construct new forms of polygons is illustrated.

Keywords: polygon; simple polygon; crossed polygon; form of a polygon; hexagon.[2]

1 Introduction

Polygons represent a well-known topic in Mathematics. In Euclid's Elements (Book 1, definition 19) we read: "Rectilinear figures are those contained by straight-lines: trilateral figures being those contained by three straight-lines, quadrilateral by four, and multilateral by more than four" (Fitzpatrick, 2008). But many problems about polygons are still open. The issue of classifying polygons in one of them.

2 Definition of a polygon

Let n be an integer number, with $n > 2$. On the plane, we consider n different points: $P_1, P_2, \dots , P_n$, called *vertices*. The set of the segments: $[P_1, P_2]$, $[P_2, P_3]$, …, $[P_{n-1}, P_n]$, $[P_n, P_1]$ is called *n-gon* or *polygon* $P = P_1P_2 \dots P_n$. The above mentioned segments are called *sides*. So a polygon is a cyclically ordered sequence of vertices and sides (Grünbaum, 2012). This definition is

[1] Accademia Nazionale Virgiliana, Mantova (Italy); Liceo Scientifico "Belfiore", Mantova luigi.togliani@gmail.com.
[2] Received on June 29th, 2019. Accepted on October 28th, 2019. Published on December 31th, 2019. doi: 10.23756/sp.v7i2.473. ISSN 2282-7757; eISSN 2282-7765.

different from Euclid's one: according to this author, a polygon is a limited part of the surface of the plane, while our definition concerns only a set of segments.

An *ordinary* polygon is one in which no point of the plane belongs to three or more sides of the polygon. A polygon is *proper* if two sides in sequence aren't aligned. A polygon is *simple* if two sides haven't internal points in common; otherwise, it is called *self-intersecting* or *crossed*. In this paper, I only consider ordinary and proper polygons (Grünbaum, 1975).

3 Classifying polygons

Two n-gons $P = P_1P_2 \ldots P_n$ and $Q = Q_1Q_2 \ldots Q_n$ have the same *form* if there exist a set of ordinary and proper n-gons $R(t) = R_1(t)R_2(t)\ldots R_n(t)$, with $0 \le t \le 1$, so that $R(0) = P$, $R(1) = Q$ or $R(1) = Q^*$, where Q^* is a mirror image of Q and $R_1(t)$, $R_2(t)$, …, $R_n(t)$ are continuous functions for every $i = 1, 2, \ldots, n$.

So the n-gons P and Q have the same form when we can obtain Q from P by means of a continuous deformation through a set of ordinary and proper n-gons; a reflection may be necessary. The *form* can be considered the equivalence class containing all the n-gons having the same form of a particular n-gon.

We *classify* n-gons when we can fix the number $T(n)$ of all different forms of n-gons existing for a particular value of the integer n , $n > 2$. It has been proved that for $n = 3, 4, 5$ the different forms of n-gons are respectively: $T(n) = 1, 3, 11$ (figure 1).

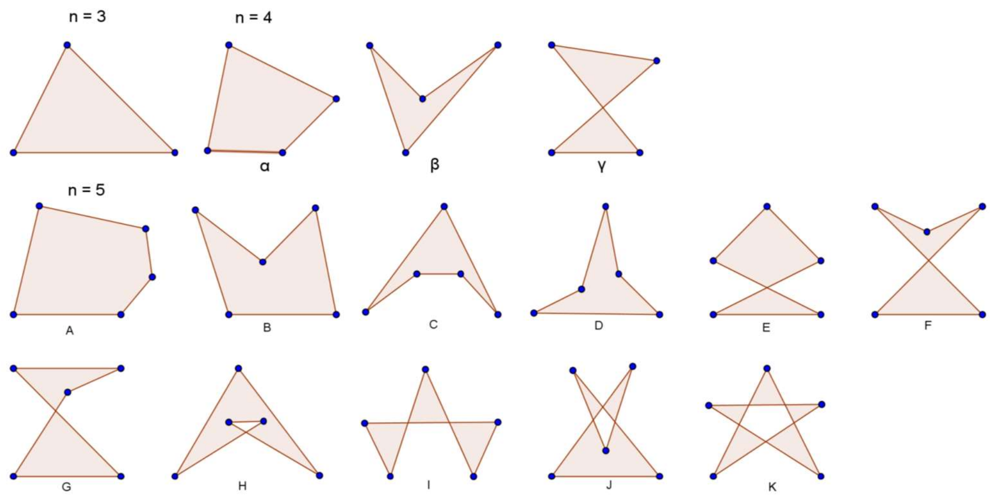
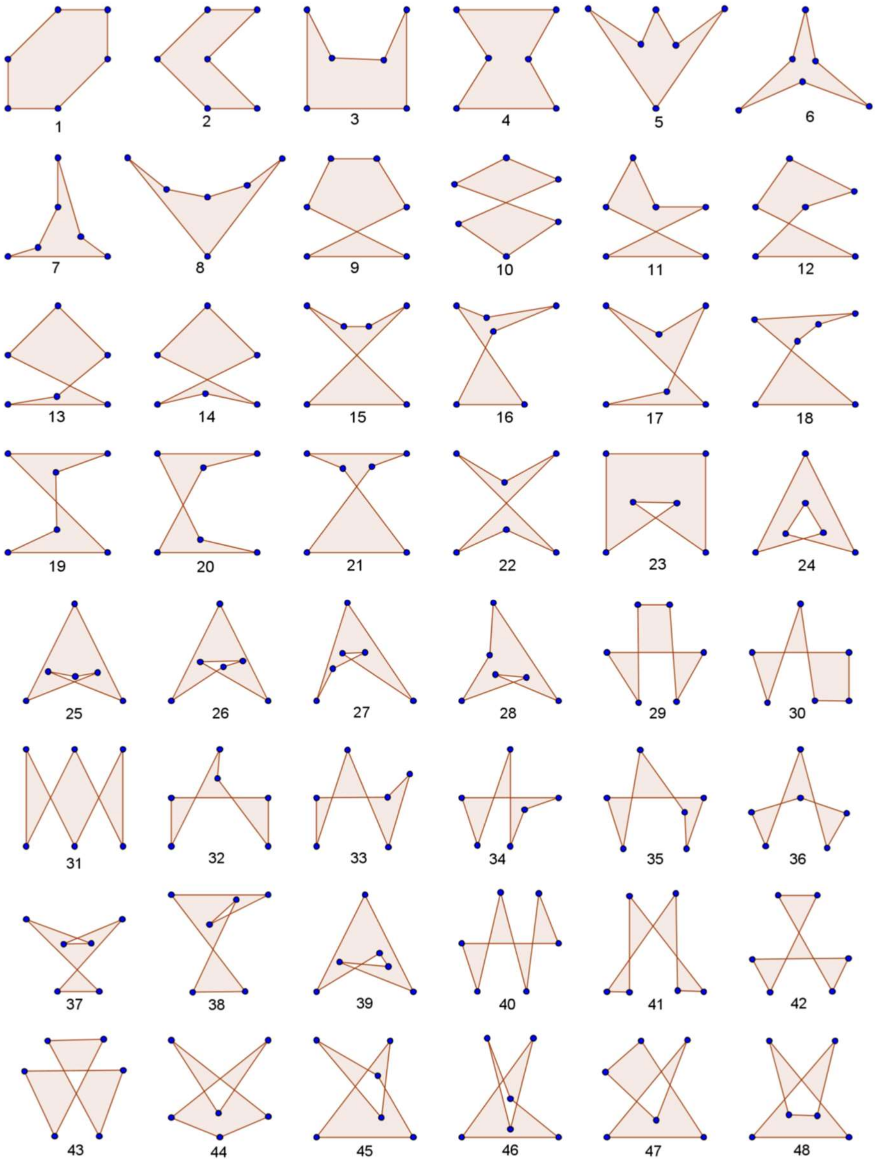


Figure 1. The forms of n-gons for $n = 3, 4, 5$.

How many different forms of hexagons are there? The answer is not simple. In 17th century Girard established that $T(6) = 69$, but three centuries later Steinitz affirmed that the number was $T(6) = 70$ (Girard, 1626; Steinitz, 1916). However, neither Girard nor Steinitz depicted the forms of hexagons in their essays. More recently Grünbaum added two new forms and conjectured that $T(6) = 72$ (Grünbaum, 1975). In 1977 I found a new form of hexagon, the 73rd one, and I demonstrated that $T(6) = 73$. In figure 2 the 73 different forms of hexagons are drawn: the hexagon number 73 represents the new and the last form of hexagon (Togliani, 1978).



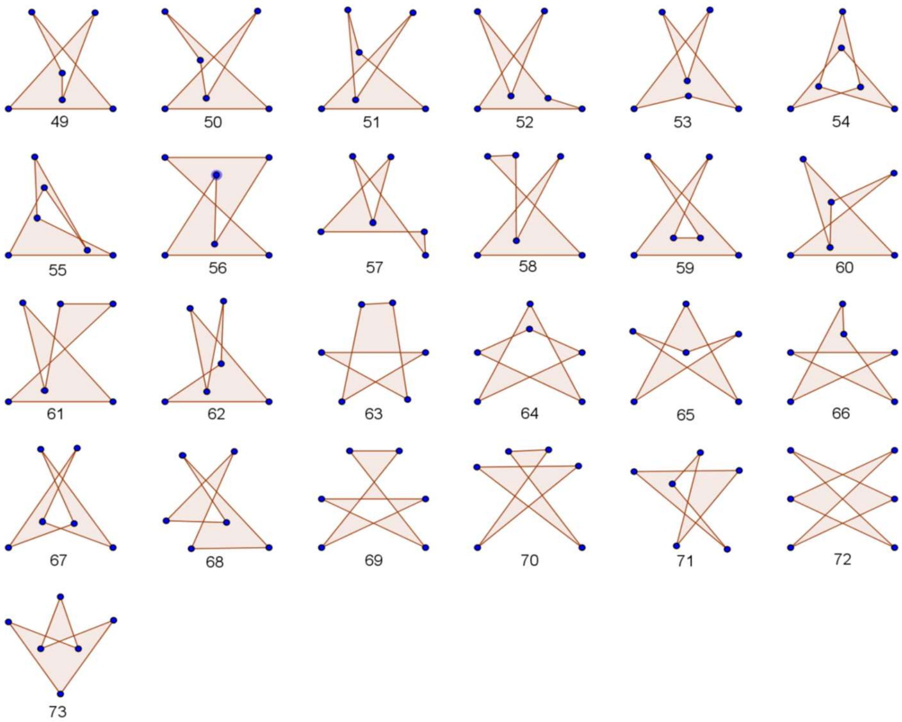


Figure 2

Before proving what has been established about hexagons, it’s necessary to introduce some new elements.

4 The kind of a polygon

The *direction* of a polygon P is established when we choose one of the two possible driving ways of P; so we a have an *oriented polygon*. In an oriented n-gon $P = P_1P_2 \ldots P_n$ we introduce a *hatching* immediately on the left of the sides of P. The *internal angle* related to the vertex P_i is the one put where the hatching is. In figure 3 we see the pentagon P with its different hatchings.

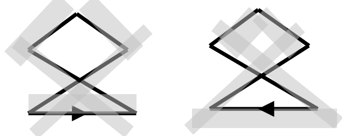


Figure 3

If J is the sum (expressed in radiant) of all internal angles and k is the number of reflex ones, we define:

$$a = \frac{n\pi - J}{2\pi} \quad , \quad a' = a + k = \frac{n\pi - J}{2\pi} + k \,,$$

where a is the *kind of P according to Wiener* and a' is the *kind of P according to Hess* (Brusotti, 1936).

Obviously J may assume two different positive values for every n-gon P, depending on the chosen direction: we select the value of J corresponding to the minimum value of k. We denote with h the number of self-intersection points (*knots*) of P (Togliani, 2001). A polygon divides the plane into an unlimited part and one or more limited ones, called *cells*. Clearly a simple polygon has one cell. Now we attribute the 5-tuple (h, a, a', k, J) to every hexagon in figure 2, as shown in the following table.

hex	*h*	*a*	*a'*	*k*	*J*	hex	*h*	*a*	*a'*	*k*	*J*
1	0	1	1	0	4π	**2**	0	1	2	1	4π
3	0	1	3	2	4π	**4**	0	1	3	2	4π
5	0	1	3	2	4π	**6**	0	1	4	3	4π
7	0	1	4	3	4π	**8**	0	1	4	3	4π
9	1	0	4	4	6π	**10**	1	0	3	3	6π
11	1	0	3	3	6π	**12**	1	0	3	3	6π
13	1	0	4	4	6π	**14**	1	0	4	4	6π
15	1	0	2	2	6π	**16**	1	0	2	2	6π
17	1	0	3	3	6π	**18**	1	0	2	2	6π
19	1	0	3	3	6π	**20**	1	0	3	3	6π
21	1	0	2	2	6π	**22**	1	0	3	3	6π
23	1	2	2	0	2π	**24**	1	2	2	0	2π
25	1	2	3	1	2π	**26**	1	2	3	1	2π
27	1	2	3	1	2π	**28**	1	2	3	1	2π
29	2	1	3	2	4π	**30**	2	1	2	1	4π
31	2	1	3	2	4π	**32**	2	1	2	1	4π
33	2	1	3	2	4π	**34**	2	1	3	2	4π
35	2	1	3	2	4π	**36**	2	1	2	1	4π
37	2	1	3	2	4π	**38**	2	1	3	2	4π
39	2	1	3	2	4π	**40**	3	0	3	3	6π

41	3	0	3	3	6π	**42**	3	2	2	0	2π
43	3	2	2	0	2π	**44**	3	2	2	0	2π
45	3	2	2	0	2π	**46**	3	2	3	1	2π
47	3	2	2	0	2π	**48**	3	2	2	0	2π
49	3	2	3	1	2π	**50**	3	2	3	1	2π
51	3	2	3	1	2π	**52**	3	2	3	1	2π
53	3	2	3	1	2π	**54**	3	2	2	0	2π
55	3	0	3	3	6π	**56**	3	0	3	3	6π
57	4	1	3	2	4π	**58**	4	1	3	2	4π
59	4	1	3	2	4π	**60**	4	1	3	2	4π
61	4	1	3	2	4π	**62**	4	1	3	2	4π
63	5	2	2	0	2π	**64**	5	2	2	0	2π
65	5	2	3	1	2π	**66**	5	2	3	1	2π
67	5	0	3	3	6π	**68**	5	0	3	3	6π
69	6	1	3	2	4π	**70**	6	1	3	2	4π
71	6	1	2	1	4π	**72**	7	0	3	3	6π
73	3	0	3	3	6π						

Table 1

5 The classification of hexagons

With reference to previous observations, it's now possible to demonstrate the following theorems.

Theorem 1 - *The hexagon 73 in figure 2 has a form different from other ones in the same figure.*

Proof. The hexagons number 40, 41, 55, 56 are the only ones having the same 5-tuple (3, 0, 3, 3, 6π) of the hexagon 73; so 73 might have the same form of one of them. But 40 and 41 are excluded because they have only triangular cells. Moreover, for passing from hexagon 55 (or 56) to hexagon 73 using a continuous transformation, it's necessary to pass through a form of a non-ordinary hexagon, as shown in figure 4. Furthermore, 73 has two consecutive sides without knots, contrary to what happens in 55.

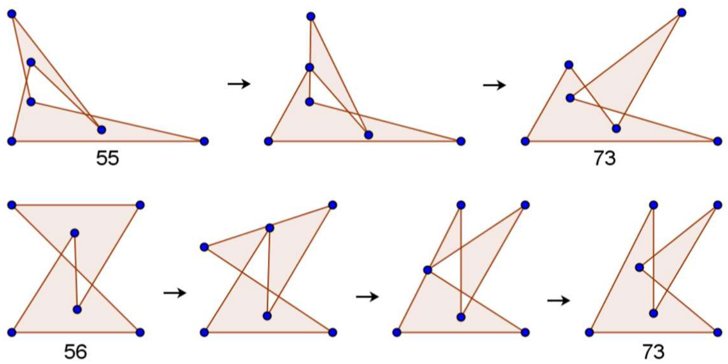


Figure 4

The open problem of classifying hexagons is closed by the following statement.

Theorem 2 – *The hexagon 73 represents the last possible form for hexagons; therefore T(6) = 73.*

To prove this theorem, it's necessary to introduce a new definition. Given the *n*-gon *P*, we call *basic graphic operations* the following ones:

a) *dulling* of a vertix P_i , using a secant straight line crossing the sides [P_{i-1}, P_i] and [P_i, P_{i+1}] in *Z* and *Z*' respectively;

b) *bending* of a side [P_i, P_{i+1}], substituting [P_i, P_{i+1}] for two new sides [P_i, *Z*] and [*Z*, P_{i+1}], where *Z* is a point of the plane not belonging to *P*;

c) *extension* of the sides [P_{i-1}, P_i] and [P_i, P_{i+1}] substituting them for [P_i, *Z*] and [*Z'*, P_{i+1}] and introducing the new side [*Z*, *Z'*], where *Z* and *Z'* are points of the plane not belonging to *P*.

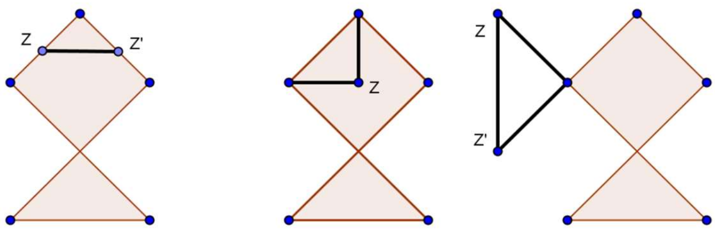


Figure 5

Proof. Each basic graphic operation allows the *n*-gon *P* to transform itself into the (*n*+1)-gon *P'*. It's not difficult to prove that using the three basic graphic operations in every possible way we can obtain all forms of hexagons starting from all forms of pentagons. Then $T(6) = 73$; in other words, starting from all the 11 forms of pentagons it's possible to obtain all the 73 forms of hexagons and no other one. q.e.d.

The introduction of the basic graphics operations is very important because it allowed me to obtain the 73rd form of the hexagon in several different ways. In figure 6 some of these ways are represented, using only the operation of bending a side.

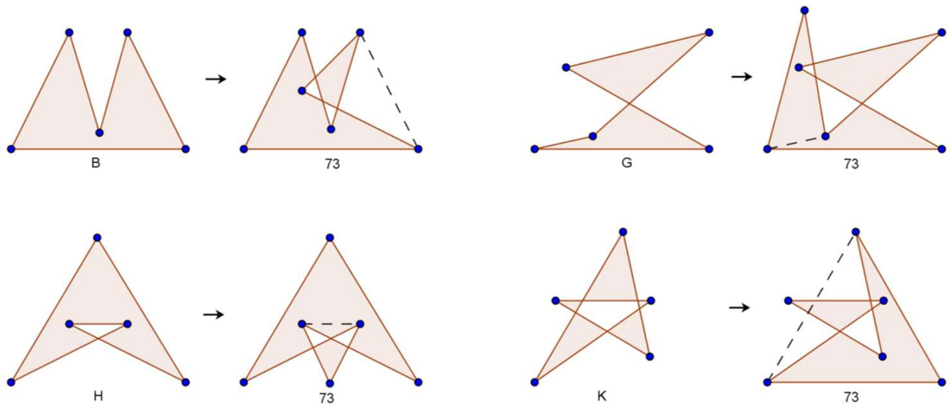


Figure 6

6 Forms of simple polygons

Let's reduce the problem of classifying polygons considering only simple ones. Now the question is: what is the number $S(n)$ of forms of simple n-gons for every $n > 2$? The problem is solved for $n = 3, 4, 5, 6$; among the well-known forms of n-gons we can only consider the simple ones and consequently we have: $S(3) = 1$, $S(4) = 2$, $S(5) = 4$, $S(6) = 8$ (figures 1 and 2).

In the research of forms of simple heptagons, octagons and nonagons I used the graphic operations of dulling and bending and also a "label" attributed to every polygon. Essentially the difference between two forms of n-gons is due to the number and to the position of their reflex angles. The *label* of a form of a simple n-gon is a sequence of n bit attributed to the interior angles of the n-gon: 0 for every reflex angle and 1 for every convex one. For example, the forms of the heptagons labelled with 0011111 and 0110111 are different: both have 2 reflex angles but these angles are differently positioned (figure 7). Obviously the label 0011111 is equivalent to other ones: 0111110, 1001111, 1111100 … ; they are all related to the same form of the heptagon.

In figures 7, 8 and 9 are respectively represented the forms of simple heptagons, octagons and nonagons found in my research. So we may conjecture that the numbers of their forms are $S(7) = 13$, $S(8) = 24$, $S(9) = 39$.

I tried to investigate simple decagons and I obtained 68 different forms. But I am not sure that this number is right. However, it's interesting to note that the found values of $S(n)$ i.e. 1, 2, 4, 8, 13, 24, 39, 68 are the same of the beginning of the sequence A096573 in Sloane's *The On-Line Encyclopedia of Integer Sequences* (https://oeis.org/A096573).

7 Conclusion and outlook

The basic graphic operations permit us to solve the problem of classifying hexagons: $T(6) = 73$. But what about the forms of heptagons? Using the same graphics operations and starting from the 73 forms of hexagons I tried to produce forms of heptagons, but the outcome was discouraging: with the only operation of dulling – used in part – the number of heptagons exceeded 200. So the basic graphic operations appear ineffective if we want to classify n-gons with $n > 6$.

Furthermore: how many forms of simple n-gons are there for every $n > 2$? This open problem can be graphically solved using only two basic graphic operations for small values of n; but for $n > 10$ the problem appears to be too arduous. However, the question seems to be also a combinatorial one if we associate an appropriate sequence of bit to every form of n-gon. Probably this second way to approach the problem might have interesting future developments.

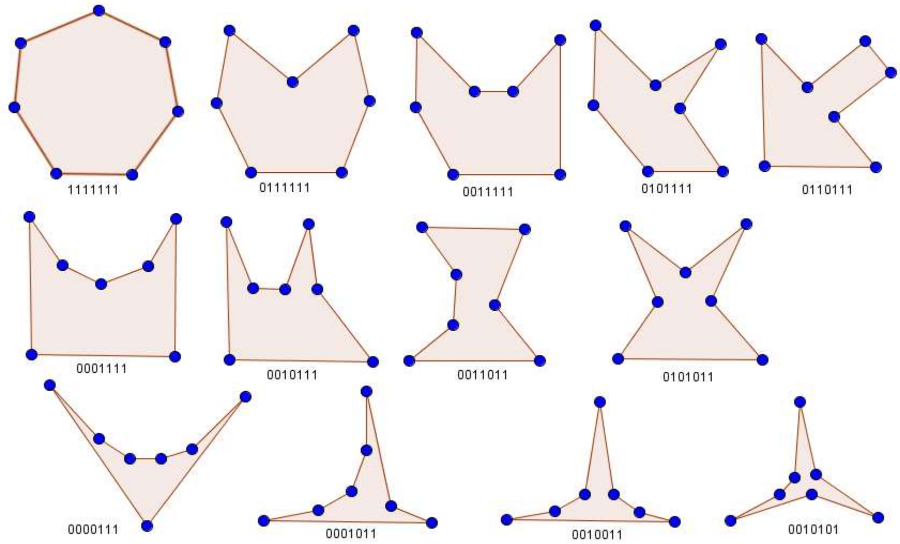


Figure 7. Forms of simple heptagons.

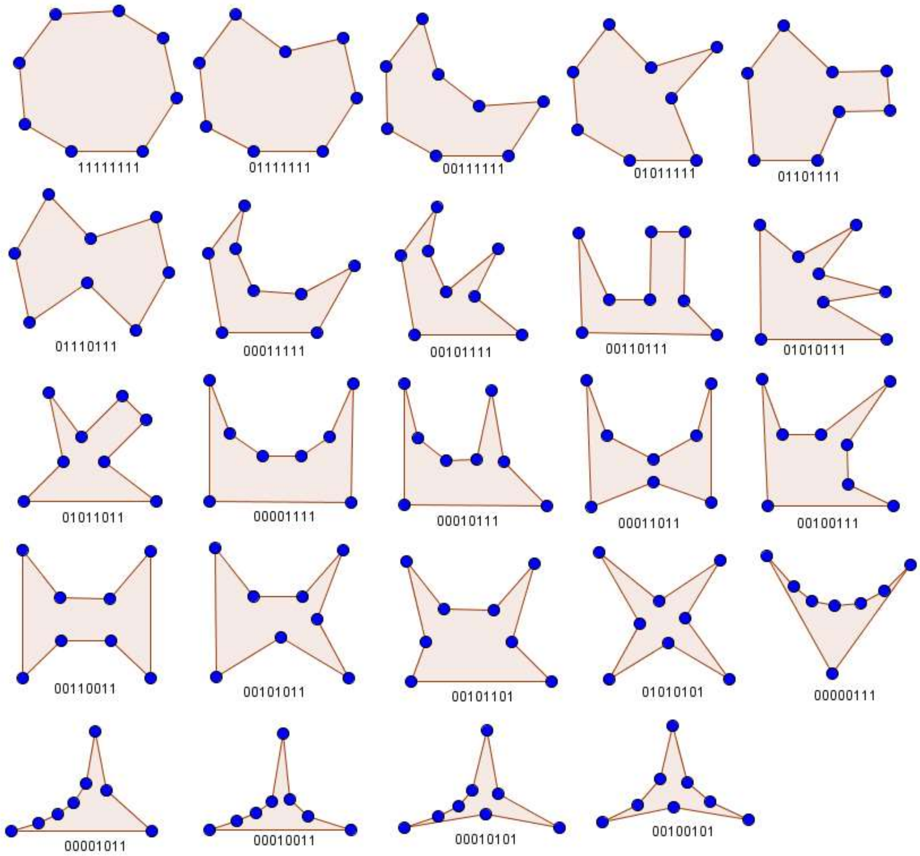


Figure 8. Forms of simple octagons.

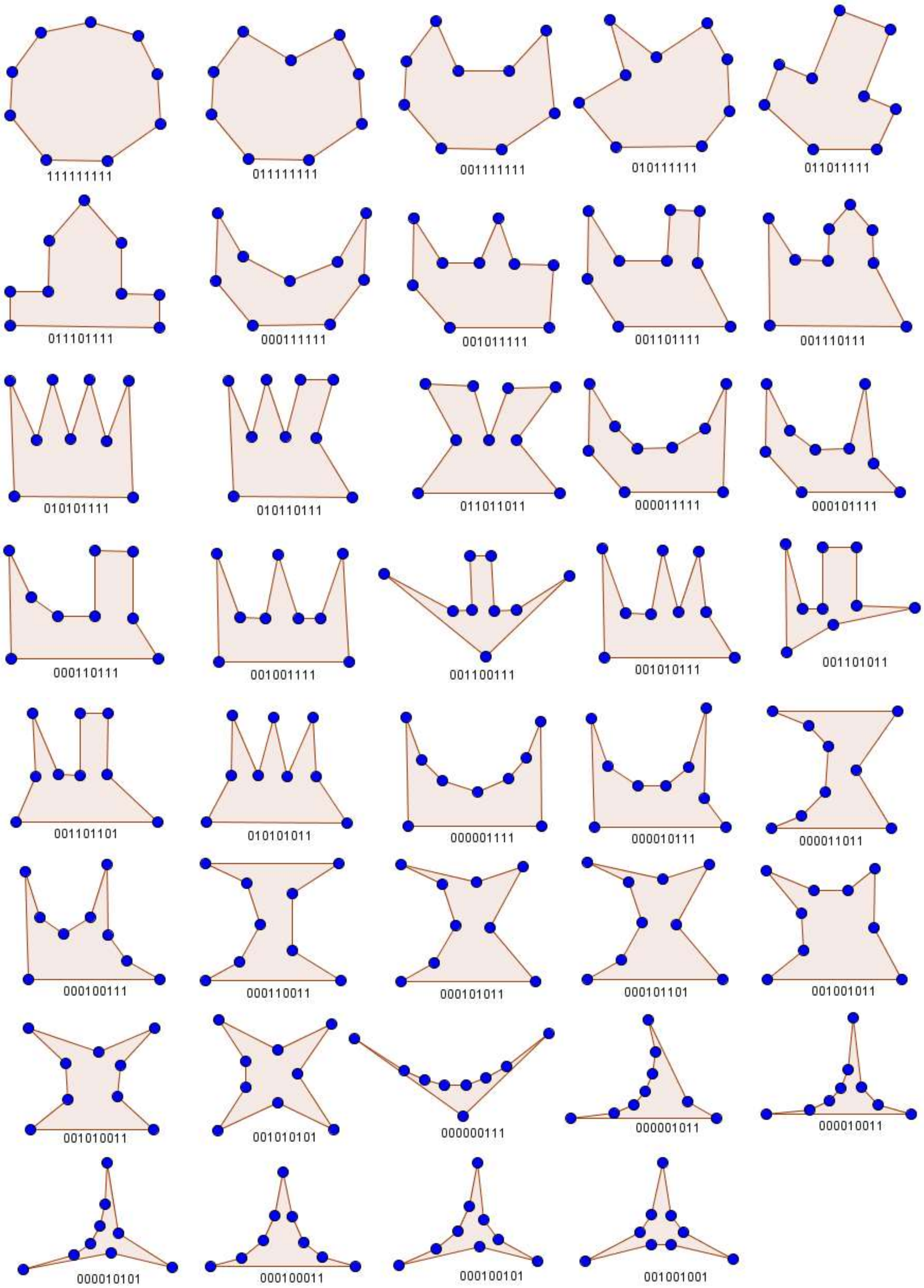


Figure 9. Forms of simple nonagons.

References

[1] Brusotti, L. (1936). "Poligoni e poliedri". Enciclopedia delle matematiche elementari, II, 259-320.

[2] Fitzpatrick, R. (2008). Euclid's Elements of Geometry. http://farside.ph.utexas.edu/Books/Euclid/Elements.pdf ; last access: 2018-07-05.

[3] Girard, A. (1626). Tables de sinus, tangentes & secantes. A la Haye: Ed. Iacob Elzevir.

[4] Grünbaum, B. (1975). "Polygons". Lecture Notes in Mathematics - The Geometry of Metric and Linear Spaces, 490, 147-184.

[5] Grünbaum, B. (2012). "Polygons: Meister was right and Poinsot was wrong but prevailed". Beiträge zur Algebra und Geometrie / Contributions to Algebra and Geometry, 53, 57–71.

[6] Sloane, N.J.A., editor (2018), The On-Line Encyclopedia of Integer Sequences, https://oeis.org; last access: 2019-06-28.

[7] Steinitz, E. (1916). "Polyeder und Raumeinteilungen". Encyklopädie der mathematischen Wissenschaften, Band III, 12, 3-14.

[8] Togliani, L. (1978). "Morfologia degli esagoni piani". Archimede, 30 (4), 201-210.

[9] Togliani, L. (2001). "Nodi di un poligono piano". Lettera Matematica Pristem, 39-40, 73-77.

Science & Philosophy Volume 7(2), 2019, pp. 83-112

Is the golden section a key for understanding beauty? Part III (La sezione aurea è una chiave per la comprensione del bello?) Parte III

Franco Eugeni*
Luca Nicotra°

Abstract♥
Our goal is to prove that the golden section, however important, is not the only key to understand a mathematical-formalizing approach to the idea of beauty. Having developed, from this point of view, reading keys linked to the post-modern, it is necessary to link together the multiple rivulets of knowledge that gather in this direction. Moreover the canons of the approaches presented up to now are very indicative for the understanding of many aspects of beauty, which however depends on the historical moment and the cultures created in the various civilizations. Therefore we can affirm that there is no effective definition of "beauty" that can be codified through fixed canons, but that the concept is expressed by a series of stratifications and interpretations that tend to link several major variations, expressing the various answers given by man to the question: what is the beauty?

Keywords: Golden section, golden number, beauty, golden rectangle, fractals.

---

* Teramo University. Full Professor of Logics and Science Philosophy,Teramo, Italy; eugenif3@gmail.com.
° Cultural Association "Arte e Scienza", President. Mechanical Engineer and Editor in charge of the *ArteScienza* magazine, of the *Bollettino dell'Accademia di Filosofia delle Scienze Umane* magazine and of the *Periodico di Matematica* magazine, Rome, Italy; luca.nicotra1949@gmail.com.
♥ Received on June 29th, 2019. Accepted on August 28th, 2019. Published on December 31th, 2019. doi: 10.23756/sp.v7i2.470. ISSN 2282-7757; eISSN 2282-7765.

Sunto

Nostro obiettivo è provare che la sezione aurea, per quanto di importanza notevole, non è l'unica chiave per comprendere un approccio matematico-formalizzante dell'idea di bellezza. Essendosi sviluppate, da questo punto di vista, chiavi di lettura legate al post-moderno, occorre legare tra loro i molteplici rivoli di saperi che si addensano in questa direzione. Inoltre i canoni degli approcci fino ad oggi presentati sono molto indicativi per la comprensione di numerosi aspetti della bellezza, che però dipende dal momento storico e dalle culture createsi nelle varie civiltà. Pertanto possiamo affermare che non esiste una effettiva definizione del "bello" che possa essere codificata attraverso canoni fissi, ma che il concetto si esprime con una serie di stratificazioni e interpretazioni che tendono a collegare fra loro numerose varianti principali, esprimenti a loro volta le varie risposte date dall'uomo alla domanda: cosa è il bello?

Parole chiave: Sezione aurea, numero aureo, bellezza, rettangolo aureo, frattali.

12 La sezione aurea non basta più! Tra bellezza e stupore: matematica e idee

Molti cultori di quella matematica connessa con la "divina proporzione"coltivano l'idea di un "canone estetico" incentrato appunto sull'idea di regolarità delle forme e quindi, sostanzialmente, di misura.

L'idea nasce con Luca Pacioli nella sua opera *De Divina Proportione.* A Pacioli fece seguito la scuola neoplatonica/neoplotiniana fiorentina alla quale aderirono personaggi come Marsilio Ficino e altri, che influenzarono i grandi pittori del tempo (Sandro Botticelli, Raffaello Sanzio, Michelangelo Buonarroti) che della divina proporzione fecero uso continuo nelle loro opere. Ma se ben osserviamo le opere prodotte ai tempi del barocco, è facile accorgersi che la bellezza si è allontanata da quell'idea della affannosa ricerca della regolarità, in quanto già da allora si inizia a pensare che il "senso del bello" sia molto di più della regolarità e quindi presente anche in quelle forme ove le non-regolarità non appaiono chiaramente espresse e talvolta addirittura non esprimibili.

Con l'avvento del post-moderno nascono idee nuove e con esse numerosi oggetti. Tali oggetti, oramai tutti codificabili in sequenze binarie e quindi facilmente trasportabili e accessibili via Internet, nascono dalle idee trasferite in scritti, dalle immagini, dalle irregolarità, dalla confusione o se si vuole dall'interesse causato da certi prodotti della cultura, siano essi di natura musicale, filmica, poetica o letteraria, specie quando esse tendono a sfuggire sia al controllo degli esperti sia alle analisi di mercato e al controllo della qualità. Spesso accade, misteriosamente, che tra due prodotti di uno stesso genere, di qualità press'a poco equivalente, uno sbanca sul mercato, l'altro è destinato a prematura sparizione. Tale fenomeno è ben noto[94] come *Effetto formicaio*. Spesso è il primo prodotto a essere giudicato bello mentre il secondo non è giudicato tale, indicando una identità, tipica del mondo attuale, tra l'essere bello e l'essere accettato dalla massa.

Cominciamo, in questo paragrafo, a parlare delle idee, le belle idee[95] che si traducono in fatti concreti.

Vogliamo, per questo, occuparci in primo luogo, del cosiddetto *principio del cassetto* (*pigeonhole principle*) e di qualche sua applicazione. Anche se molto semplice, l'uso di questo principio esprime molto bene il modo di ragionare della matematica discreta, traducibile anche in amabili osservazioni salottiere. Spesso, per illustrare con una rapida battuta il modo di ragionare della combinatoria, si parla del *principio del pecoraio*: se vuoi contare le pecore del gregge, conta le zampe e dividi per quattro. La battuta, che esprime una specie di assurdità, è sicuramente di buon effetto, esprime il fatto che si può contare anche in modi impensabili.

Il nome inglese *pigeonhole principle* deriva dal fatto che se un certo numero di piccioni vogliono appollaiarsi sopra un certo numero di trespoli (o entrare in certi cassetti) in numero minore dei piccioni stessi, allora almeno su un trespolo ci saranno almeno due piccioni. La validità del principio è dunque ovvia, e nulla deve essere provato. Esemplifichiamo.

Problema 1 - In ogni insieme di 13 o più persone, almeno due compleanni cadono nello stesso mese.

Se le persone sono i piccioni (in numero di 13) e i trespoli sono i mesi (in numero di 12) due persone sono nello stesso trespolo-mese!

Problema 2 - In ogni insieme di 366 o più persone, almeno due sono nate lo stesso giorno.

Le persone-piccioni sono 366 e i giorni-trespoli sono 365 in un anno.

---

[94] Franco Eugeni, Ezio Sciarra, Raffaele Mascella, *Matematica ed Arte: il senso del bello*, in TABULARIA A.MMX (S.S.Quator Coronatorum),"academia" editrice d'Italia e San Marino, 2010.

[95] Le idee contenute in questo paragrafo e le formule riportate nel paragrafo successivo sono riprese, in forma semplificata, da: Franco Eugeni, *Le due rivoluzioni matematiche del Secolo: da Bourbaki alla matematica del discreto*, dedicato dall'Autore al padre, prof. Carlo Eugeni, nel giorno del suo 80° compleanno, «Periodico di Matematiche», Serie VI, Vol 68, N1, Roma, (1981) pp.3-21.

Problema 3 - In ogni insieme di un milione di persone, almeno due hanno lo stesso numero di capelli.

Basta sapere che ogni persona-piccione ha meno di un milione di capelli.

E ora qualcosa di più difficile.

Problema 4 - In ogni insieme di 12 numeri (distinti) ne esistono almeno due la cui differenza è divisibile per 11.

Siccome il resto della divisione di un numero positivo per 11 è un numero tra 0 e 10, almeno due dei numeri dati hanno Io stesso resto. Ciascuno di questi due è un multiplo di 11 più un reso eguale per entrambi. Segue che la differenza dei due, eliminati i resti è un multiplo di 11. In formule siano a e b (con a>b) i due numeri che divisi per 11 hanno eguale resto r, allora risulta a= 11 h+r e b=11 k + r , da cui a – b = (h – k) 11.

Molte problematiche di tipo combinatorio possono essere presentate in modo salottiero anche quando la matematica sottogiacente non è semplice. Può essere interessante consultare volumi dedicati alla Matematica Discreta, ove appare il principio del doppio conteggio.[96]

Concludiamo questo paragrafo con un ulteriore principio noto con il nome di *principio del doppio conteggio*.[97]

Dati due insiemi finiti A e B, vogliamo contare gli elementi di una parte R dell'insieme delle coppie ordinate che come è usuale si denota con A X B. Possiamo contare per questo il numero N delle coppie di R nei seguenti due modi diversi:

Si fissi l'elemento x nell'insieme A. Denotiamo con N (x, —) il numero delle coppie di R, aventi x al primo posto. Allora N = ∑ N (x, —) somma estesa al variare di x in A.

Nell'insieme Si fissi y ε B. Denotiamo con N (—, y) il numero delle coppie di R, aventi y al secondo posto. Allora N = ∑ N (—, y) somma estesa al variare di y in B.

Vediamo alcuni esempi applicativi.

Problema 5 - Calcolare il numero dei lati di un cubo tridimensionale.

[96] Vedasi ad esempio Mauro Cerasoli, Franco Eugeni, Marco Protasi, *Elementi di Matematica Discreta*. Bologna, Zanichelli, 1988.
[97] Ibidem.

Sia F l'insieme delle 6 facce ed S l'insieme degli spigoli di cui si vuole trovare il numero s. Sia R l'insieme delle coppie faccia-spigolo appartenentisi in numero di N. Risulta:

N (x, —) = 4 (ogni volta che x è fissato in F)
N = ∑ N (x, —) = 24 (somma estesa al variare di x in A)
N (—, y) = 2 (ogni volta che y è fissato in S)
N = ∑ N (—, y) = 2 s (somma estesa al variare di y in B).

Dall'eguaglianza 24 = N = 2s segue s = 12.

Naturalmente questo numero si poteva stabilire anche, e facilmente, contando gli spigoli su un modello, anche mentale, di cubo, ma la cosa non è così banale nel caso che segue:

Problema 6 - Calcolare il numero dei vertici e degli spigoli di un dodecaedro regolare.

Il dodecaedro ha 12 facce pentagonali. Sia F l'insieme delle f = 12 facce pentagonali del dodecaedro e sia S l'insieme degli spigoli di cui si vuole trovare il numero s. Sia R l'insieme delle coppie faccia-spigolo appartenentisi in numero di N. Risulta:
N (x,—)= 5 (ogni volta che x è fissato in F), N(-,y)= 2(ogni volta che y è fissato in S)
Dunque:

N = ∑ *N* (*x*, —) = 12x5 = ∑ *N* (—, *y)* = 2x s da cui s = 30.

Sia ora V l'insieme dei vertici in numero di v. Contiamo le coppie vertice-spigolo appartenentisi. Per ogni vertice passano tre spigoli. Per ognuna delle 12 facce ci sono 5 spigoli. Allora:

*N (*x,—)= *3* (ogni volta che x è fissato in V), N(-,y)= 3*(*ogni volta che y è fissato in S)

N = ∑ *N* (*x*, —) = vX3 = N = ∑ *N* (—, *y)* = 12X5 da cui v = 20.

Problema 7 - Su un pallone da football ci sono disegnati un insieme P pentagoni ed un insieme E di esagoni. Ogni pentagono ha un lato comune con un esagono. Ogni esagono ha tre pentagoni e tre esagoni adiacenti. Sapendo che sul pallone ci sono 12 pentagoni, vogliamo sapere il numero degli e esagoni.

Si ha per le coppie penta-esagoni adiacenti N (x,-) = 5 e N (-, y)=3, da cui 12X 5 = 3Xe, da cui e = 20.

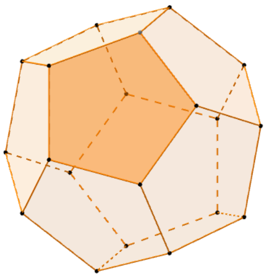


Figura 38 – Dodecaedro regolare.

Il paradosso del compleanno afferma che la probabilità che due persone in un gruppo compiano gli anni lo stesso giorno è largamente superiore a quanto potrebbe dire l'intuito! In tale caso il termine paradosso non è da intendersi nel senso di una contraddizione logica (antinomia), ma nel senso che la verità matematica contraddice l'intuizione naturale. Fu il matematico austriaco Richard Von Mises (1983-1953) che nel 1939, quando era ad Harvard, propose il problema nella interessante forma: *quante persone ci devono essere in una stanza perché la probabilità che due di loro siano nate lo stesso giorno sia maggiore del* 50% ? Si è calcolato che la probabilità $P(n)$ che due persone in un gruppo di n perone abbiano lo stesso compleanno è:

P(n) = $365!/365^{n}(365-n)!$
$P(23)$ = circa 51%;
$P(30)$ = circa 70%;
$P(50)$ = circa 97%;
$P(366)$ = 100% .

13 La sezione aurea non basta più! Tra bellezza e stupore: matematica e formule

Diceva il grande matematico britannico Godfrey Harold Hardy (1877 – 1947), che ha presentato al mondo il genio indiano Srinivasa Ramanujan (1887-1920):

> Le forme create dal matematico, come quelle create dal pittore o dal poeta, devono essere "belle"; le idee, come i colori o le parole,

> devono legarsi armoniosamente. La bellezza è il requisito fondamentale: al mondo non c'è un posto perenne per la matematica brutta.[98]

Si parla di "belle formule" in matematica. Regina delle formule è considerata l'identità di Eulero:

(21) $$e^{i\pi} = -1$$

che collega, misteriosamente, ma non tanto, i due numeri trascendenti e naturali allo stesso tempo: e , π con le due importanti unità, il numero 1 e l'unità immaginaria i. La formula è una meraviglia, ma comprensibile ai soli esperti.

È interessante introdurre le seguenti considerazioni sui numeri e , π e chiedersi: perché taluni li chiamano "naturali", assimilandoli quasi agli oggetti del contare? Molti rispondono a tale domanda affermando che essi si trovano in natura, proprio come la sezione aurea.

Per il numero e vi proponiamo un esperimento: prendete due chiodi, con un martello inchiodateli al muro, a una ugual distanza dal suolo e con una fissata distanza tra loro, per esempio 30 cm.

Prendete ora una catena di lunghezza superiore ai 30 cm. Ad esempio 40 cm, e appendetene gli estremi ai due chiodi predisposti al muro. Si disegna una curva che sembra avere l'apparenza di una parabola, ma che una parabola non è! Si tratta di una curva speciale denominata catenaria, che è data dalla formula :

(22) $$y = \frac{e^{x} + e^{-x}}{2} = \cosh x$$

che è anche l'ovvio luogo dei punti medi (figura 39) delle due funzioni esponenziali:

(23) $$y = e^{-x} \qquad y = e^{x}$$

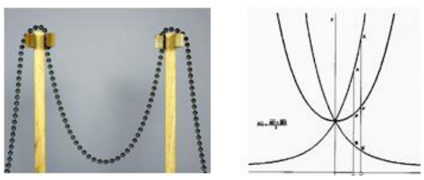


Figura 39 - La catenaria luogo dei punti medi.

[98] Godfrey Harold Hardy, *Apologia di un matematico*. Trad. Luisa Saraval, Milano, Garzanti, 1989.

La catenaria in letteratura è nota come *coseno iperbolico* dell'arco di $\boldsymbol{x}$ radianti.

È interessante notare che così come il punto (*cos x, sen x*) descrive la circonferenza di equazione $x^2 + y^2 = 1$, in modo del tutto analogo il punto (*cosh x, senh x*), descrive l'iperbole equilatera di equazione $x^2 - y^2 = 1$, fenomeno incredibilmente bello per questa regolarità asimmetrica!

Più semplice forse comprendere perché sia considerato naturale il numero π, forse per il fatto che esprime il rapporto costante tra una qualsiasi circonferenza e il suo diametro!

Infatti prendiamo in esame un poligono regolare di n lati iscritto in una circonferenza di raggio R. Il lato AB di tale poligono è la base di un triangolo isoscele che è simile all'analogo triangolo di una differente circonferenza di raggio R' avente per lato il segmento $A'B'$. Risulta chiaramente

(24) $$AB : R = A'B' : R'$$

ovvero:

(25) $$n\,AB : 2R = n\,A'B' : 2\,R'$$

che esprime il fatto che il rapporto tra la lunghezza di un qualsiasi poligono regolare iscritto in una qualsiasi circonferenza al diametro della stessa è costante.[99] Come caso limite (o ragionando su opportune classi contigue di poligoni iscritti e circoscritti) implica la costanza (o meglio l'indipendenza dal raggio) del rapporto d'una circonferenza al suo diametro.

Un cenno a un singolare autore del ventennio fascista, Dino Segre (1893-1975),[100] in arte Pitigrilli[101] è opportuna. Una interessante formula matematica

[99] Ragionando a posteriori e supposto di aver già definito π, osserviamo che il lato del poligono regolare di n lati iscritto in una circonferenza di raggio R vale $AB = 2R\cos(\pi/n)$. Ne segue che la costante del rapporto tra poligono di n lati al diametro della circonferenza che lo circoscrive vale $nAB/2R = n\cos(\pi/n)$.

[100] Dino Segre è stato un interessante personaggio del periodo del ventennio fascista. Fu Direttore e fondatore, dal 1924, della rivista satirica «Le grandi Firme», spesso finito in tribunale per oscenità, ma fortemente protetto dall'OVRA come ricordato in Domenico Zugaro, *Lettere di una spia*, Milano, Sugar Ed., 1977. Nel 1938 la rivista fu soppressa per motivi razziali. Fu difeso e assolto nel 1940 da Edvige Mussolini, sorella del duce, per una accusa di antifascismo e tra il 1943 e il 1947 riparò in Svizzera con la moglie Lina Furlan e il figlio Pier Maria Furlan, futuro cattedratico in psichiatria a Torino.

[101] Siamo nel filone degli anni '20, ove opere simili alimentarono l'interesse di un pubblico moderno e smaliziato alla ricerca di *boutades* e giochi di parole evoluti e destinati ad avere successo nel tempo ma anche di colta spregiudicatezza. Opere del genere, considerate pornografiche, furono scritte, ad esempio, dall'antifascista Mario Mariani (1884-1951) e dall'israelita Guido da Verona (1881-1939), iniziatore del romanzo d'appendice in Italia e

molto bella è quella che porta il suo nome,[102] formula che codificherebbe un rapporto numerico ideale tra le età di un uomo e di una donna prossimi a nozze. Se indichiamo rispettivamente con D e U queste età, la formula è: $D = U/2 + 7$, che conduce alla tabella 1, piuttosto maschilista.

Peccato che tale formula, pur essendo molto gradita al pubblico maschile,[103] non ha alcun valore scientifico ed è del tutto inventata, quale perfetto atto di umorismo.

Tabella 1	
Età uomo U	Età donna D
30	22
40	27
50	32
60	37
70	42

In un lavoro[104] di Franco Eugeni, dove è riportata la formula di Pitigrilli, si asserisce che: «chiunque si sia interessato di divulgazione matematica conosce il magico potere che hanno le formule sul pubblico non specialistico». Naturalmente queste formule devono avere alcune caratteristiche:

- devono essere corte;

---

definito il «D'Annunzio delle sartine e delle manicure». Da notare che tali opere venivano lette nascostamente dagli adolescenti, dalle signore e dai signori del tempo ed erano ad alta tiratura.

[102] Umberto Eco nel suo *Diario Minimo* gli dedica un interessante capitolo dal titolo "Pitigrilli l'uomo che fece arrossire la mamma" per via dei suoi due romanzi *Cocaina* (1921) e *Dolicocefala Bionda* (1936), caratterizzati da un umorismo a sfondo erotico, per questo considerati scandalosi al tempo, ma che oggi farebbero appena sorridere un'educanda. Tra le numerosissime opere di Pitigrilli ricordiamo in particolare *Mammiferi di lusso* (1920), *La cintura di castità* (1921), *Oltraggio al pudore* (1922) *La vergine a diciotto carati* (1924), e dopo tanti altri volumi, oltre cinquanta, delle sue *Short Stories*, raccolte di racconti graffianti, di costume, critici della società, umoristici che riletti oggi sono uno specchio significativo di una società borghese ricca, ipocrita, egoista descritta da uno scrittore brillante, egocentrico e deluso pubblicati, dal 1920 a dopo la guerra e ristampati in molteplici edizioni.

[103] Narra Dino Segre (Pitigrilli) in *Sette Delitti* (1971), uno dei suoi ultimi volumi, nel quale appare la citata formula (nel racconto *Il Medium*), che quando in qualche sua conferenza presentava la formula, vedeva molti signori sorridenti e incuriositi, estrarre di tasca una penna e annotare, quasi furtivamente la formula in un qualche foglietto apparso dal nulla.

[104] Franco Eugeni, *Le due rivoluzioni matematiche del Secolo: da Bourbaki alla Matematica del discreto*, op. cit., p.3.

- i simboli che intervengono in esse devono essere di ovvia traduzione (codice universale);
- devono presentare un giusto equilibrio tra la simmetria perfetta (di per se noiosa) e la completa casualità (non attraente e addirittura fastidiosa all'occhio).

In altre parole una bella formula fa sempre il suo effetto. Naturalmente "bella esteticamente" parlando, quasi come osservare un disegno di Escher. Osserviamo che in un disegno quasi tutto si vede con l'occhio, mentre in una formula parte si vede con l'occhio e parte con la mente.

Interessante circa le belle formule quella che interviene nel cosiddetto gioco di Wythoff **[105]** (1907), che costituisce un esempio di gioco, strettamente matematico, basato sulla sezione aurea.[106]

Due mucchi di fiammiferi, due giocatori *A* e *B* i quali, a turno, devono prendere i fiammiferi dai mucchi secondo le seguenti regole:

- il giocatore prende fiammiferi, in quantità totalmente arbitraria, da un solo mucchio;
- il giocatore prende fiammiferi, in quantità sempre arbitraria, ma in numero uguale, da entrambi i mucchi;

Domanda: esiste una strategia vincente per A? Affinché il giocatore *A*, che inizia il gioco, vinca è sufficiente che lasci le seguenti quantità:

(1, 2), nel primo mucchio

(3, 5), (4, 7), (6, 10), ... nel secondo mucchio

cioè, in generale la relazione fondamentale:

$$([n\Phi]\ ,\ [n\Phi] + n) \qquad (26)$$

dove n è un numero qualunque e $[n\Phi]$ è la parte intera del numero nelle parentesi quadre.

Quindi da una qualunque mossa dell'avversario, *A* si può ricondurre a una quantità dettata sempre dalla stessa legge con n più piccolo. Esplicitando

---

[105] Willem Abraham Withoff (1856-1939) fu un matematico olandese cultore della combinatoria, delle tassellazioni e dei giochi.

[106] Willem Abraham Withoff, *A modification of the game of nim*, Nieuw Archief voor wiskunde, 2 (1905-1907), pp. 199–202. Vedasi anche: Franco Eugeni, Ezio Sciarra, Raffaele Mascella, *Matematica ed Arte: il senso del bello*, ….., op.cit.

adesso la relazione fondamentale si ottengono i casi particolari precedentemente esposti:

$$
(26)' \qquad
\begin{array}{ll}
n = 1 & ([1,61],[1,61]+1) = (1,2) \\
n = 2 & ([3,2],[3,2]+2) = (3,5) \\
n = 3 & ([4,8],[4,8]+3) = (4,7) \\
n = 4 & ([6,4],[6,4]+4) = (6,10) \\
n = 5 & ([8,0],[8,0]+5) = (8,13) \\
n = 6 & ([9,6],[9,6]+6) = (9,15)
\end{array}
$$

e così via.[107]

14 La sezione aurea non basta più! Tra bellezza e verità: fisica e formule

Il gusto estetico ha influenzato la ricerca scientifica e, in qualche caso, l'ha soccorsa nel suo cammino. Nella scienza, la simmetria è associata spesso all'idea di bellezza. Nella fisica, in particolare, la ricerca della simmetria nei fenomeni naturali ha sortito risultati notevoli.

Un primo esempio clamoroso è fornito dalle ricerche sui fenomeni magnetici ed elettrici compiute nel secolo XIX dal grande fisico sperimentale Michael Faraday (1791-1867) e dal grande matematico e fisico teorico James Clerk Maxwell (1831-1879).

Faraday nel 1831 scopri sperimentalmente che un campo magnetico variabile genera un campo elettrico. Nel 1865 Maxwell riprese e formalizzò matematicamente in maniera simmetrica l'idea di Faraday: un campo elettrico variabile genera un campo magnetico. Una perfetta simmetria di "riflessione" delle leggi fisiche che, prima di scoprire tale simmetria, sembravano riguardare due campi distinti di fenomeni fisici: il magnetismo e l'elettricità.

Proprio grazie a questa simmetria, invece, Maxwell potette legare fra loro nelle sue celebri equazioni, in una interazione reciproca, il campo elettrico e il campo magnetico, unificati in un unico "campo elettromagnetico". Ma cosa intendeva Maxwell per interazione fra campo elettrico e campo magnetico? Un campo elettrico variabile genera un campo magnetico che però, non esistendo nell'istante prima che fosse generato, è variabile e quindi genera un campo

[107] Franco Eugeni - Raffaele Mascella - Daniela Tondini, *Un'applicazione del calcolo binario: il gioco del Nim*, www.apav.it/master/gioconim.pdf.

elettrico. Ma il campo elettrico così generato si va ad aggiungere a quello preesistente e, provenendo anch'esso da una situazione in cui non esisteva, è anch'esso variabile e quindi genera un altro campo magnetico variabile che genera un altro campo magnetico variabile e così via. Siamo in presenza di una specie di "reazione a catena", o meglio di un fenomeno autosostenentesi: un campo elettrico variabile genera un campo magnetico variabile che a sua volta genera un campo elettrico variabile, ecc. Questa combinazione di campi elettrici e magnetici variabili, in grado di autosostenersi, costituisce un'onda elettromagnetica perché le perturbazioni dei due campi elettrico e magnetico si propagano nello spazio come un'onda.[108]

Ancora l'irrinunciabile senso estetico della simmetria è alla base della Teoria della Relatività di Albert Einstein (1879-1955). [109]

Le vere ragioni della genesi della Teoria della Relatività sono da ricercare nel subconscio di Einstein e sono state chiaramente espresse da lui stesso: ragioni estetiche, oltre che filosofiche.

Sul ruolo dell'ideale di bellezza nell'opera scientifica di Einstein, così si esprime Banesh Hoffmann:

> L'essenza della profondità di Einstein stava nella sua semplicità; e l'essenza della sua scienza stava nel suo senso artistico, nel suo fenomenale senso della bellezza.[110]

Ma cosa, nella fisica di fine Ottocento, urtava il senso estetico del sedicenne Albert?

Riferendosi al principio di relatività già affermato da Galileo Galilei, ad Einstein sembrava «poco verosimile che un principio così generale, che vale con tanta precisione in un campo di fenomeni, riesca invece fallace in un altro campo».[111] Einstein osservava che il principio di relatività galileiana aveva già una grande generalità, essendo applicabile con successo nel vasto campo dei fenomeni meccanici, terrestri e celesti. Pertanto riteneva inaccettabile che la Natura non lo applicasse a tutti i fenomeni, compresi quelli ottici ed elettrodinamici. Era dunque questa asimmetria nel campo della sua applicabilità che turbava il suo "senso estetico".

Vale la pena soffermarsi su questa genesi della Teoria della Relatività di Einstein, perché coinvolge in un *unicum* indivisibile: subconscio,

---

[108] Luca Nicotra, Il disordine nell'ordine della materia, in «*ArteScienza*», *Anno IV, N. 8*, p. 26.

[109] Luca Nicotra, L'ideale estetico nell'opera dello scienziato, in Luca Nicotra, Rosalma Salina Borello (a cura di) *Nello specchio dell'altro. Riflessi della bellezza tra arte e scienza*, Roma, UniversItalia, 2011, pp. 35-38.

[110] Banesh Hoffmann, *Albert Einstein: creatore e ribelle*, (trad. it.), Milano, Bompiani, 1977, p.3. Riportata anche in Alice Calaprice (a cura di), *Albert Einstein. Pensieri di un uomo curioso*, Milano, Mondadori, 1999, p.176.

[111] Francesco Albergamo, *Storia della Filosofia*, Palermo, Palumbo, 1965, p. 693.

immaginazione e ricerca del bello nel senso più classico di ricerca della regolarità.

Il principio di relatività galileiana (o classica) asseriva che all'interno di un sistema di corpi isolato (cioè non soggetto a forze o soggetto a forze con risultante nulla) non è possibile eseguire alcun esperimento in grado di far capire se il sistema stesso si muove di moto rettilineo uniforme o è in quiete. Il principio afferma l'invarianza delle leggi della meccanica rispetto a qualunque sistema di riferimento in quiete[112] o in moto rettilineo uniforme. Questo principio,valido nella meccanica, non sembrava valido per i fenomeni ottici ed elettromagnetici. Einstein, a sedici anni, con uno di quegli esperimenti ideali (*Gedankenexperiment*) realizzati con la fantasia - da lui coniati e ai quali ricorrerà spesso anche da scienziato - immaginava di cavalcare un'onda luminosa. Ma perché ricorrere a un esperimento ideale, e quale può essere la sua validità? La risposta l'ha data magistralmente il grande fisico teorico Max Planck (1858-1947):

> Un esperimento concettuale non è legato ad alcun limite di precisione, perché i concetti sono più sottili degli atomi e degli elettroni, ed in essi cessa anche il pericolo di un influsso causale dello strumento di misura sull'evento da misurare.[113]

Il giovane Albert immaginava di trovarsi a cavallo di un'onda luminosa e quindi di muoversi con la stessa velocità della luce. Si chiedeva come avrebbe visto il mondo.Una persona in una tale situazione non avvertirebbe più il fenomeno ondulatorio, perché non sarebbe attraversata dall'onda, muovendosi lei stessa rigidamente con questa: la luce scomparirebbe. E ciò accade soltanto quando il corpo si muove con la velocità della luce. Dunque l'esperimento ideale del giovane Einstein mostrava che, in contrasto con il principio di relatività galileiano, era possibile stabilire all'interno del sistema stesso, nell'ambito dei fenomeni ottico-elettromagnetici, se un corpo si muove o sta fermo, mostrando nel caso citato che si muove con la velocità della luce. Una tale esperienza, teoricamente possibile, dimostrerebbe che il principio di relatività classico non sarebbe applicabile ai fenomeni ottico-elettromagnetici. A questa stessa conclusione, qui qualitativamente basata sull'esito dell'esperimento ideale del giovane Einstein, si giunge formalmente verificando il cambiamento delle equazioni di Maxwell nel passaggio da un sistema di riferimento in "quiete"[114] ad uno in moto rettilineo uniforme:

---

[112] Fino all'avvento della Teoria della Relatività di Einstein si postulava l'esistenza di uno spazio assoluto e quindi di una quiete assoluta.

[113] Max Planck, *Scienza, filosofia e religione.* Milano, 1973, Fratelli Fabbri Editori, p.146.

[114] Ovviamente Maxwell fa riferimento ad una quiete assoluta, oggi invece dimostrata inesistente.

ovvero le equazioni di Maxwell valgono soltanto rispetto a un sistema di riferimento in quiete.

Questa conclusione non soddisfaceva il giovane Albert, per il quale invece doveva valere in ogni caso il principio di relatività galileiano, affermando:

> Esempi analoghi, come pure i falliti tentativi di constatare un moto della Terra relativamente al mezzo luminoso [allude probabilmente all'etere dell'esperimento di Michelson. Nota d. A.] conducono alla presunzione che al concetto della quiete assoluta, non solo nella meccanica, ma anche nell'elettrodinamica, non corrisponda alcuna delle proprietà di ciò che si manifesta, ma che piuttosto, per tutti i sistemi di coordinate per i quali valgono le equazioni della meccanica, debbano anche valere le stesse leggi elettrodinamiche ed ottiche.[…] Noi vogliamo elevare questa presunzione (il contenuto della quale verrà detto Principio della relatività) a presupposto fondamentale e inoltre introdurre il presupposto, solo apparentemente incompatibile col *precedente, che la* luce nello spazio vuoto si propaghi sempre con una velocità determinata c indipendente dalla velocità del corpo emittente.[115]

I due esempi citati mostrano che la bellezza nella scienza, identificata nella simmetria è legata alla ricerca della verità in fisica. Essa diventa il *leit motiv* dell'opera scientifica di uno dei fisici più geniali del Novecento, ma taciturno e introverso fino a sfiorare l'autismo: Paul Adrien Maurice Dirac (1902-1984), scopritore dell'antimateria, di cui predisse l'esistenza nel 1928 in base a una sua famosa equazione:[116]

$$(i\gamma^{\mu}\,\partial_{\mu} - m)\,\psi = 0 \qquad (27)$$

Un'altra notazione più compatta molto diffusa utilizza la notazione "a barra" introdotta da Feynman $\not{\partial} \equiv \gamma^{\mu}\partial_{\mu}$; per cui l'equazione di Dirac si scrive come $(\not{\partial} - m)\psi = 0$ ovvero $\not{\partial}\,\psi = m\,\psi$, come è incisa sulla lapide dedicata a Dirac nell'Abbazia di Westminster a Londra (figura 40).[117]

Per Dirac valeva il motto rinascimentale «*pulchritudo splendor veritatis*». Per lo scopritore dell'antimateria laddove c'è bellezza c'è verità. Il principio euristico della ricerca scientifica di Dirac era dunque la bellezza: ricercare la verità in fisica per lui equivaleva a inseguire la bellezza. Ma qual era l'ideale estetico di questo geniale fisico inglese di origine francese? Era l'eleganza di un'equazione. Quando gli chiesero cosa intendesse per eleganza di

---

[115] Albert Einstein, Sull'elettrodinamica dei corpi in moto, in «*Annalen der Physik», 17, 1905*, pp. 891-921. Trad. it. di Paolo Straneo in *Cinquant'anni di Relatività,* Firenze, Marzocco, 1955, pp. 479-504.

[116] Luca Nicotra, L'ideale estetico nell'opera dello scienziato, *Op. cit*., pp. 41-42;

[117] Per il significato e la comprensione dell'equazione di Dirac si rimanda ai testi di fisica teorica.

un'equazione, rispose: «Non posso spiegarlo a chi non conosce la matematica, perché non comprenderebbe; mentre chi conosce la matematica sa già cosa intendo dire».[118]

La bellezza per Dirac era qualcosa che non si poteva "spiegare" ma "sentire", come accadeva a Dante che non sapeva comunicare l'emozione che provava alla vista della sua Beatrice e nel sonetto *Tanto gentile e tanto onesta pare* (*Vita Nuova)* scriveva:

Mostrasi sì piacente a chi la mira,
che dà per li occhi una dolcezza al core,
che 'ntender no la può chi no la prova:

Versi che esprimono in maniera sublime lo stesso pensiero di Dirac. Per fortuna, in altre occasioni, questo originalissimo fisico ha espresso più analiticamente il suo pensiero riguardo alla bellezza in matematica e quindi in fisica: per lui se un'equazione è elegante, prima o poi la teoria fisica sulla quale poggia si rivelerà vera, anche se quell'equazione temporaneamente non riesce a descrivere in maniera soddisfacente la realtà. E questo è proprio quello che è accaduto alla sua famosa equazione che nel 1928 prediceva teoricamente l'esistenza delle antiparticelle molti anni prima della loro scoperta sperimentale: la prima particella di antimateria, il positrone (l'antiparticella dell'elettrone) sarà sperimentalmente rivelata soltanto cinque anni dopo, nel 1933, da Carl David Anderson.

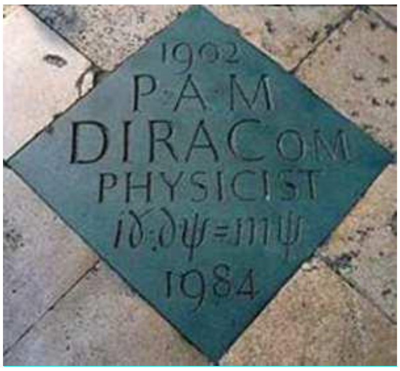


Figura 40 – La formula di Dirac incisa sulla lapide commemorativa di Paul Dirac, inaugurata il 13 novembre 1995 in una navata dell'Abbazia di Westminster (Londra), vicina al monumento dedicato a Newton.

[118] Thomas Kuhn, I*nterview with Dirac*, 7-05-1963, Niels Bohr Archive, Copenhagen, p. 53. Trad. it. in Etienne Klein, *Sette volte la rivoluzione*, Milano, Raffaello Cortina, 2006, p.79.

Quanto fosse stretto, per Dirac, il rapporto tra bellezza, matematica e fisica risulta chiaramente espresso da lui stesso nel 1956, quando, durante una visita all'Università di Mosca, accondiscendendo alla richiesta di scrivere alla lavagna una frase rappresentativa del suo lavoro, Dirac scrisse: «Una legge fisica deve possedere bellezza matematica».

Spesso si identifica la bellezza matematica con la semplicità; non era così per Dirac che dichiarò a tal proposito:

> La teoria di Newton è molto più semplice della teoria di gravitazione di Einstein; ma la teoria di Einstein è migliore, più profonda e più generale. La bellezza matematica, non la semplicità, è la caratteristica principale della teoria della relatività, e questo è il concetto fondamentale nella relazione esistente tra la fisica e la matematica.[119]

Ma cosa intendeva Dirac per "bellezza matematica"? I formalismi matematici, per lui, sono tanto più eleganti quanto più "invarianti" offrono, intendendosi per "invarianti" tutte quelle entità o quantità che non cambiano quando si effettuano trasformazioni geometriche (per es. una rotazione) o quando si cambia sistema di riferimento. E quanti più invarianti ci sono in una equazione, tanto maggiori sono la sua bellezza e quella della teoria fisica su di essa basata e la possibilità della sua esattezza. Ma perché la bellezza, e quindi l'invarianza, risulta essere garante della verità di una teoria fisica? La risposta è concettualmente semplice: l'invarianza rispetto a una trasformazione (geometrica o di sistema di riferimento) è la prova più convincente dell'esistenza di un oggetto. In un primo momento, per esempio, io posso credere che l'oggetto che vedo da una certa angolazione sia un cubo, ma poi ruotandolo, mi accorgo che non lo è. Se invece, pur cambiando diversi punti di vista, permane in me la vista prospettica di un cubo, mi convincerò che effettivamente quell'oggetto è un cubo. Questo in estrema sintesi il pensiero di Dirac: la bellezza di una equazione matematica porta all'invarianza e questa alla verità: la bellezza matematica conduce dunque alla verità fisica.

15 La sezione aurea non basta più! Tra bellezza e stupore : immagini e *computer graphics*

Andando avanti nei nostri esempi osserviamo che anche l'informatica ha provveduto abbondantemente a presentarci casi interessanti di "bellezza" non

[119] Juan Antonio Caballero Carretero, *Dirac, l' antimateria: il lato oscuro della materia*, RBA, 2016.

convenzionale, specialmente quando sono stati illustrati attraverso la *computer graphics*.

L'utilizzo del computer ha in realtà creato campi del tutto nuovi nella matematica applicata, come ad esempio la *teoria del caos* e la *geometria frattale,* nei quali si sono avuti sviluppi addirittura impensabili senza l'ausilio della computer grafica. Benoit Mandelbrot (1924-2010), padre della geometria frattale, riconosce ai computer il ruolo di strumenti insostituibili per questo campo di ricerca. Prendiamo in esame una semplice formula di ricorrenza:

(28) $$Z_{n+1} = Z_n^2 + C$$

dove $Z_n= X_n+i\ Y_n$, $C= a+i\ b$ sono numeri complessi. Supposto $Z_0= 1$, la successione:

(29) $$Z_0, Z_1, Z_2, \dots , Z_n, \dots$$

a seconda del valore di *C*, può o no essere limitata**.** Essendo C= (a,b) assimilabile alle coordinate cartesiane di un punto, si chiama *frattale*[120] *di Mandelbrot*, il luogo dei punti *C* del piano di Argand-Gauss per i quali la successione sopra indicata è limitata. Senza l'avvento della computer grafica sarebbe stato impossibile visualizzare questo luogo (figura 41)

L'equazione ricorrente può scriversi nella forma cartesiana:

$$X_{n+1}= X_n^2- Y_n^2 + a \quad , \quad Y_{n+1}= 2X_nY_n + b$$

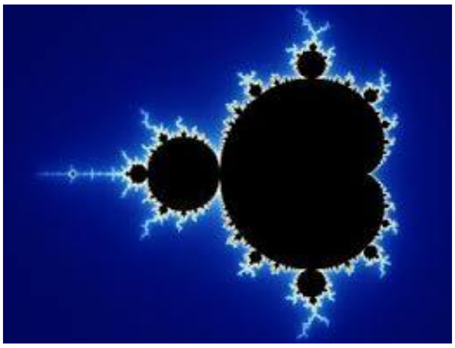


Fig. 41 – Frattale di Benoit Mandelbrot.

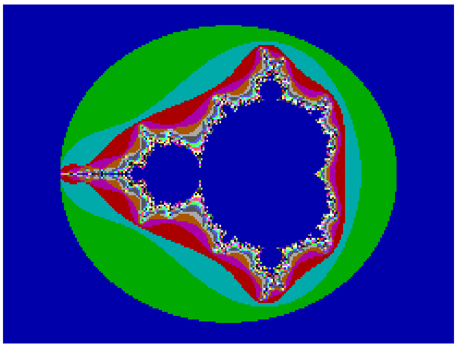


Fig. 42 – Colori esterni.

[120] Benoit Mandelbrot, *Les Objects Fractals: Forme, Hazard et Dimension*, Paris, Flammarion, 1975; Benoit Mandelbrot, *Fractals and chaos: the Mandelbrot Set and Beyond,* Springer, 2004; Benoit Mandelbrot, *La formula della bellezza. La mia vita di vagabondo della scienza*. Milano, Rizzoli, 2014.

Le equazioni cartesiane di Mandelbrot si prestano ad immediate generalizzazioni sia a forme quadratiche più generali, o anche cubiche e di gradi più alti, e anche non necessariamente algebriche. Nella "giungla di immagini" che ne derivano non è difficile reperirne altre di incredibile bellezza. Tornando al frattale di Mandelbrot, osserviamo solo che le proprietà di questa figura sono a dir poco incredibili. Si tratta di un oggetto geometrico dotato di omotetia interna, in quanto si ripete nella sua forma originale e allo stesso modo, su scale diverse anche sempre più piccole. Dunque ingrandendo una qualunque sua parte si ottiene una figura simile all'originale (*autosomiglianz*a). Se pensiamo al contorno del frattale come a una curva, questa curva in ogni suo punto è priva di retta tangente!

Una sostanziale differenza fra la rappresentazione di una curva piana e di un frattale è, nei fatti, il modo in cui l'oggetto si costruisce. Una curva piana si costruisce generalmente sul piano cartesiano, utilizzando le equazioni parametriche X = x(t), Y = y(t): al variare del parametro t varia la posizione del punto della curva sul piano, che in tal modo la descrive. La costruzione dei frattali, invece, non si basa su equazioni, ma su un algoritmo che seleziona punti di "differente natura" o, se si vuole, di "differente colore". In prima approssimazione si dividono i punti in due classi: quelli per i quali la successione diverge e quelli per i quali la successione converge, assegnando ai punti due colori diversi. Ma in una fase successiva possiamo graduare le convergenze, indicando convergenze inferiori a numeri dati e ottenere ulteriori partizioni e colori.

Si può provare che se $|Z_2| > 2$, allora la successione diverge e quindi il punto C = (a,b) è esterno al frattale di Mandelbrot. Le immagini multicolori che si vedono nella figura 42, sono generate colorando i punti esterni all'insieme in dipendenza di "quanto rapidamente " la successione diverge all'infinito. Il minimo valore di *n* per cui $|Z_2| > 2$ è un indice di quanto "lontano dal contorno" si trova un punto e viene utilizzato per la rappresentazione "a colori". Ancora possiamo trovare il minimo *n* per il quale ad esempio $|Z_2| > 3$ e così via… Paradossalmente, i punti colorati che conferiscono il fascino al frattale di Mandelbrot sono proprio quelli che non appartengono all'insieme.

Fig. 43. Logica iterativa ad albero del frattale.

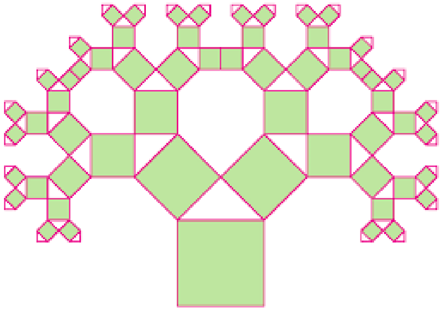


Fig. 44. L’albero di Pitagora.

L'algoritmo non è mai applicato una volta sola: può essere iterato un numero di volte teoricamente infinito.

A ogni iterazione, la curva si avvicina sempre più al risultato finale e, dopo un certo numero di iterazioni, l'occhio umano non è più in grado di distinguere le modifiche (inoltre l’hardware non è più in grado di consentire ulteriori miglioramenti). Pertanto, quando si disegna concretamente un frattale, ci si può fermare dopo un congruo numero di iterazioni.

Il frattale di Mandelbrot, al di la della comprensione scientifica del fenomeno, presenta tutte le caratteristiche del “bello”: se si espone come poster! È significativo e cattura l’attenzione di una qualunque persona così come una bella musica colpisce l’uditore anche sprovveduto. Dunque sono immagini molto utili per la pubblicità, come appare nella maglietta di figura 45 sulla quale è stampato un frattale di Mandelbrot.

Si ritiene che in qualche modo i frattali abbiano delle corrispondenze con la struttura della mente umana, è per questo che la gente li trova così familiari. Questa familiarità è ancora un mistero e più si approfondisce l'argomento più il mistero aumenta.

Fig. 45. Maglietta con il frattale di Mandelbrot.

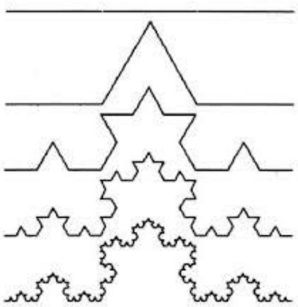


Figura 46 – La curva di Koch.

Una piccola variazione nella formula di Mandelbrot

(30) $$Z_{n+1} = (*Z_n)^2 + C$$

dove *(a+ib) = a-ib è il complesso coniugato del numero dato, conduce a una figura totalmente diversa ma egualmente molto bella.

Una curva interessante di tipo patologico, riportata in tutti i testi, è la curva del matematico svedese Helge Von Koch[121] (1870-1924) presentata nel 1904 come esempio di funzione continua e non derivabile in alcuno dei suoi punti, costruita con un processo iterativo (figura 46).

Il concepire una curva priva di retta tangente in ogni suo punto è un antico problema considerato patologico nella matematica. Una curva siffatta[122] fu scoperta nel 1890, prima di quella di Von Koch, da Giuseppe Peano (1858-1932), ma da un lato ebbe minore diffusione mentre da un altro lato si presentava patologicamente molto più interessante, per il fatto che si tratta di una sequenza di curve, la cui curva limite del processo, che non si vede, permette di intuire che in essa ogni punto è uno "spigolo" , quindi privo di tangente, e inoltre si intuisce anche che la curva limite riempie interamente il quadrato (figura 47)! Naturalmente la curva limite può essere studiata, ma ciò esula dalla nostra trattazione.

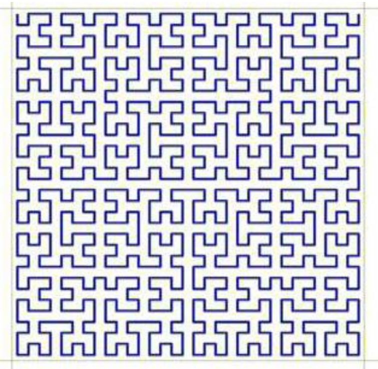


Fig. 47 - La curva di Peano.

Uno dei personaggi di grande interesse, che deve molto all'avvento dell'informatica, è il fisico, matematico e cosmologo inglese Sir Roger Penrose (n.1931) molto famoso per avere ideato alcune figure impossibili che portano il suo nome (figure 48 e 49). Oltre ai grandi contributi forniti in vari campi

[121] Helge von Koch, *Sur une courbe continue sans tangente, obtenue par une construction géométrique élémentaire*, Archiv för Matemat., Astron. och Fys. 1, 1904, pp. 681-702.
[122] Eric W. Weisstein, *Curva di Peano*, in MathWorld, Wolfram Research.

- specialmente l'astrofisica, l'intelligenza artificiale e la filosofia della scienza[123] - Penrose ha lavorato anche nella cosiddetta "matematica creativa" e ha scoperto nel 1974, assieme a Robert Amman (1946-1994), una particolare tassellatura che porta il suo nome (*Penrose tiling*).

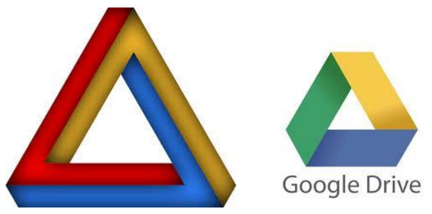


Figura 48 – Il triangolo impossibile di Roger Penrose e il logo dell'App. Google Drive.

Figura 49 – La losanga impossibile di Roger Penrose e il logo della Renault.

Si tratta di un *pattern* di figure geometriche basate sulla sezione aurea, in quanto costituite da triangoli aurei. Esistono diverse tassellature del tipo Penrose. Una delle più utilizzate è composta da due tasselli, a forma di rombo, ognuno avente quattro lati di lunghezza unitaria (figura 50), legate entrambe alla sezione aurea: un tassello ha due angoli di 72° e due di 108°; l'altro tassello ha due angoli di 36° e due di 144°.

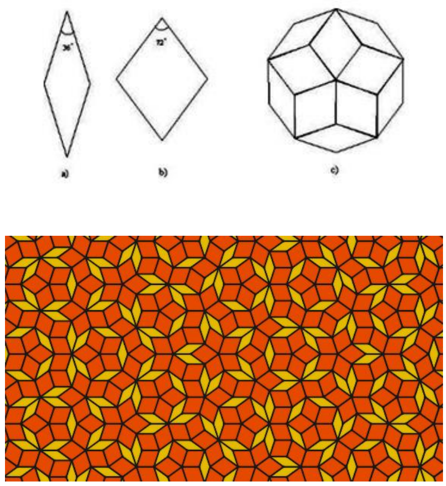


Figura 50 – Le tassellature di Roger Penrose.

[123] Roger Penrose, *La mente nuova dell'imperatore*, Milano, Rizzoli (BUR), 1989.

16 La sezione aurea non basta più! Tra bellezza e coazione: le immagini nella pubblicità

Spesso noi ci chiediamo: che cos’è la pubblicità? Qual è il suo scopo? Il concetto di pubblicità è, secondo il semiologo triestino Ugo Volli,[124] uno «strumento estetico e ideologico di massa, serbatoio a cui attingiamo il nostro modo di guardare le cose, di scoprire il bello, di divertirci e sognare».

Naturalmente la pubblicità, o meglio il messaggio pubblicitario, è una forma di comunicazione che utilizza i più svariati linguaggi, quali il testo, le immagini, le parole, la musica, tutti trasformati in opportune sequenze binarie,[125] per poter essere diffusi in rete da Internet nei nuovi canali di vendita, quali *Amazon*, o i cosiddetti *social network*, come *Instagram* e altri simili, Ancora si ricorre a tecnologie più semplici, ma ancora efficaci, che si servono del *flyer* (volantino), del cartellone, dell’inserzione sui giornali, dell’insegna, sempre al fine di permettere la conoscenza e il costo dei prodotti, gli eventi culturali e sociali, gli spettacoli, in generale ogni tipo di servizi adatti

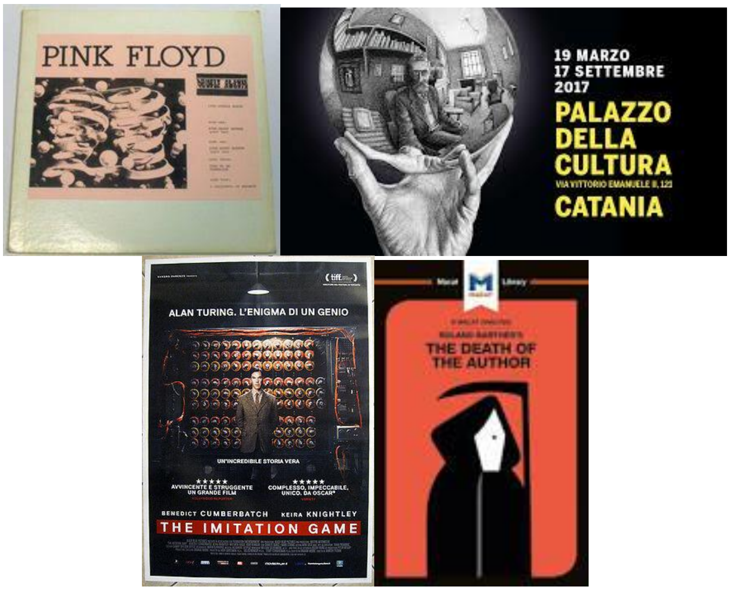


Figura 51

---

[124] Ugo Volli, *Semiotica della pubblicità*, Bari-Roma, Laterza, 2005. Ugo Volli è Professore Ordinario di Filosofia e Teoria dei Linguaggi, presso l’Università di Torino).

[125] Il “ linguaggio” finale che permette a un computer di eseguire un programma è costituito da una sequenza di cifre binarie 0 e 1 (programma oggetto).

a un pubblico di massa (figure 51, 52).

Spesso la pubblicità, specie quella meno corretta, si basa su tecniche di “lavaggio del cervello”. I servizi segreti furono i primi ad adottare queste tecniche di controllo della mente - scoperte durante le guerre - in seguito utilizzate e sfruttate anche dal settore pubblicitario, al quale, negli anni ’50 del secolo scorso, la psicologia offrì un campo illimitato di potenziali manipolazioni. Queste erano peraltro considerate fondamentali nell'ottica di una sempre crescente prosperità. Infatti, secondo una regola fondamentale dell’economia, l'offerta è regolata dalla domanda. Grazie alle manipolazioni psicologiche della mente, si può indurre negli uomini un bisogno incessante (spesso non reale) di consumi, incrementando così la domanda e quindi il processo produttivo per soddisfarla. Ogni incremento del potere di acquisto del consumatore si trasforma così in nuova domanda che genera nuova offerta.

A metà degli anni Cinquanta del secolo scorso, soprattutto negli Stati

Figura 52.

Uniti, il conformismo rappresentava il fondamento della nuova e quanto mai prospera società. Per fabbricanti e pubblicitari, il "colletto bianco" era la figura ideale, che andava allettata con tutte le tecniche della manipolazione psicologica. Le industrie cominciarono a utilizzare tali tecniche non solo sui consumatori ma anche sui propri dipendenti. I test e i profili psicologici divennero una pratica comune per stabilire la "normalità" del personale verificandone il conformismo. L'insidiosità del processo in atto non sfuggì agli studiosi più attenti, quali Vance Packard[126] (1914-1996) e John Kenneth

[126] Vance Packard, *I persuasori occulti*, Torino, Einaudi,1957.

Galbraith[127] (1908-2006). Scrive Galbraith, con l'ironia e l'autorevolezza che lo hanno reso tra i pensatori più originali del Novecento, che la «società opulenta» demolisce alcuni miti e svela l'inganno della «mentalità convenzionale» che impedisce di guardare al di là delle leggi di mercato. Solo quando il benessere riguardava pochi eletti, aveva un senso porre l'accento sulla produzione. Davanti a una società agiata, ma massificata, è del tutto errato fare della produttività il centro e il fine dell'economia, poiché in tale errore si può rinvenire l'origine di molte delle contraddizioni che caratterizzano il nostro tempo.

Pertanto, appare chiaramente che lo scopo del messaggio pubblicitario, che dovrebbe essere informativo-commerciale, sia in realtà un "oggetto" ben più complesso. Ad esempio, nel presentare le qualità e i pregi di un prodotto, si opera in maniera manipolativa, così da fornire informazioni esclusivamente appaganti i potenziali clienti, così da spingere un'alta percentuale di essi all'acquisto.

Nel suo libro *La galassia Gutenberg*, Herbert Marshall McLuhan[128] sottolinea l'importanza dei mass media[129] e illustra come l'avvento della stampa nel 1455 produsse il passaggio dalla cultura orale alla cultura testuale, ponendo al centro dell'attenzione un solo senso: la vista, che egli considera un tipo di relazione che distanzia i singoli e che è meno emotiva. Così egli propone un necessario ritorno alla comunicazione orale, che si veicola attraverso l'udito e ci avvolge, poiché il suono si propaga in ogni direzione, è più coinvolgente e amplifica il nostro senso di comunità. Comunicando quindi attraverso il senso della vista, tendiamo pertanto a esercitare maggiormente la nostra singolarità e razionalità. Egli asserisce[130] che «quale che sia il mezzo tecnologico utilizzato, questo produce effetti persuasivi sull'immaginario collettivo, in modo indipendente dal contenuto informativo presentato».

Volendo avanzare una critica a McLuhan circa l'identificazione del mezzo (*medium*) con il messaggio[131] va notato che, secondo altri autori, non sarebbe affatto vero che il pubblico sia indifferente ai contenuti, come invece asserisce McLuhan parlando anche della sua idea di "villaggio globale".

Si tratta di una intrigante metafora, atta a indicare come l'evoluzione dei mezzi di comunicazione e la costruzione di comunicazioni via satellite hanno

---

[127] John Kenneth Galbraith, *La società opulenta,* Roma, Edizioni di Comunità, 1958 (rieditato 2014).

[128] Herbert Marshall McLuhan (1911-1980) è stato un sociologo, filosofo, critico letterario e professore canadese.

[129] Herbert Marshall McLuhan, *The Gutenberg Galaxy: The Making of Typographic Man* (Routledge & Kegan Paul). 1962 (Ed italiana del 1976).

[130] Herbert Marshall McLuhan, *Understanding Media: The Extensions of Man,* Gingko Press, 1964.

[131] Herbert Marshall McLuhan, Quentin Fiore, *Il medium è il messaggio,* Milano, Feltrinelli, 1967.

permesso sia comunicazioni in tempo reale sia comunicazioni a grande distanza. In altre parole, la "geometria del web satellitare" sarebbe uno spazio-tempo nel quale la distanza di due punti distinti è zero e il tempo di percorrenza da un punto a un altro è il tempo delle e-mail, prossimo a zero. Così ci piace asserire come il mondo, "diventato piccolo" ha assunto il comportamento usuale di un villaggio:

> Oggi, dopo più di un secolo di tecnologia elettrica, abbiamo esteso il nostro sistema nervoso centrale fino a farlo diventare un abbraccio globale, abolendo limiti di spazio e tempo per quanto concerne il nostro pianeta.[132]

Il concetto alla base di questa affermazione, come abbiano sostenuto in varie occasioni, è il fatto che la tecnologia elettronica è diventata una effettiva protesi dell'intera umanità.

In ogni caso, seguendo McLuhan, può ipotizzarsi che il linguaggio pubblicitario attuale sia una sorta di meta-pubblicità, sempre la medesima, nella quale di volta in volta cambiano immagini e prodotto, ma non cambia la "storia presentata". Pertanto le pubblicità non opererebbero per vendere i singoli prodotti, ma affinchè in ogni caso qualche acquisto sia fatto, utilizzando quella modalità che il nostro famoso semiologo Umberto Eco[133] (1932-1916) definisce «coazione al consumo», operazione che spinge i potenziali clienti fuori di casa a comprare qualcosa, magari anche molto diversa da quella che avevano in mente e che non desideravano affatto voler acquistare.

Il semiologo francese Roland Barthes (1915-1980), nelle sue molteplici opere, si è dedicato allo studio[134] delle relazioni esistenti tra i miti-feticci della realtà contemporanea e il sociale, con particolare riguardo al mondo della moda.[135] Ha studiato il rapporto di incontro-scontro tra la lingua intesa come patrimonio collettivo e il linguaggio individuale. Il criterio da lui proposto oltrepassa la tesi accademico-filologica e si pone come una continua e sollecita interrogazione del testo, facendo notare che il pubblico di oggi cerca di appropriarsi, con personali interpretazioni ed elementare ermeneuticità, del messaggio pubblicitario, tentando sia di falsificarlo, sia di attribuire ad esso una nuova forma, magari oggetto del desiderio individuale. Tuttavia, per uscire dal banale, occorre osservare che comunque il messaggio deve rimanere impresso attraverso slogan facilmente leggibili, utilizzando immagini che

[132] Herbert Marshall McLuhan, Bruce-R-Powers *The Global Village*, Oxford University Press, 1989.
[133] Umberto Eco (a cura di), *Estetica e teoria dell'informazione*, Milano, Bompiani, 1972.
[134] Roland.Barthes, *Miti d'oggi*, (trad. Lidia Lonzi), Torino, Einaudi, 1975 (nuova ed. 1989).
[135] Roland Barthes, *Sistema della Moda*, trad. Lidia Lonzi, Torino, Einaudi,1970 (nuova ed. 1990).

colpiscano l'inconscio, o un manifesto o un *banner*, che comunque viene visualizzato soltanto per qualche frazione di secondo. Inoltre, le parole del messaggio pubblicitario devono essere poche e facili da ricordare, devono avere la medesima efficacia di un collaudato marchio di una casa di produzione, devono ispirare, a colpo d'occhio, serietà, fiducia, la convinzione di un ottimo acquisto. Il messaggio commerciale deve necessariamente contare sull'impatto combinato di una immagine con uno slogan e su una collocazione opportuna. Ad esempio un manifesto deve necessariamente collocarsi in posti strategici, ad elevato traffico di circolazione di persone (piazze, stazioni ferroviarie, autobus e pensiline di attesa di mezzi pubblici, strade centrali trafficate ecc.).

La semiotica è la disciplina principe di questo mondo, avendo per obiettivo l'analisi profonda del testo. Esamina ogni messaggio pubblicitario, le strutture di senso, la sintassi, i modelli semantici del testo, tentando di andare al di là delle purtroppo molto diffuse letture superficiali.

Oggi un pubblicitario, che voglia analizzare quali siano gli effetti delle comunicazioni di massa, deve essere consapevole che questa è portata a tal punto da livellare e conglobare in un modello standard le notizie, che per quantità e similitudine offrono al proprio pubblico una specie di rumore che non sappiamo se definire indifferenziato o addirittura bianco.

La filosofia del linguaggio e della comunicazione, seguendo ancora Umberto Eco,[136] asserisce che il pubblicitario, nell'innovarsi, dovrebbe porsi in una posizione intermedia fra gli apocalittici, che pensavano che le tecnologie delle comunicazioni avrebbero massificato l'intero universo umano, e gli integrati, i quali erano al contrario fiduciosi in una divulgazione globale dei valori culturali che li avrebbero resi alla portata di tutti.

Nella pubblicità vi sono alcune immagini, provenienti da intuizioni grafiche sorprendenti, come le immagini del cosiddetto "effetto Droste" o delle ripetizioni infinite nate, con la pubblicità della olandesina del cacao Droste e similari, dalla matematica o da ambienti creativi molto vicini a tale disciplina, delle quali abbiamo accennato nei paragrafi precedenti, quali le figure proposte dall'incisore Escher, dall'astrofisico Penrose, dai cosiddetti frattali, figure che pur comprensibili solo da esperti nei loro dettagli, costituiscono uno stimolo visivo notevole.

[136] Umberto Eco, *Apocalittici e integrati*, Milano, Bompiani, 1964 e *Semiotica e filosofia del linguaggio*, Torino, Einaudi,1984.

Seguendo l'ipotesi di McLuhan, in sintesi si può affermare che "il *medium* è il vero messaggio", indipendentemente se il prodotto commercializzato sia un buon prodotto, se un libro sia un buon libro o se il capo di abbigliamento sia un buon capo o ancora se il prezzo sia reale o legato invece all'importanza che all'oggetto viene attribuito dall'intera comunità dell'ignaro ricevente. Oggi una operazione del genere è traslata anche dagli oggetti al cibo, l'immagine che una comunità attribuisce ad uno scelto *chef* di turno ha sostituito il giudizio individuale sul prodotto dello *chef*, così che la bontà del suo prodotto è solo funzione dell'immaginario collettivo. Noi assistiamo a un fenomeno antico, che è giusto chiamare di "persuasione occulta" ovvero di "lavaggio del cervello", del quale sarebbe interessante tracciare una mini-storia. Questo è stato il mondo di ieri per certi aspetti, ma per altri questo è il nostro mondo di oggi!

Figura 53.

Bibliografia

Albergamo F. (1965). *Storia della Filosofia*, Palermo, Palumbo.

Barthes R. (1975). *Miti d'oggi*, (trad. Lidia Lonzi), Torino, Einaudi, (nuova ed. 1989).

Barthes R. (1970). *Sistema della Moda*, trad. Lidia Lonzi, Torino, Einaudi, (nuova ed. 1990).

Caballero Carretero J A. (2016). *Dirac, l' antimateria: il lato oscuro della materia*, RBA.

Calaprice A. (a cura di) (1999), *Albert Einstein. Pensieri di un uomo curioso*, Milano, Mondadori.

Cerasoli M., Eugeni F., Protasi M. (1988). *Elementi di Matematica Discreta*, Bologna, Zanichelli.

Eco U. (1963). *Diario Minimo*, Milano, Arnoldo Mondadori.

Eco U. (1964). *Apocalittici e integrati*, Milano, Bompiani.

Eco U. (a cura di) (1972), *Estetica e teoria dell'informazione*, Milano, Bompiani.

Eco U. (1984). *Semiotica e filosofia del linguaggio*, Torino, Einaudi.

Einstein A. (1905). Sull'elettrodinamica dei corpi in moto, in «*Annalen der Physik*», 17, 1905, pp. 891-921. Trad. it. di Paolo Straneo in *Cinquant'anni di relatività*, Firenze, Marzocco, 1955, pp. 479-504.

Eugeni F. (1981). Le due rivoluzioni matematiche del Secolo: da Bourbaki alla matematica del discreto, «*Periodico di Matematiche*», *Serie VI, Vol 68, N1*, pp.3-21.

Eugeni F, Sciarra E., Mascella R. (2010). *Il senso del bello* in TABULARIA A.MMX (S.S.Quator Coronatorum),"academia" editrice d'Italia e San Marino.

Eugeni F., Mascella R., Tondini D. (n.d.). *Un'applicazione del calcolo binario: il gioco del Nim.* On-line: www.apav.it/master/gioconim.pdf.

Galbraith J. K. (1958). *La società opulenta*, Roma, Edizioni di Comunità, (rieditato 2014).

Hardy G. H. (1989). *Apologia di un matematico*, trad. Luisa Saraval, Milano, Garzanti.

Hoffmann B. (1977). *Albert Einstein: creatore e ribelle*, (trad. it.), Milano, Bompiani.

Klein E. (2006). *Sette volte la rivoluzione*, Milano, Raffaello Cortina.

Kuhn T. (1963). I*nterview with Dirac, 7-05-1963*, Niels Bohr Archive, Copenhagen, p. 53. Trad. it. in Etienne Klein, *Sette volte la rivoluzione*, Milano, Raffaello Cortina, 2006, p.79.

Mandelbrot B. (1975). *Les objets fractals : Forme, hasard et dimension*, Paris, Flammarion.

Mandelbrot B. (2004). *Fractals and chaos: the Mandelbrot Set and Beyond,* Springer Verlag.

Mandelbrot B. (2014). *La formula della bellezza. La mia vita di vagabondo della scienza*, Milano, Rizzoli.

McLuhan H. M. (1962). *The Gutenberg Galaxy: The Making of Typographic Man* (Routledge & Kegan Paul). (Ed italiana del 1976).

McLuhan H. M. (1964). *Understanding Media: The Extensions of Man,* Gingko Press.

McLuhan H. M., Fiore Q. (1967). *Il medium è il messaggio*, Milano, Feltrinelli.

McLuhan H. M., Bruce-R-Powers (1989). *The Global Village*, Oxford University Press.

Nicotra L. (2011). L'ideale estetico nell'opera dello scienziato, in Nicotra L., Salina Borello R. (a cura di), *Nello specchio dell'altro. Riflessi della bellezza tra arte e scienza*, Roma, Universltalia.

Nicotra L. (2017). Il disordine nell’ordine della materia, «*ArteScienza*», *Anno IV, N. 8,* pp. 5-38.

Packard V. (1957). *I persuasori occulti*, Torino, Einaudi.

Penrose R. (1989). *La mente nuova dell’imperatore*, Milano, Rizzoli (BUR).

Planck M. (1973). Scienza, filosofia e religione. Milano, Fratelli Fabbri Editori.

Segre D. (1971). *Sette delitti*, Milano, Sonzogno.

Volli U. (2005). *Semiotica della pubblicità***,** Bari-Roma, Laterza.

Von Koch H. (1904). *Sur une courbe continue sans tangente, obtenue par une construction géométrique élémentaire*, Archiv för Matemat., Astron. och Fys. 1, 1904, pp. 681-702.

Weisstein E. W. (n. d.). *Curva di Peano*, in MathWorld, Wolfram Research.

Withoff W. A. (1905-1907). *A modification of the game of Nim*, Nieuw Archief voor wiskunde, 2: pp. 199–202.

Zugaro D. (1977). *Lettere di una spia*, Milano, Sugar Editore.

Mathematics is a Science!

Luca Granieri[1]

Abstract

Mathematics plays a central role in modern science. However, it is very common an instrumental and utilitarian view of math leading to the underestimation of its scientific nature. We propose some consideration to emphasize a different idea on the fundamental role of math in modern science.

Keywords: mathematics; positivism; philosophy of science; history of science; demarcation.[2]

Sunto

La matematica riveste un ruolo fondamentale nella scienza moderna. Ma nell'immaginario collettivo è molto diffusa, anche tra gli insegnanti, una concezione piuttosto utilitaristica e strumentale che ne ridimensiona o talvolta nega lo status di scientificità vera e propria. Si propone una pista di riflessione che supporti un'immagine diversa della matematica e del suo ruolo fondante nell'impresa scientifica.

Parole chiave: matematica; scienza; positivismo; storia della scienza; filosofia della scienza; demarcazione.

---

[1] Liceo Scientifico E. Fermi, Bari, Italy; granieriluca@libero.it.

[2] Received on October 28th, 2019. Accepted on December 25th, 2019. Published on December 30th, 2019. doi: 10.23756/sp.v7i2.488. ISSN 2282-7757; eISSN 2282-7765.

1 Introduzione

Le conoscenze più affidabili e accurate provengono dalla scienza. Ma di *scienze* ce ne sono tante, ciascuna con i suoi punti di forza e di debolezza. E questo panorama così variegato nasconde anche insidie e pericoli. In effetti, talvolta il termine *scientifico* viene utilizzato in modo piuttosto generico con lo scopo di rendere più *autorevole* il corpus di conoscenze alle quali è applicato. Oggi c'è la tendenza a dare della *scienza* a tutto o quasi. Senza sconfinare nelle *scienze occulte*, anche a scuola, con tutto rispetto parlando, la ginnastica si chiama ormai *scienze motorie*.

Talvolta si distingue tra *scienze esatte (o dure)* e meno esatte a seconda del grado di matematizzazione che le caratterizzano. Ma, quasi paradossalmente, la matematica in sé spesso non rientra in questa categoria. La matematica è o non è una scienza?

2 Matematica e scienza

Di norma, la nascita della scienza moderna si colloca nel Seicento con personaggi del calibro di Galileo, Newton ecc. Il percorso che porta a questa grande conquista è lungo e variegato (si veda [4,5,14]), ma sicuramente un ingrediente decisivo che caratterizza il passaggio dalla scienza antica a quella moderna è il ruolo (decisivo) giocato dalla matematica. Nella tradizione aristotelica c'è una separazione netta tra matematica e fisica. Perché la matematica è la scienza dell'essere, di ciò che è eterno ed immutabile, mentre la fisica è il regno del divenire. La matematica è allora esclusa quasi per definizione, o relegata in pochi ambiti circoscritti (statica, astronomia, musica). Principalmente, l'avvento della scienza moderna si caratterizza proprio nel superamento dell'aristotelismo e nel recupero della centralità della matematica nella comprensione scientifica del mondo.

Celebre è la metafora di Galileo tratta dal *Saggiatore* secondo la quale il mondo sarebbe *un libro scritto in lingua matematica* senza la quale ci si ridurrebbe a brancolare in un oscuro labirinto. Anzi, tale immagine del libro è molto di più che una semplice analogia o metafora, richiamando la radicata tradizione dei *due libri*. Il primo è ovviamente la Bibbia che contiene la Parola di Dio, responsabile della creazione (*Dio disse: sia la luce. E la luce fu ...* come riportato nel libro della Genesi). Il secondo è il *libro della natura* scritto in lingua matematica. Entrambi ricondotti a Dio quale unico autore. La matematica è allora molto più di un semplice linguaggio che possa descrivere i fenomeni naturali, giacché la Parola di Dio (*Il Verbo*) è incarnata e causa trascendente del mondo (*In principio era il Verbo, il Verbo era presso Dio e il Verbo era Dio. Egli era in principio presso Dio: tutto è stato fatto per mezzo di lui, e senza di* *lui niente è stato fatto di tutto ciò che esiste. [...] E il Verbo si fece carne e venne ad abitare in mezzo a noi*. Dal Prologo del Vangelo di Giovanni). Sulle orme di una concezione se vogliamo *pitagorica* in cui la matematica è intrinseca alla realtà, anzi la causa della realtà stessa.

Nonostante la grandiosità di questa immagine *originaria*, oggi è invece piuttosto diffusa una concezione molto più utilitaristica e strumentale del ruolo della matematica nella scienza. La matematica è spesso considerata solo come un linguaggio tra tanti altri, magari comodo ma non indispensabile. Una specie di cassetta degli attrezzi che lo scienziato utilizza secondo necessità. In linea di principio se ne potrebbe anche fare a meno e la utilizziamo nella fisica ad esempio al mero scopo di formularne precisamente le leggi e rendere l'indagine scientifica più efficace, come una sorta di *compressione algoritmica*. Oppure allo scopo di collegare le previsioni teoriche con i dati empirici rendendole quantitative. In quest'ottica la matematica non sarebbe una scienza ma soltanto un efficace strumento al servizio delle altre scienze. Del resto, quale può essere il contenuto empirico della matematica? Nessuno? E' solo un linguaggio che non parla di nulla? Si può rispondere di sì, ovviamente. Questa è la risposta del positivismo che in fondo ha dominato la visione della scienza per tutto il XX secolo, fino a oggi.

La concezione positivista è solo lo "scheletro" della scienza. E in verità un certo positivismo ed empirismo è decisamente utile nella prassi scientifica e tecnologica, in cui diventa l'idea di una crescita delle conoscenze dovuta a un'opera naturalistica collettiva e condivisa; non è fruttuoso però quando si traduce in una concezione della matematica/logica come semplice strumento linguistico di una scienza sostanzialmente empirica. Di fatto la grande matematica greca non ha trovato nell'antichità e nel Medioevo sostanzialmente alcuna applicazione, un dato che permarrà con pochissime eccezioni fino a pochi secoli fa, mentre la matematica moderna è stata (ed è) la cornice culturale -prima ancora che lo strumento linguistico- tanto della pratica di laboratorio, quanto delle teorie delle scienze "dure" moderne (chimica, fisica, informatica).

[…] La storia "positivista" della scienza si rivela, allora, solo una "cronaca" di teorie ed esperimenti tenuta insieme da un puro precetto ideologico […] Un aspetto tipico dei positivisti: la sottovalutazione del carattere genuinamente scientifico della matematica, che resta di fatto fuori dalla loro analisi. E' addirittura comune considerare la matematica esente dalle "rivoluzioni scientifiche". Ho cercato di descrivere quanto questo sia errato, e come invece nella matematica si realizzino autentici "mutamenti antropologici", molto più radicali e impercettibili delle rivoluzioni scientifiche [6 p.75-76;103].

Sono possibili allora altre risposte, forse più vicine alla *natura* della matematica, qualunque essa sia. Stranamente, anche in alcuni matematici di professione si può instillare il dubbio sulla scientificità della loro disciplina. In [7] si sostiene ad esempio che la matematica non dovrebbe essere annoverata tra le scienze *in senso stretto*. La motivazione *anagrafica* ivi sostenuta sulla base del fatto che una matematica già matura preceda di parecchi secoli l'epoca di Galileo ci pare poco calzante per escluderla dal novero delle scienze. La scienza non è un corpo unitario e ogni scienza matura in tempi diversi. Il fatto è che nel Seicento nasce se vogliamo la fisica, e spesso si tende ad identificare tout court l'impresa scientifica con la fisica, o con un certo tipo di fisica. Magari la statica era già matura ai tempi di Archimede (si veda anche [22]). Anzi, se vogliamo, il fatto che la matematica greca fosse già sviluppata prima della sua applicazione alla meccanica del Seicento potrebbe dimostrare proprio il contrario della tesi del carattere non scientifico della matematica. Infatti rivela esattamente il fatto che la meccanica medievale non era una scienza ma solo una tecnica (e nell'antichità e nel medioevo scienze e tecniche erano due ambiti del tutto distinti!) e fu solo nella sua forma matematica - geometrica prima e analitica poi - che la meccanica divenne una *scienza*! Questo dovrebbe già farci capire che la matematica non è soltanto *una* scienza ma la condizione di esistenza della scienza tout court!

Ma ad ogni modo, in [7] si procede poi delineando in maniera efficace e competente le virtù della matematica. E se non è scienza quella di cui si parla allora cosa lo può essere? Uno degli scopi in [7] è anche quello di spiegare perché la matematica in genere piace agli scienziati. Il lettore potrà immaginare la nostra risposta al riguardo.

3 Demarcazione

A conti fatti non è così immediato distinguere le conoscenze scientifiche da quelle che non lo sono. Una delle proposte più conosciute è il *falsificazionismo popperiano*. Sommariamente, una teoria è *scientifica* se è possibile falsificarla in qualche modo. Se cioè è possibile escogitare qualche esperimento i cui risultati siano in grado di confutare la teoria in oggetto. Questa semplice idea può essere chiarita dalle parole di Einstein: *Nessuna montagna di esperimenti potrà mai provare che ho ragione: ma un singolo esperimento potrà sempre provare che ho torto*. Così, l'affermazione: *il vento è causato da un dio del vento* non è scientifica poiché per definizione un dio non è osservabile o sperimentabile in alcun modo o, qualora sia possibile, non certamente con le caratteristiche di ripetibilità tipiche dell'approccio scientifico. Né è chiaro come escogitare un esperimento che possa confutare l'esistenza di questo dio. Qualunque cosa accada, si potrà sempre pensare che il dio del vento l'abbia fatto apposta per eludere ogni nostra ingerenza nei suoi affari.

Per quello che riguarda la matematica, Popper sembra escluderla quasi *per definizione* dalla sua indagine perché ritenuta priva di contenuto empirico. Dove ritiene vi possa essere, come per la probabilità ([8,9,12]) propende per negarne lo stato di scientificità galileiana, non potendo soddisfare i suoi criteri di demarcazione. In [12] si dice che *Popper non si avvide che la Teoria delle Probabilità non è una teoria scientifica nel senso galileiano del termine, ma una branca della matematica che* *quindi, in quanto tale, riveste solo un ruolo strumentale in ambito scientifico*.[…] *Popper non richiede il requisito di falsificabilità per le teorie matematiche, e non potrebbe essere altrimenti, dato che la matematica è il linguaggio con cui formulare una teoria scientifica ed estrapolarne le conseguenze da sottoporre ad indagine sperimentale.* Senza entrare nel merito se la teoria della probabilità potesse o no essere considerata una teoria matematica matura al tempo di Popper (per i matematici sicuramente sì), la difficoltà ad inquadrare la matematica in un paradigma scientifico ha anche qualcosa di grottesco e paradossale. Ma siamo così sicuri che i matematici non *falsifichino* o effettuino esperimenti? In realtà questo lo fanno continuamente. Nella pratica quotidiana è quello che fanno i matematici nei loro studi, mettendo alla prova le loro teorie e congetture, facendo esperimenti, cercando falsificazioni, controesempi ecc. Certo non è esattamente quanto si fa nella fisica più strettamente sperimentale e per la maggiore riguardano esperienze interne alla matematica stessa, ma non molto lontano rispetto a quanto potevano fare Einstein e Bohr durante i celebri *congressi Solvay*, quando tentavano di falsificarsi a vicenda a suon di *esperimenti mentali*. Che sono di tipo logico, anche se teoricamente hanno a che fare con il mondo esterno per la loro *interpretazione fisica*. Galileo stesso era un maestro di esperimenti mentali. Si dice che Galileo abbia fatto cadere dalla torre di Pisa due sfere identiche, ma composte di materiali differenti, per dimostrare che la caduta non dipende dal materiale. Questo tipo di esperimento fu svolto in maniera spettacolare sulla Luna dall'astronauta D. Scott durante la storica missione Apollo 15. Lasciando cadere un martello e una piuma sul suolo lunare poté esclamare: Galileo aveva ragione! Anche se probabilmente Galileo non effettuò mai i lanci dalla torre di Pisa, sicuramente escogitò degli esperimenti mentali per falsificare la dipendenza della caduta dal peso nella fisica aristotelica. Argomentava ad esempio che, se due palle identiche vengono fatte cadere, queste devono farlo assumendo velocità identiche. Ma se immaginiamo di collegarle con un filo sottilissimo questo non dovrebbe influire sulla caduta. Ma in questo modo si avrebbe un unico corpo di peso doppio che, secondo gli aristotelici, dovrebbe cadere con velocità doppia rispetto alle due palle separate. Contraddizione. Certo il ruolo dell'esperimento è fondamentale ma quest'ultimo non è soltanto empirico ma spesso proprio di tipo logico-matematico. Del resto discipline come la fisica teorica sono molto affini a una teoria matematica vera e propria. Ad ogni modo, anche nella matematica in senso stretto c'è spazio per l'esperimento: *Oggi molti matematici usano computer non solo per le email e il web, e nemmeno per calcoli numerici, ma come strumento che li aiuta ad esplorare i problemi in modo quasi sperimentale. Appaiono infatti ogni tanto dimostrazioni assistite dal computer, spesso per problemi importanti che hanno resistito ai metodi più tradizionali a base di penna, carta e intelligenza umana* ([23]). Ma non solo, la mole di risultati sempre più numerosi e difficili da controllare contribuisce a spostare l'ago della bilancia da un controllo classico di tipo dimostrativo ad uno di tipo sperimentale. Nessun matematico oggi è più in grado di controllare per filo e per segno tutte le dimostrazioni che vengono prodotte anche soltanto in un settore limitato di ricerca. Man mano che raggiungiamo i limiti delle capacità umane si renderà sempre più necessario il ricorso a strategie *sperimentali*. Ma il legame tra matematica ed esperimento è molto più profondo e articolato, anzi potremmo dire che non esiste nella scienza moderna l'esperimento di laboratorio che non abbia una forma immediatamente matematica. Lo sforzo di trovare nella matematica moderna qualcosa di *sperimentale* potrebbe allora essere bilanciato dal considerare che in fondo tutta la prassi sperimentale è per sua natura *matematica*.

Certo, forse la questione è che l'attenzione di Popper è rivolta essenzialmente alle scienze empiriche. La fisica è senz'altro una scienza sperimentale. Ma il punto è che non è *soltanto sperimentale*. Paradossalmente poi, proprio nella fisica o nelle scienze empiriche in generale, non sempre le falsificazioni producono il loro effetto di confutare una teoria portando alla sua sostituzione. In genere con le contraddizioni si convive finché si può. E queste contraddizioni sono di tipo sperimentale, ma anche di tipo logico-matematico. Ad esempio nel considerare l'incompatibilità tra elettromagnetismo e meccanica Newtoniana nel rendere conto della natura della luce e del presunto *etere* in cui questa doveva propagarsi, il fenomeno di aberrazione della luce stellare mostrava che la Terra non trascina con sé l'etere. La Terra quindi deve muoversi rispetto all'etere. Ma le esperienze di Michelson-Morley mostravano che la Terra è in quiete rispetto all'etere. Una contraddizione su base empirica dunque.

Einstein si muoveva invece su un piano più logico legato all'esistenza di sistemi inerziali privilegiati, partendo cioè dall'incompatibilità logica tra i principi della meccanica classica e quelli dell'elettromagnetismo.

Inoltre, non tutto è falsificabile empiricamente e il ricorso ad un piano logico-matematico è per certi versi quasi obbligato. Basti pensare al principio d'inerzia della meccanica classica. Ci sono, o possono esserci, delle procedure empiriche per validare o falsificare il principio di inerzia (o principio di inerzia generalizzato)? Nessun corpo è *veramente* isolato e controllare il suo moto (rettilineo uniforme) significherebbe seguirlo per uno spazio e un tempo imprecisati. Discrepanze osservate sarebbero attribuibili a influenze esterne di cui non è possibile tener debito conto né in linea teorica né pratica. Insomma, si tratta di un principio logico che prescrive come si comporterebbe la natura in una situazione ideale (che non può esistere). Lo accogliamo alla fine perché serve a definire in modo coerente (matematico) il concetto di forza e la dinamica. Queste a grosse linee alcune delle considerazioni su cui si basa il cosiddetto convenzionalismo di Poincaré (si veda ad esempio [21 p. 161]).

Paradossalmente, il luogo in cui la falsificazione Popperiana trova maggiore vigore è proprio nella matematica stessa. Sì, poiché il fondamento del falsificazionismo di Popper è proprio di tipo logico-matematico. Un Teorema è infatti in generale una scrittura del tipo A→B. L'enunciato A si dice *ipotesi* mentre B si dice *tesi*. Tra i primi elementi di logica si trova che *l'implicazione* A→B è sempre vera tranne in un caso, quello in cui l'ipotesi A è vera e la tesi B è falsa. Da questa proprietà segue una certa *asimmetria*: dalla conoscenza della sola verità della tesi B non possiamo concludere nulla sulla bontà dell'ipotesi; ma invece dalla falsità di B segue automaticamente quella di A (altrimenti avremmo proprio il caso in cui l'implicazione è falsa). Se la tesi B corrisponde a quanto può essere soggetto a controllo empirico di qualche ipotesi A, allora Popper ne deduce che i controlli empirici possano soltanto *confutare* una teoria e mai *verificarla* in senso stretto. A questo quadro aggiungiamo un altro ingrediente: la cosiddetta legge di Duns Scoto secondo la quale da una contraddizione segue qualunque cosa. Così, in matematica, con la contraddizione non si può convivere. Ne basta anche una sola. Per quanto innocua possa apparire la legge di Duns Scoto non lascia vie d'uscita. In quella teoria sarebbe vero tutto e il contrario di tutto. Insomma, tutto da rivedere. In questo modo è proprio nell'ambito della matematica che il falsificazionismo può mostrare tutta la sua forza. Nel piccolo di ogni giorno i matematici cercano costantemente piccole falsificazioni come una bussola che li orienti evitando strade sbagliate. Uno degli episodi più clamorosi è la scoperta del paradosso di Russell all'interno della cosiddetta *teoria ingenua degli insiemi*. Il noto matematico G. Frege mirava a costruire tutta la matematica su basi logiche, secondo un programma molto vasto: il cosiddetto *logicismo*. Frege aveva profuso sforzi enormi nell'impresa pubblicando molti risultati e un grosso e importante volume sui *principi dell'aritmetica* e ne aveva già in cantiere un seguito quando ricevette una famosa lettera da B. Russell nel 1902. In questa lettera Russell informava il collega di aver trovato una contraddizione nella sua teoria, corrispondente a quello che oggi chiamiamo *paradosso di Russell* appunto. La desolante risposta di Frege, pubblicata in appendice del secondo volume dei *Principi di Aritmetica*, che vedeva vanificare il suo progetto di ridurre l'aritmetica alla logica fu: *A uno scrittore di scienza ben poco può giungere più sgradito del fatto che, dopo aver completato un lavoro, venga scosso uno dei fondamenti della sua costruzione. Sono stato messo in questa situazione da una lettera del signor Bertrand Russell, quando la stampa di questo volume stava per essere finita*.

La teoria degli insiemi doveva essere rifondata completamente. Anzi, se vogliamo molte delle complicazioni e delle difficoltà della matematica nascono proprio dalla necessità di evitare le antinomie. Riassumendo. Le scienze non sono tutte uguali e si distinguono per caratteristiche, per oggetto di studio ecc. Hanno molto in comune ma anche molte differenze. La biologia studia gli esseri viventi, diciamo, la matematica gli oggetti matematici. Come nelle altre scienze, per la maggiore la base empirica o sperimentale è interna alla disciplina stessa. Così gli esperimenti matematici sono fatti con carta e penna, o con il computer, o semplicemente con la mente. Si consideri ad esempio l'Ipotesi di Riemann ([11]), uno dei più importanti problemi della matematica moderna (vale un milione di dollari!). Sommariamente: gli zeri della cosiddetta *Funzione zeta di Riemann* hanno tutti parte reale uguale a $\frac{1}{2}$. Possiamo tentare di falsificare l'affermazione calcolando gli zeri di questa funzione e controllandone la parte reale. Con carta e penna, oppure istruendo un calcolatore che lo faccia per noi. Ad oggi questo controllo è stato fatto con metodi vari per moltissimi casi, tutti a favore dell'ipotesi di Riemann. Oppure possiamo controllare come l'affermazione si armonizza con tutte le altre conoscenze scientifiche. Abbiamo al momento vaste teorie matematiche che dicono che se l'ipotesi di Riemann è vera allora accade questo e quest'altro. E l'affermazione di Riemann si incastra in modo notevole nel panorama scientifico (questo è il motivo per cui è così importante). Ma se domani trovassimo un controesempio che la falsifica, o contrasti con altre conoscenze, tutta quella matematica sarebbe da buttare via o comunque da riformulare profondamente.

Conoscenze come quelle filosofiche ad esempio non sarebbero invece scientifiche perché, tranne che in casi speciali, non è possibile in generale produrre osservazioni o esperimenti in modo da confutarne le affermazioni, nemmeno restando all'interno del campo filosofico stesso.

Talvolta si dice che vere falsificazioni in matematica non sono possibili perché *la Matematica non è un'opinione* e se un teorema è dimostrato allora vale per sempre e non può mai essere contraddetto. Fare matematica, si dice, significherebbe soltanto dedurre cose vere dagli assiomi. Ma così facendo si rischia di perpetrare lo stereotipo di una visione piuttosto statica e formalistica della matematica: solo assiomi e deduzioni dagli assiomi. Se riduciamo la matematica ai soli aspetti logico-formali allora sì, la matematica non sarebbe una scienza. Anzi, sarebbe poco più di un gioco: *prendi assiomi e deduci*. Ma la matematica è molto ma molto di più. Altrimenti dovremmo dire che Cauchy o Eulero non facevano matematica perché la sistemazione assiomatica dei numeri reali è di secoli posteriore.

In effetti, questa visione riecheggia la contrapposizione tra sintassi e semantica. Non bisogna dimenticare che quest'ultima è una creazione ottocentesca, sostanzialmente nata dalla filosofia kantiana: prima non esisteva e infatti prima di allora nessuno pensava neanche lontanamente che la matematica potesse essere qualcosa di puramente formale e *privo di contenuto scientifico*. D'altra parte chi dice che *la sintassi è vuota di contenuto*? Solo chi ritiene che il linguaggio (una volta il greco, oggi la logica matematica) sia perfettamente *naturale*, e quindi *oggettivo*, un semplice riflesso dell'ordine *immediato* delle cose. Ma il linguaggio stesso, specialmente quello logico-matematico, racchiude già in sé una concezione del mondo. Del resto la nostra stessa logica e matematica moderne *mostrano* implicitamente una forma di conoscenza strutturale, non solo formale, molto profonda e inevitabile, ma pur sempre una forma autonoma di conoscenza. In particolare la stessa coppia vero/falso è mutata nel corso della storia e allora nel ricercare qualcosa di *falsificabile*, specialmente nella logica e nella matematica, dovremmo comunque tener conto che la stessa nostra idea di *falso* ha natura linguistica e logica.

Certamente la matematica ha le sue peculiarità e le sue caratteristiche che la contraddistinguono dalle altre scienze, fisica compresa, ma come Russell ha contraddetto Frege, così domani qualcuno potrà contraddire qualcun altro e costringere i matematici a smantellare e ricostruire tutto o parte di quanto fatto fino ad ora. Non lo possiamo certo escludere.

4 Mondo Matematico

Comunque sia, ammesso che anche in matematica si possa parlare di procedure *sperimentali* queste riguardano comunque il suo stesso *mondo matematico* e non una realtà esterna. Talvolta si dice che i numeri non camminano per strada (ma Pitagora avrebbe da ridire su questo).

Quali sono le ragioni profonde per cui siamo sicuri che la matematica non ci possa ingannare? C'è una risposta classica a questo problema, che a prima vista può apparire paradossale: ci possiamo fidare della matematica, perché la matematica "non parla di nulla", non ha vero contenuto. Pertanto non può essere confermata o smentita dall'esperienza. Eppure Galileo, nel dare l'avvio a quella che divenne la scienza moderna, aveva affermato che il libro della natura "è scritto in lingua matematica". Dopo di che siamo indotti a domandarci: è davvero possibile che quella lingua non abbia nulla a che fare con i "contenuti" di cui parla il libro? ([10 p. 38]).

La matematica, da sola, non parlerebbe della realtà. In che senso il mondo è matematico, come talvolta si dice? Allora è la fisica a parlare della realtà? Neanche forze e particelle ad esempio camminano per le nostre strade. Sono concetti astratti, definiti *matematicamente*, poi noi interpretiamo gli esperimenti alla luce di quei concetti. La matematica non è soltanto un linguaggio per parlare della natura o realtà, ma ha spesso (specialmente in fisica) un ruolo costitutivo e serve per costruire gli oggetti stessi della scienza e la loro *corrispondenza* con la realtà. In definitiva, il problema è che in un certo senso la realtà esterna è già matematizzata quando la consideriamo scientificamente, proprio per rendere possibile l'indagine fisica stessa. La realtà studiata dalla scienza non è semplicemente il mondo empirico dei sensi ma qualcosa di diverso. Qualcosa di matematizzato. La forza di gravitazione Newtoniana ad esempio è data tra due *punti materiali*, cose quest'ultime che non esisterebbero in natura. Nessun contenuto empirico? Poi la forza diciamo tra Sole e Terra si ottiene *sovrapponendo* tutte le forze di interazione tra le *infinite* particelle che compongono questi due corpi celesti tramite i concetti di *numero reale, integrazione* e così via. L'immagine scientifica del mondo, specialmente quella fisica, è matematizzata alla fonte, non solo per descrivere i fenomeni ma in un certo senso per creare gli oggetti di indagine. Non esiste cioè una netta distinzione tra quello che chiamiamo realtà fisica e realtà matematica ma queste realtà sono interconnesse tra loro. Anzi, è proprio da questa interconnessione che nasce la *scienza moderna* (su questo punto si vedano [2,3,4,5]). Ma su questo versante si scoperchia un vaso di Pandora: In che senso esistono gli enti matematici? Sono scoperti o inventati? Le possibili risposte spaziano in molte direzioni diverse: realismo, convenzionalismo, formalismo ecc. E ci sarebbe anche l'idealismo che porta all'estremo la presunta riduzione della matematica a puro linguaggio e basta. Se la matematica non parla del mondo fisico, nemmeno la fisica può farlo ed anche un'equazione come la legge del moto di Newton **F**=m**a** non avrebbe relazione con la realtà. Se le "forze" sono termini matematici di equazioni qual è il loro significato fisico? Questa era la posizione del famoso vescovo Berkley per sostenere che la realtà esterna della fisica Newtoniana non esiste ed esistono solo le idee e gli intelletti. *Berkeley affermava che le forze in meccanica erano analoghe agli epicicli in astronomia, vale a dire costruzioni matematiche utili per calcolare i moti dei corpi. Tuttavia, secondo Berkeley, sarebbe stato un errore attribuire a queste costruzioni un'esistenza reale nel mondo. Berkeley affermava che tutto il contenuto della meccanica newtoniana è espresso da un insieme di equazioni [...] Queste "forze" altro non sono che entità matematiche* (21 p. 155-156]).

Certo, si potrebbe dire che quanto detto poteva essere vero per la scienza fino al Settecento, ma che la scienza contemporanea ha trovato invece un suo metodo scientifico autonomo, sostanzialmente empirico, con la matematica e la logica ridotte a strumento linguistico. Ma ancora la storia ([2,3,4,5,6]) mostra quanto questo sia irrealistico: Einstein ha trovato i tensori e il calcolo differenziale assoluto già fatti e la meccanica quantistica ha trovato gli spazi di Hilbert e i suoi modelli (matriciali e funzionali) già teorizzati. E' come se fosse stato inventato l'apriscatole prima delle scatole…

La vera questione allora non è soltanto stabilire se la matematica sia o no una scienza, ma piuttosto dove essa si collochi nell'architettura concreta della scienza reale, e non in quella *sognata* da certa (moderna) filosofia della scienza.

La matematica è senz'altro un linguaggio utile alla fisica ma in un senso costitutivo ne è anche oggetto. E se la matematica non è una scienza che fine fa la fisica?

Ricapitolando, il problema è chiarire in cosa consista l'universo sensibile. Ne fanno parte gli oggetti matematici? La questione è importante per la scienza perché la fisica non parla del mondo sensibile così com'è ma lo sostituisce con concetti matematici. Rispondere in maniera del tutto negativa significherebbe privare la scienza di componenti essenziali. Altrimenti dovremmo anche concludere che la teoria delle stringhe o la meccanica razionale non sono scienza. Certo lo si può anche fare. Basti pensare alle concezioni neopositiviste, analitiche, naturaliste che hanno un'idea della matematica come puro strumento linguistico della scienza. Tesi che può anche avere il suo ascendente, ma senz'altro non è la concezione di scienza di Galileo, Keplero, Newton, Einstein e tanti altri.

Se immaginiamo di apporre un'etichetta sugli oggetti dell'universo che ne esplicitino gli ingredienti costitutivi, dovremmo inserire anche: contiene matematica? Il punto è questo. Galileo la pensava proprio così! Il mondo è anche fatto di matematica. Facciamo notare che la famosa controversia col cardinale Bellarmino era centrata proprio su questo punto. Per il cardinale, sulla scia della tradizione aristotelica, il matematico può parlare *ex suppositione,* senza preoccuparsi cioè della realtà dei modelli geometrici. Quello Copernicano sarebbe solo uno tra i possibili modelli matematici che rendono conto dei fenomeni astronomici. Ma non ci dice nulla su quanto accade *realmente* in natura. Ma questo non poteva valere per Galileo che era realista. E ancora meno per Keplero o Newton. La matematica, eterna e consustanziale a Dio, è una sorta di demiurgo, il mezzo con cui Dio crea e si relazione al mondo. Lo spazio in Newton ad esempio non è solo un ente geometrico ma molto di più. E' il sensorio di Dio, una parte di Dio, Dio stesso. L'immagine è quella di "Dio geometra (matematico)" o anche di "Dio musicista". Certo si tratta di una lettura di tipo mistico-pitagorico. Può non piacerci. Ma la scienza moderna si pone proprio in una tradizione archimedeo-pitagorica e in questi autori il mondo fisico e quello matematico non sono separati e distinti tra loro. Una curva è sia un oggetto geometrico che fisico. La leva è uno strumento sia fisico che matematico. E cosa sono le forze, i campi, le particelle della fisica?

Dire che *la matematica è il linguaggio della scienza* non è allora errato, a condizione però di non avere del linguaggio (anche matematico) una idea strumentale e convenzionalistica, ma riconoscere in esso la costituzione di una determinata *concezione del mondo* e quindi di un determinato tipo di *esperienza,* così che il metodo scientifico non è tanto alla fine qualcosa da *applicare* alla matematica e nemmeno *esterno* ad essa, ma esso trova piuttosto proprio nella matematica le sue stesse specifiche condizioni e forme di esistenza.

Allora perché la matematica piace così tanto agli scienziati? Forse una risposta possibile è semplicemente perché la matematica è essa stessa una scienza. Anzi, perché, come direbbe il buon Gauss, *La matematica è la regina delle scienze!*

Ringraziamenti

Un sentito ringraziamento a L. Borzacchini per le utili discussioni sul tema e per aver letto una bozza iniziale dell'articolo proponendo numerosi miglioramenti.

References

[1] Boncinelli E., Bottazzini,U. (2000). La Serva Padrona, Raffaello Cortina Editore.

[2] Borzacchini L. (2005). Il Computer di Platone, Dedalo Editore.

[3] Borzacchini L. (2009). Il Computer di Ockham, Dedalo Editore.

[4] Borzacchini L. (2015). Il Computer di Kant, Dedalo Editore.

[5] Borzacchini L. (2016). La Scienza di Francesco, Dedalo Editore.

[6] Borzacchini L. (2019). La Solitudine di Leonardo, Dedalo Editore.

[7] Bramanti M. (2003). Che cos'è la Matematica, ovvero perché la matematica può piacere, Emmeciquadro 17, 38-48.

[8] Carbonaro B. (2012). La Probabilità nello sviluppo della scienza secondo Karl Popper, Mathesis Periodico di Matematiche 1, 50-62.

[9] Carbonaro B., De Rosa C. (2013). La Probabilità nello sviluppo della scienza secondo Karl Popper II, Mathesis Periodico di Matematiche 1, 75-86.

[10] Dalla Chiara M. L., Toraldo di Francia G. (2000). Introduzione alla Filosofia della Scienza, Laterza Editore.

[11] Du Sautoy M. (2005). L'Enigma dei Numeri Primi, Rizzoli Editore.

[12] Giusti E. (1999). Ipotesi sulla Natura degli Oggetti Matematici, Boringhieri Editore.

[13] Granieri L. (2015). Dio c'è e la Scienza..., LaDotta Editore.

[14] Granieri L. (2004). Paradossi, Ulisse SISSA Bibiloteca dei 500, Trieste.

[15] Granieri L. (2016). Per definizione, AIRInforma.

[16] Granieri L. (2016). Essere o non essere, questo è il problema! Scienze e Ricerche 24, 71-74.

[17] Granieri L. (2016). Pi-Greco & Company, Mahesis Periodico di Matematiche 3, 9-16.

[18] Israel G. (2003). Scienza pura e applicata nell'ultimo trentennio: una trasformazione radicale, LLULL Revista de la Sociedad Espanola de Historia delas Ciencias y de las Tecnicas 26, 859-888.

[19] Israel G. (1996). La Visione Matematica della Realtà, Laterza Editore.

[20] Losee J. (2009). Filosofia della Scienza, Il Saggiatore Editore.

[21] Russo L. (1996). La rivoluzione dimenticata, Feltrinelli Editore.

[22] Stewart I. (2018). I Numeri Uno, Einaudi Editore.

[23] Veronesi C. (2015). Fisica senza Matematica: è possibile? MATEpristem.

[24] Wigner E. P. (2017). L'Irragionevole Efficacia della Matematica nelle Scienze Naturali, Adelphi Editore.

Science & Philosophy Volume 7(2), 2019, pp. 125-140

A research on Kırghız students' before and after their internship period about perceptions of Turkey*

Yusuf AVCI[1]
Gamze ÇELİK[2]
Ayşe Dağ PESTİL[3]

Abstract

Among Turkic speaking countries, there is solidarity in economic, political and military fields. Moreover, they carry out common studies within the universities of these countries. As a result, the relationship among the communities is getting stronger via these studies. This research serves as an example of this development. The problem sentence of the research; "Do students' perceptions change about Turkey after they've completed an internship period in Turkey?". In this research, it was studied to determine Kyrgyz students' impression about our country Turkey, before and after their internship period in Turkey. The study was implemented within the survey model design. Research's universe is the students who study in Yusuf Balasagun Krygyz National University, Liberal Arts University (Bugu), in Kyrgyzstan Turkey Manas University during their education in the year of 2018-2019. As for the research sampling, students who are in the city of Antalya for the purpose of the internship were selected from Yusuf Balasagun Kyrgyz National University, Liberal Arts University (Bugu), in Kyrgyzstan Manas University. A total of 49 students attended the research. According to the results of the research, internship students have generally positive opinions about Turkey and Turkish people. This is a pleasing result for our country. The students think that the Language Enhancement Program will be useful for them to learn Turkish better.

Key Words: Kyrgyzstan, Turkey, Linguistics, Sociolinguistics.[4]

---

* This research derived from the ÇOMÜ BAP Project coded as SUA-2018-2766 – and called as "Socio-Linguistic Evaluation of Language Reinforcement Program". This article has been expanded and prepared from the paper presented at the Department of Communication and Social Research (CORIS) of the Sapienza University (12 December 2019) in Rome.

[1] Çanakkale Onsekiz Mart University, Education Faculty, Turkish Language Education Department, Çanakkale, Turkey; yavci@comu.edu.tr.

[2] Çanakkale Onsekiz Mart University, Education Faculty, Turkish Language and Literature Education Deparment, Çanakkale, Turkey; gamzecelik@comu.edu.tr .

[3] Çanakkale Onsekiz Mart University, School of Foreign Languages, Department of Translation and Interpreting, Çanakkale, Turkey; aysedag@comu.edu.tr

1. Introduction

Turkic speaking countries are states which share common linguistic and cultural components. Today, even though these countries are spread out over wide geographies, these states manage their relationship at a high level to improve their common target.

A language is a communication tool in its simplest aspect. The aim in communication is to convey the emotion, thought and concept that occur in the person and to get the result accordingly. The concept is formed and shaped first in the mind and then poured into the molds to be transmitted to the other party. The pouring process into these molds, that is, the syntax, forms the tongues. The way of living determines this way of thinking. In this respect, language is a differentiated practice that separates cultural communities. Culture, on the other hand, is a way of life and thinking that shows differentiation from the community to community as well as the general method of adapting to the social environment. In this aspect, "Culture is the mirror and reflection of a language!" is also expressed as well. In addition to these considerations, Avcı [2] said that about languages; “language is a lifestyle”.

We see the society within the language and understand it with the language. The language of a society is the spirit of that society and the spirit of that society is its language. It is really difficult to think of two other things that are highly identical. The first reason for the alphabet change under the leadership of Atatürk is, to maintain relationships with Turkic countries [3].

We can see that, with the structures that do not have a depth of meaning, cultural depth and national consciousness do not occur [4]. There is a close relationship between languages and worldviews of the nations. It is not only the rules that distinguish a language from others. Yet, language gives the society the ability to be different, to think differently, to act and to live differently as well. In this way, societies' views of the world and the values they attach to human beings differ. Within this framework, the thoughts of societies and people manifest themselves through the balance formed between matter and human or based on caring one more over other by way of the languages in which they use attitudes. Every living language is open to discussion and change [1].

When we look at the language of Kyrgyzstan, it is possible to see that Kyrgyz language has not been disturbed, Kyrgyz culture lives in any environment and has not become corrupted. Kyrgyz language has preserved itself intact with

[4] Received on November 30th, 2019. Accepted on December 25th, 2019. Published on December 30th, 2019. doi: 10.23756/sp.v7i2.484. ISSN 2282-7757; eISSN 2282-7765.

children's purity. Many words from foreign languages were able to protect themselves by becoming Kirkhiz. On the other hand, Turkish words, as a result of spoken language, continue to exist and subject to advanced sound adaptations. In this respect, we see that it has existed outside the negative impact area of foreign languages and cultures. Despite the Russian tsars and the communist ideology and culture, the Kyrgyz culture has preserved its originality. In every society, sometimes there may be those who have undergone excessive changes. Whereas, we should not be surprised to see Kyrgyz culture original. Not only in Kyrgyz, but in all Turkish republics, the lack of unity of language causes problems [8]

Along with this, there may be people who sometimes change too much, as in every society. These are not enough to affect the actual structure. In a similar study, Kayadibi [6], who conducted a similar study with graduate students, stated that the persistence of what was learned in teaching environments where the application dimension of education was lacking would be low and that the effect of teaching processes was not at the desired level.

According to Radloff [7]; no language family in the world is as wide as Turkish. Among Turkic speaking countries, there is solidarity in the economic, political and military fields. Moreover, within the universities of these countries, they implement common studies. As a result, the relationship among the communities is getting stronger via these studies. This research serves as an example of this common interest.

2. Problem sentences

Research's problem sentence: "Do students' perceptions change about Turkey after they've completed an internship period in Turkey?" It is determined by way of the questions below based on the problem sentence:

What are students' opinions concerning having information about Turkey?

What are students' opinions concerning their thoughts about Turkey's opportunities?

What are students' opinions concerning their ideas about Turkish culture?

What are students' opinions concerning their thoughts about getting an education in Turkey?

What are students' opinions concerning their internship aid for them in Turkey?

What are students' opinions concerning having an internship in Turkey?

3. Method

In this research, it is studied to determine Kyrgyz students' impression about our country Turkey, before and after their internship impression about our country Turkey, before and after their internship period in Turkey. The research method is the survey model. According to Karasar [5], the survey model includes a universe consisting of many elements. In order to create a general perception of the whole universe, survey arrangements are established on the whole universe or on a group taken from it. In our study, the individuals who were the subject of the study were defined in their natural conditions. After this definition, results were tried to be found. In addition, evaluations were made in light of the data obtained.

4. Universe and sample of the study

Research's universe is students who study in Yusuf Balasagun Krygyz National University, Liberal Arts University (Bugu), in Kyrgyzstan Turkey Manas University during their education in the year of 2018-2019. As for the research sampling, students who are in the city of Antalya for the purpose of the internship were selected from Yusuf Balasagun Kyrgyz National University, Liberal Arts University (Bugu), in Kyrgyzstan Manas University.

Participants are a total of 49 undergraduate students. Participants who have partaken in our research have been chosen among students who came for an internship in Turkey. They were volunteer students who wanted to join the research with their own consent.

Gender	**N**	**%**
Man	9	18.4
Woman	40	81.6
Total	49	100.0

Table 1. Distribution of students in the sample by gender.

According to Table 1, the results show that 9 of the students (18.4%) are male and 40 (81.6%) are female.

According to the Table 2, the results shows that 2 (4.5%) of the participants are 17 years old, 3 (6.8%) 18 years old, 21 (47.7%) 19 years old, 8 (18.2%) 20 years old, 5 (11.4%) 21 years old, 3 (6.8%) 22 years old and 2 (4.5%) are 23 years old. In addition, 5 people did not give information about their genders. Most of the participants were 21 years old with a mean of 47.7 %.

According to Table 3, the results show that 37 (78.7%) of the students are 1st-grade students. 7 (14.9%) of them are 3rd-grade students. 3 (6.4%) are 4th-grade students. And, 2 students did not specify in which class they studied. As it is seen from the data, the majority of the participants are 1st-grade students with an average of 78.7%.

Age	**N**	**%**
17	2	4.5
18	3	6.8
19	21	47.7
20	8	18.2
21	5	11.4
22	3	6.8
23	2	4.5
Total	44	100.0

Table 2. Distribution of students in the sample by age range.

Class	**N**	**%**
1	37	78.7
3	7	14.9
4	3	6.4

Table 3. The distribution of the sample of students according to the class they read.

5. Findings

In this part of the research, statistical analysis of the data obtained from the questionnaires was conducted. In this section, the findings and interpretations related to the findings can be seen.

Students' Perception of Learning About Turkey	I do not agree at all		Disagree	Agree	I slightly agree	Certainly you're right
I have sufficient information about Turkey.	f	-	6	6	14	5
	%	-	19,4	19,4	45,2	16,1
I learned first about Turkey from my parents.	f	14	10	10	8	9
	%	27,5	19,6	19,6	15,7	17,6

My parents went to Turkey and they gave information about Turkey.	f	24	9	8	5	6
	%	46,2	17,3	15,4	9,6	11,5
My parents, who went to Turkey, shared with positive opinions about Turkey. (The family who went to Turkey can answer.)	f	12	7	9	5	8
	%	23,1	13,5	22,0	12,2	19,5
I know Turkey from the television and I wonder about it so much.	f	3	10	17	5	16
	%	5,9	19,6	33,3	9,8	31,4
I learned that there is the same origin of language between people who live in Turkey and us. For this reason, I want to know about this country from close.	f	3	3	12	9	24
	%	5,9	5,9	23,5	17,6	47,1
I learned about Turkey from Turkish people who live in Kyrgyzstan and live around the university	f	5	7	8	11	21
	%	9,6	13,5	15,4	21,2	40,4
My interest in Turkey began after I won the university exam.	f	5	9	13	9	16
	%	9,6	17,3	25,0	17,3	30,8
My knowledge about Turkey was formed through the exchange students who go to Turkey and come back.	f	7	9	15	14	6
	%	13,7	17,6	29,4	27,5	11,8

Table 4. Description of the results related to the students' perception of learning about Turkey.

According to Table 4, the results show that the Process of the Students' Learning about Turkey as follows:

16.1% of respondents replied the article "I have enough information about Turkey'' as "Certainly you're right,". 45.2% of the respondents stated their preferences as 'I slightly agree ", 19.4% as " Agree ", 19.4% as " Disagree ".

"I learned first about Turkey from my parents." of respondents replied the item % 17,6 as "Certainly you're right", % 15,7 as "I slightly agree", % 19,6 as "Agree", % 19,6 as "Disagree", % 27,5 as "I do not agree at all". Most students do not participate in that question. This shows that the area is considerably less than the number of students has enough information from their family about Turkey. This situation shows that Turkey remains far away from Kyrgyzstan's society in Turkic speaking countries. However, it could have been possible for a country where we are close as a culture to get to know us better and to introduce us to its own society. We should not break our social ties with Kyrgyzstan.

"My parents went to Turkey and they gave information about Turkey." of respondents replied the item generally % 46,2 as "I do not agree at all". Students said % 11,5 as "Certainly you're right", % 9,6 as "I slightly agree", % 15,4 as "Agree", % 17,3 as "Disagree". According to participants of a very small part of the students' families have an experience to come to Turkey. However, for the development of dialogue between the two countries, visits between countries are of great importance. It would be beneficial to carry out studies to improve this situation in our country.

My parents, who went to Turkey, shared with positive opinions about Turkey. (The family who went to Turkey can answer.) of respondents replied the item % 19,5 "Certainly you're right", % 12,2 "I slightly agree", % 22,0 "Agree", % 13,5 "Disagree" and % 23,1 "I do not agree at all". Having positive thoughts about Turkey is a pleasing situation for our country. Nevertheless, in order to increase this perspective, we need to continue to show the sensitivity required as a country.

"I know Turkey from the television, and I wonder about it so much." of respondents replied the item generally % 33,3 as "Agree". Students said % 31,4 as "Certainly you're right", % 9,8 as "I slightly agree", % 19,6 as "Disagree" and % 5,9 as "I do not agree at all". This case shows that students get to know Turkey through the media.

"I learned that there is the same origin of language between people who live in Turkey and us. For this reason, I want to know this country from close." of respondents replied the item, major part % 47,1 as "Certainly you're right". Other participants said, % 17,6 as "I slightly agree", % 23,5 as "Agree", % 5,9 as "Disagree" and % 5,9 as "I do not agree at all". Turkey and Kyrgyzstan have the language and cultural unity thanks to be in the same language family. This case of reality played an important role for the student in getting to know Turkey closely.

"I learned about Turkey from Turkish people who live in Kyrgyzstan and live around the university." of respondents replied the item % 40,4 as "Certainly you're right". Other participants said % 21,2 as "I slightly agree", % 15,4 as "Agree", % 13,5 as "Disagree" and % 9,6 as "I do not agree at all". A large part of the information they learn about Turkey from the Turks living around the university in their countries.

"My interest to Turkey began after I won the university exam." of respondents replied the item % 30,8 as "Certainly you're right". Other participants said, % 17,3 as "I slightly agree", % 25,0 as "Agree", % 17,3 as "Disagree" and % 9,6 as "I do not agree at all". According to this, students have begun to increase their knowledge about Turkey after beginning their university education. University is a period in which young people get to know themselves better. In addition, the desire to gain experience of working and living in different places is more intense in this period. Therefore, it will not be wrong to assume increased students' interest in Turkey for that period.

"My knowledge about Turkey was formed through the exchange students who go to Turkey and come back." of respondents replied for the item % 29,4 as "Agree". The majority agreed with this item. Other participants said, % 11,8 as "Certainly you're right", % 27,5 as "I slightly agree", % 17,6 as "Disagree", % 13,7 as "I do not agree at all". Kyrgyz students come up with programs to strengthen their language in Turkey has allowed them to have a wider knowledge about Turkey. This shows that the language reinforcement program is beneficial for the students.

Students' Perception of Opportunities in Turkey		I do not agree at all	Disagree	Agree	I slightly agree	Certainly you're right
I want to prove the information that I learned from my parents, by my own experience.	f	3	5	17	4	21
	%	6,0	10,0	34,0	8,0	42,0
I know about Turkey's advanced economy and culture and I want my expectation to be real.	f	-	4	13	8	27
	%	-	7,7	25,0	15,4	51,9
I think Turkey is a powerful country in the world regarding education.	f	3	2	16	9	20
	%	6,0	4,0	32,0	18,0	40,0
I think Turkey is a powerful country in the world regarding the industry.	f	-	3	19	15	12
	%	-	6,1	38,8	30,6	24,5
I think Turkey is a powerful country in the world regarding the services sector (tourism, health etc.).	f	1	2	17	7	24
	%	2,0	3,9	33,3	13,7	47,1
I think Turkey is a powerful country in the world regarding military education.	f	2	7	19	14	10
	%	3,8	13,5	36,5	26,9	19,2
I think finding a job and earning money is easy in Turkey.	f	7	14	17	13	1
	%	13,5	26,9	32,7	25,0	1,9

I think Turkey is a country which is reliable, comfortable and peaceful.	f	4	8	17	10	13
	%	7,7	15,4	32,7	19,2	25,0

Table 5. Description of the results related students' descriptions about the opportunities in Turkey.

"I want to prove the preliminary information about Turkey that I learned from my family by seeing with my own eyes": for this item the 42.0% of the participants answered as "Certainly you're right". 8% of the participants answered as "I slightly agree', 34% as "Agree", 10% as "Disagree "and 6% "I do not agree at all".

"I know about Turkey's advanced economy and culture and I want my expectation to be real." for this item the % 51,9 of the participants answered as "Certainly you're right", % 25 of the participants answered as "Agree". % 15,4 of the participants answered as "I slightly agree'" and % 7,7 of the participants answered as "Disagree". Nobody said "I do not agree at all". As seen, the majority of the participants stated that they agree with this article.

"I think Turkey is a powerful country in the world regarding to education." of the participants answered % 40 as "Certainly you're right". Participants said % 18 as "I slightly agree'", % 32 as "Agree", % 4 as "Disagree" and % 6 as "I do not agree at all".

"I think Turkey is a powerful country in the world regarding to industry." of the participants answered % 38,8 as "Agree". They accept this item mainly. % 30,6 as "I slightly agree'", % 24,5 as "Certainly you're right" and % 6,1 as "Disagree". Any students said, "I do not agree at all".

"I think Turkey is a powerful country in the world regarding to services sector (tourism, health etc.)" of the participants answered % 47,1 as "Certainly you're right". The other participants said %33,3 as "Agree", % 13,7 as "I slightly agree'", % 3,9 as "Disagree" and % 2 as "I do not agree at all".

"I think Turkey is a powerful country in the world regarding to military education." of the participants answered % 36,5 as "Agree". So, generally it is accepted. % 26,9 as "I slightly agree", % 19,2 as "Certainly you're right", % 13,5 as "Disagree", % 3,8 as "I do not agree at all".

"I think finding a job and earning money is easy in Turkey." of the participants answered % 32,7 as "Agree", % 26,9 as "Disagree". As in many countries, finding a job for young people does not seem to be easy in our country as well. The other participants said % 25 as "I slightly agree", % 13,5 as "I do not agree at all" and % 1,9 as "Certainly you're right".

"I think Turkey is a country which is reliable, comfortable and peaceful." of the participants answered % 32,7 as "Agree". % 25 as "Certainly you're right", % 19,2 as "I slightly agree", % 15,4 as "Disagree", % 7,7 as "I do not agree at all". As seen, the majority of respondents have positive opinions about Turkey.

Students' Ideas About Turkish Culture		I do not agree at all	Disagree	Agree	I slightly agree	Certainly you're right
My parents have negative opinions about the Turkish people.	f	16	17	12	4	3
	%	30,8	32,7	23,1	7,7	5,8
People around me say that Turkey and Turkish people aren't reliable.	f	10	18	9	11	4
	%	19,2	34,6	17,3	21,2	7,7
I think there are a lot of people in Turkey also, who don't get pleasure from life, don't know Turkey's blessings and don't use them.	f	4	18	13	14	3
	%	7,7	34,6	25	26,9	5,8
I think Turkish people are helpful.	f	1	6	17	12	14
	%	2	12	34	24	28
I think Turkish people are self-interested (selfish).	f	5	24	12	6	8
	%	9,6	46,2	23,1	11,5	9,6
I think food and clothes are various and cheap in Turkey.	f	4	18	12	9	8
	%	7,8	35,3	23,5	17,6	15,7

Table 6. Description of the results related to students' ideas about Turkish culture.

The majority of the participants stated that I do not agree for the item "My family elders have negative information about the Turks". 32.7% of the participants think that this kind of situation never exists among the family elders. 30.8% of the participants stated the item as "Disagree", 23.1% of them stated as "I agree ", 7.7% stated that "I slightly agree "and 5.8% stated that "You are absolutely right."

"People around me say that Turkey and Turkish people aren't reliable." Most of the participants stated that disagree for the item. % 34,6 stated that "Disagree". The participants said % 21,2 as "I slightly agree", % 19,2 as "I do not agree at all" % 17,3 as "Agree" % 7,7 as "Certainly you're right".

"I think there are a lot of people in Turkey also, who don't get pleasure from life, don't know Turkey's blessings and don't use them." The majority of the participants stated that disagree for the item. As can be seen in the table;

participants said %34,6 as "Disagree", % 26,9 as "I slightly agree", % 25 as "Agree" % 7,7 as "I do not agree at all" and % 5,8 as "Certainly you're right".

"I think the Turkish people are helpful." The majority of the participants stated that agree for the item. % 34 participants said as "Agree", % 28 participants as "Certainly you're right", % 24 participants as "I slightly agree", % 12 participants as "Disagree" and % 2 participants as "I do not agree at all". Most of the participants think that Turks are helpful. The participants have a positive point of view towards the Turks.

"I think Turkish people are self-interested (selfish)." The majority of the participants stated that disagree for the item. The participants said % 46,2 "Disagree", % 23,1 "Agree", % 11,5 "I slightly agree", % 9,6 "I do not agree at all" and equal with this % 9,6 "Certainly you're right".

"I think food and clothes are various and cheap in Turkey." The majority of the participants stated that disagree for the item. The participants said % 35,3 "Disagree", % 23,5'i "Agree", % 17,6 "I slightly agree", % 15,7 "Certainly you're right" and % 7,8 "I do not agree at all".

Students' Ideas about Education in Turkey		I do not agree at all	Disagree	Agree	I slightly agree	Certainly you're right
I think I will meet my expectation about Turkey thanks to Language Enhancement Program.	f	-	4	13	3	27
	%	-	7,8	25,5	5,9	52,9
I think my Turkish will improve thanks to Language Enhancement Program.	f	3	2	10	5	30
	%	6	4	20	10	60
I think my work and life experience will improve thanks to Language Enhancement Program.	f	2	4	10	8	27
	%	3,9	7,8	19,6	15,7	52,9
Because I don't have work experience, I suppose I will overcome my work fear.	f	4	6	12	8	21
	%	7,8	11,8	23,5	15,7	41,2

Table 7. Description of the Results Related Students' Ideas about Education in Turkey Students' Ideas about Education in Turkey

"I think I will meet my expectation about Turkey thanks to Language Enhancement Program." Most of the participants stated that positive for the item. Participants said 52,9 "Certainly you're right", % 25,5 "Agree", % 7,8 "Disagree" and % 5,9 "I slightly agree". Nobody said "I do not agree at all".

"I think my Turkish will improve thanks to Language Enhancement Program." of the participants answered as "Certainly you're right". The other participants said % 60 "Certainly you're right", % 20 "Agree", % 10 "I slightly agree", % 6 "I do not agree at all" and % 4 "Disagree".

"I think my work and life experience will improve thanks to Language Enhancement Program". Most of the participants stated that positive for the item. % 52,9 participants said "Certainly you're right". % 19,6 participants said "Agree", % 15,7 participants "I slightly agree", % 7,8 participants "Disagree" and % 3,9 participants "I do not agree at all".

"Because I don't have work experience, I suppose I will overcome my work fear." of the participants answered as % 41,2 "Certainly you're right". Participants % 23,5 as "Agree", % 15,7 as "I slightly agree", % 11,8 as "Disagree" and % 7,8 as "I do not agree at all".

Students' Opinions on "The Contribution of the Internship They Do in Turkey for Their Own Personal Development"		I do not agree at all	Disagree	Agree	I slightly agree	Certainly you're right
I think my knowledge and experiences will change.	f	2	4	16	8	22
	%	3,8	7,7	30,8	15,4	42,3
I want to see that work of interpreter can be useful in different social stratum.	f	-	-	15	9	28
	%	-	-	28,8	17,3	53,8
I think my practical Turkish language will be improved.	f	1	4	10	5	32
	%	1,9	7,7	19,2	9,6	61,5
I think my knowledge about the same origins of Kyrgyz and Turkish language will be improved.	f	-	3	11	10	27
	%	-	5,9	21,6	19,6	52,9
I think that the knowledge I obtain will contribute to Turkish World in terms of social, commercial and economy.	f	-	4	13	15	18
	%	-	8	26	30	36
I think this program can be effective to start a business easily in Turkish World.	f	-	5	14	21	11
	%	-	9,8	27,5	41,2	21,6
I don't think this program will be helpful for me.	f	10	6	9	5	18
	%	20,8	12,5	18,8	10,4	37,5

This program doesn't meet my expectations in Turkey except for earning money.	f	13	15	7	10	6
	f	25,5	29,4	13,7	19,6	11,8

Table 8. Description of the results related to students' opinions on "the contribution of the internship they do in Turkey for their own personal development".

For the item "I think that my knowledge and experience will change", 42.3% of the participants answered as "Certainly you're right". 30.8% of the participants stated "I agree", 15.4% as "I slightly agree", 7.7% as "I do not agree" and 3.8% as "I do not agree at all".

"I want to see that work of interpreter can be useful in different social strata." of the participants answered as "Certainly you're right" % 53,8, % 28,8 as "Agree", % 17,3 as "I slightly agree". Nobody said "Disagree" or "I do not agree at all".

"I think my practical Turkish language will be improved." of the participants answered % 61,5 as "Certainly you're right", % 19,2 as "Agree", % 9,6 as "I slightly agree", % 7,7 as "Disagree" and % 1,9 as "I do not agree at all".

"I think my knowledge about the same origins of Kyrgyz and Turkish language will be improved." of the participants answered % 52,9 as "Certainly you're right", % 21,6 as "Agree", % 19,6 as "I slightly agree", % 5,9 as "Disagree". Nobody said "I do not agree at all".

"I think that the knowledge I obtain will contribute to Turkish World in terms of social, commercial and economy." of the participants answered % 36 as "Certainly you're right", % 30 as "I slightly agree", % 26 as "Agree" and % 8 as "Disagree". Nobody said "I do not agree at all".

"I think this program can be effective to start a business easily in Turkish World." of the participants answered % 41,2 as "I slightly agree", % 27,5 as "Agree", % 21,6 as "Certainly you're right", % 9,8 as "Disagree". Nobody said "I do not agree at all".

"I don't think this program will be helpful for me." of the participants answered % 37,5 as "Certainly you're right", % 20,8 as "I do not agree at all", % 18,8 as "Agree", % 12,5 as "Disagree" and % 10,4 as "I slightly agree".

"This program doesn't meet my expectations in Turkey except earning money." of the participants answered % 29,4 "Disagree", % 25,5 as "I do not agree at all", % 19,6 as "I slightly agree", % 13,7 as "Agree" and % 11,8 as "Certainly you're right".

Students' Opinions On "Having Information About the Internship Program in Turkey"		I do not agree at all	Disagree	Agree	I slightly agree	Certainly you're right
I learned about Language Enhancement Program after I won the university examination.	f	5	4	13	3	25
	%	10	8	26	6	50
I learned about Language Enhancement Program from Turkish teachers.	f	9	6	16	5	15
	%	17,6	11,8	31,4	9,8	29,4
I learned about Language Enhancement Program from students who previously benefited from this program.	f	8	7	12	9	14
	%	16	14	24	18	28

Table 9. Description of the results related to students' opinions on "having information about the internship program in Turkey".

50% of the participants stated that "Certainly you're right" for the item. "I learned The Language Reinforcement program after I entered the university." 26% of the participants stated as " I agree ", 10% stated as "I completely disagree ", 8% of the participants stated as " I do not agree at all "and 6% of them stated as "I slightly agree."

"I learned about Language Enhancement Program from Turkish teachers." of the participants answered % 31,4 as "Agree", % 29,4 as "Certainly you're right", % 17,6 as "I do not agree at all", % 11,8 as "Disagree" and % 9,8 as "I slightly agree".

"I learned about Language Enhancement Program from students who previously benefited from this program." of the participants answered % 28 as "Certainly you're right", % 24 as "Agree", % 18 as "I slightly agree", % 16 as "I do not agree at all" and % 14 as "Disagree".

6. Results, Discussion and Recommendations

The perception of change may vary from society to society. When we look at the issue in the case of Kyrgyzstan, the reason and direction of these changes are thought-provoking, and these should be examined. Based on the opinions on meeting the housing needs, it was found that the expectations of students for housing needs were not met to a large extent.

In linguistics studies, it has been seen that changes in language always occur in its place. We cannot eliminate the change in language. Language is a living entity and change is in its nature [1].

People live under the management and control of a certain language that constitutes the communication environment of the society in which they are members. The biggest mistake is to assume that people are adapted to the real world directly and without the effects of language use, and that language is merely an ordinary tool for meeting their thinking or communication needs. What is certain is that the "real world" is largely based on the subconscious language habits of the community.

The person is satisfied or rewarded as he/she integrated with the world view to the extent that the culture in which the person lives. As well as one's observable behaviour, the world of his/her consciousness is under the management and control of influences from the culture. Because the content and pattern of being conscious are reflected in the general communication environment from the beginning. For this reason, it is shaped and conditioned by the culture.

To everyone, his/her own way of life and worldview are good, pleasant, right and rational. Any behaviour, emotion, thought or belief that deviates from these "criteria" in one way or another is considered strange and contrary to the tradition.

When language and culture are taken together, it is seen as a way of life, as a whole. The easiest thing is to criticize for the features counted and mentioned above. It is not possible to conduct healthy analyzes without evaluating the historical process by way of the help of the sociological data. This research, which aims to determine the impact of cultural depth between language and society, is expected to contribute to socio-linguistic studies.

According to the results of the research, Kyrgyz students have gotten to know Turkey from television and the university environment not from their families. There is a small number of students' families who have come to Turkey before. Nonetheless, students have generally positive opinions about Turkey and Turkish people. This is a pleasing result for our country. The students think that the Language Enhancement Program will be beneficial for them to learn Turkish. It will also give them a chance of work experience and help them overcome their fear of work.

After these determinations, with the effectiveness of the government forces that do strategy designating and language and culture policy planning in Turkey, following works can be done:

Apart from Kyrgyzstan, research can be conducted with students from different countries such as Azerbaijan, Uzbekistan and Turkmenistan. Comparative researches on linguistics can be done. Different researches can be done about the developments experienced in teaching the Turkish language.

Research can be done on how Turkish is taught by native teachers in different parts of the world. All human resources to be employed in these republics need to be educated since it is the human factor that raises and disrupts relations to an advanced level. For these purposes, it can be suggested to make correct studies in accordance with the historical process by identifying the deficiencies and mistakes in our relations with Turkestan Republics. In the following years, it may be ensured that new students will be educated in environments where accommodation and physical facilities are developed.

References

[1]Akay, R. (2007). Dil değişiminin dilsel ve toplumsal nedenleri, Uluslararası İnsan Bilimleri Dergisi, Cilt:4, Sayı:1, 1-9.

[2]Avcı, Y. (2012). Yabancı dil olarak Türkçe öğretiminde dil düşünce analizi teorisi, Manas Sosyal Araştırmalar Dergisi, Cilt 1, Sayı 3, 1-15.

[3]Azam, M. (1992). “Elifbamiz Ufukleri” Şark Yulduzu, s.10, Taşkent.

[4]Baltabayev, H. (2007). Fıtrat ve Ceditçilik, Alişer Nevai Namidegi Özbekistan Milli Kütüphanesi Neşriyatı, Taşkent.

[5]Karasar, N. (2007). Bilimsel araştırma yöntemi, Ankara: Nobel Yayın Dağıtım.

[6]Kayadibi, F. (2001). Eğitim Kalitesine Etki Eden Faktörler ve Kaliteli Eğitimin Üretime Etkisi, İstanbul Üniversitesi İlahiyat Fakültesi Dergisi, 3(1), 71-94.

[7]Radloff, W., Kunos, I. (1998). Proben (Aktaran ve Hazırlayan: Sakaoğlu,S., Ergun, M.) TDK, Ankara.

[8]Şaabdurahmanov, Ş. Askeroca, M. Hacıev, A. Resulov, İ.Danıyarov(1980), Hazirgi Özbek Edebi Tili, Taşkent

Science & Philosophy, Volume n.7, Issue n.2, 2019

Contents

Published by APAV (Accademia Piceno - Aprutina dei Velati in Teramo)