

Afeka Journal of Engineering and Science

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Editors' Preface

Dear readers,

The coronavirus crisis burst into our lives in Israel in the spring of 2020 and changed them in one fell swoop. The higher education system in Israel switched to online teaching within a few days and adapted the nature of studies to the demands of social distancing. This move necessitated mental flexibility, technological organization, development of teaching methods, development of assessment means and so on. We believe that the success of the academy in Israel deserves all praise, in light of its admirable coping with the complex reality that has been forced upon us, which clearly indicates the high quality of the academic and administrative staff in colleges and universities throughout the country.

The papers that are featured in the second issue of the multidisciplinary *Afeka Journal* were written during the coronavirus crisis. Some of them reflect the effects of the crisis in various areas in which engineering is a direct factor. Thus, for example, Prof. Yossi Rosenwaks and Prof. Arnon Bentur write about the expected and required change in the training of engineers in the coming years. Captain Omer Beck writes about the civil aviation industry's handling of the worst crisis in the history of airlines. Dr. Idan Militscher talks about how psychological therapies, especially sexual therapies, are performed online. Dr. Ronen Bar-El discusses the question of the effectiveness of separating the authorities regulating drugs and vaccines, while the race is on to find a vaccine for Covid-19.

Inevitably, our new associative space affects the way we read the rest of the papers in the current issue. For example, Dr. Itzik Yosef talks about the need for causal theories as opposed to statistical models to provide accurate predictions about the future. Dr. Gabi Shafat emphasizes the importance of critical and creative thinking and self-study in the world of engineering. Dr. Doron Avital writes about the Trump phenomenon as a reference point for examining the liberal order of a "flat world". Dr. Sharon Geva talks about women in the world of engineering through the story of Rachel Shalon, who was the first woman to reach the rank of professor at the Technion. Dr. Sharon Gordon shows how the evolution of money has happened through technological revolutions. Dr. Galit Wellner reveals the process we all experience in our relations with technology, in which technology directs us rather than the other way.

We are at the beginning of a new academic year, 2020-2021. The second wave of the pandemic is hitting Israel and other countries around the world, and although we hear the occasional news about progress being made in finding a vaccine for the virus, it seems that it will be quite some time before we get through the crisis. The hardship, complications and suffering of people around the world and in Israel notwithstanding, the crisis we are experiencing has forced us all to rethink our lives and act creatively to push through it. This is the finest hour of academia in Israel.

We hope you enjoy your reading,

Dr. Kuti Shoham – Chief Editor

Dr. Yaron Cohen-Tzemach – Scientific Editor

Mr. Ran Cohen – Linguistic Editor

Opening Remarks

I am both proud and excited to preface the second issue of the Afeka Journal of Engineering and Science.

The Israeli engineer is the true force behind the success of Israeli industry and specifically the high-tech industry. In order for the country to maintain its international status in the field, grow its economy and expand its industry, there is a need for excellent engineers at the forefront of technological research and development. The coronavirus crisis has made clear to the world just how crucial – and even life-saving – engineers can be in a crisis as complex as a global pandemic.

As an institute for higher education responsible for educating the next generation of engineers, we have an obligation toward the personal and professional development of each and every one of our students. In addition to being up-to-date with the latest scientific and engineering knowledge, new graduates integrating into the workforce are required to demonstrate a variety of personal skills such as multidisciplinary teamwork, self-learning, effective communication, critical thinking and creativity. At Afeka, we place an emphasis on equipping our graduates with the skills they need for successfully integrating into the industry, conducting research and development, and for becoming well-rounded individuals who contribute to society.

An awareness of the strong impact engineers have on our lives and of the vital skills modern engineers are required to demonstrate, has long led us to initiate a comprehensive cross-organizational transformation in the educational process we provide our students. The change is evident in our updated curricula and learning outcomes, pedagogy and evaluation methods, restructured learning and work spaces, wide range of extra-curricular activities offered Afeka students, and in the open dialogue we have created with the Israeli industry and education system.

The Coronavirus crisis threatened to completely disrupt academic life in Israel and around the world, but at Afeka we also view it as an opportunity for growth and innovation. As the crisis unfolded, like all academic institutes, we were forced into distance teaching virtually overnight. It soon became clear however, that online courses should not just be mirrored versions of frontal lectures. Successfully dealing with the crisis meant that we needed to cultivate a unique learning experience that combines synchronous and asynchronous learning, as well as frontal and online learning. It is this line of thinking that led to the birth of the blended pedagogy used at Afeka.

The way we view engineering education at Afeka is consistent with our ability to cope with the crisis, and it can even be said that we are now making changes that will affect Afeka for years to come. Yet, with all this being said, our main mission – educating excellent engineers with the knowledge and skills required in the modern workforce – stands firm. We will continue to see every challenge as an opportunity for development and growth, and are already preparing for the “day after” in order to ensure that our uniqueness as a forward-facing academic institution for higher education is maintained and reinforced.

This year, Afeka College of Engineering will be celebrating its 25th anniversary. Since its establishment, we have built an exceptional, vibrant and reputable academic institution.

The college has worked, and continues to work, at expanding scientific and technological knowledge, and its faculty and staff are infused with motivation and ready to face any challenge or change with resolution and determination.

Throughout the 2020-21 academic year we will make every effort to leverage the changes that have taken place. We will find ways to encourage and adapt our lively and contemporary campus atmosphere to the circumstances of the time; and the experience we have gained from distance teaching will help us reformulate

pedagogical methods in ways that incorporate effective, motivating and inspiring teaching – whether on campus, on-line or a hybrid of the two – so that our students are able to interact, participate, learn and most importantly, become the kind of engineers that desire to change the world.

Open cross-disciplinary dialogue is an important part of any process. There is no single correct way to educate engineers, and in uncertain times such as these, the exchange of opinions and ideas is more important than ever – educators, students and industry professionals – each with their own point of view and valid contribution.

This is also the basis for the Afeka Journal of Engineering and Science. It provides us with a channel for voicing our opinions and sharing our experiences. The publication of the journal is not only an academically significant achievement for the college, but also a personal achievement for all its authors and contributors, who invested great time and effort into researching, writing and editing, even during such an unusual and difficult year.

My utmost gratitude and appreciation to all.

Pleasant reading,

Prof. Ami Moyal

President

Afeka – Tel Aviv Academic College of Engineering

Bismarck with an iPhone: The Future of the Age of Reason

Doron Avital

Doron Avital holds a Ph.D. in Logic and Philosophy from Columbia University in the City of New York (2004). He held key positions in the IDF Intelligence, culminating in the position of Chief-Commanding-Officer of Israel's most distinguished elite unit (1992-4). Dr. Avital headed the Georges Leven High-Tech Management School at Tel Aviv University, and later established and directed the BRM Institute of Technology and Society at the Faculty of Management. Later he was the Director-General of the Jewish National and University Library at the Hebrew University of Jerusalem and served as venture partner in Evergreen Venture Partners. In the 2009 elections, Dr. Avital joined politics as MK of Kadima Party, and served in the Foreign and Security committee as well as the Constitution committee and led the parliamentary Knesset delegation to the Council of Europe. Dr Avital is the author of "Logic in Action" (Kineret, Zemorah-Bitan 2012).

This paper analyzes the "Trump phenomenon" as a reference point for an examination of a comprehensive historical process whose essence is an attack targeting "the liberal order." This process is gaining momentum today with the Coronavirus Pandemic and its global implications. The uniqueness of the move elaborated in this paper is the examination of the subject matter through the prism of the philosophy of language and logic that played center stage in the story of the analytic philosophy of the 20th century. This period saw the planting of the seeds that resonate today in the political and economic upheaval that is engulfing the world and that threatens to bring on the collapse of the old liberal order.

The Age of Reason and its Enemies ¹

Donald Trump's election to the presidency of the United States was perceived by liberal circles in the West – the intellectual elites as well as large sections of the financial elites, and certainly the high-tech community and the media leadership – as an attack on the formative logic of the Enlightenment or the Age of Reason and of Modernity as its crown-prize. Thomas Friedman of the New York Times, a leading representative of the liberal Zeitgeist, described it as an "attack on Truth and Science." Note: The election

1. This paper is based on a study that I have written as a senior research fellow of The School of Political Science, Government, and International Affairs at Tel Aviv University, during the academic year of 2016-2017. It began before Donald Trump's election to the presidency of the United States and ended after he assumes office. The move described in this paper is more valid now with the Coronavirus Pandemic and its global implications, as they herald the end of the old liberal order of the second half of the 20th century. I used the title "Bismarck with an iPhone" to describe the new Zeitgeist that must now be emerging. I was careful to preserve the spirit of my original paper and avoid applying its argument with hindsight from today's events, apart, perhaps, from occasional notes (marked with asterisks) that may shed light on the way the original paper anticipated the dramatic events we are now witnessing.

of Trump is not seen as an election of a political alternative but as an attack on concepts supposedly devoid of "political" meaning, that is, truth and science.

Indeed, the New York Times, a newspaper that for the Western elites represents a general and predominant political disposition, has established itself in its editorials and opinions as a political and intellectual opposition to what might be called the "Trump phenomenon": a broad global counter-reaction to liberalism and to the forces of globalization. The newspaper in fact identifies the logic of globalization, political and geopolitical alike – the logic of a "Flat World" ² – with the voice of reason of the Enlightenment. According to this line of thinking, the Trump phenomenon represents an attack on rationality, truth, science, and facts – as these concepts were formulated and shaped starting with Emanuel Kant, to mention one of the founding giants of the Enlightenment Project.

One article published in the New York Times on February 27, 2017, expounding this line of thought, is that of David Brooks. Its title is: "The Enlightenment Project."³ The article draws on insights from the work of Charles Hale, a lecturer at Yale University. The reasoning of the article is simple and schematic. I believe we will not do it injustice if we deconstruct it in the following simplistic way:

1. The Enlightenment project created the modern world
2. The modern world is a success story in terms of science and technology
3. The modern world, through its political practice and institutions strives for moral progress
4. At the basis the success of the project, lies a rebellion against authority as what anchors knowledge and replacing it with the independent voice of reason and rationality as they are being interwoven into rules that can govern our practice
5. Modern political institutions are therefore built on well-crafted rules and thereof on respect to the rule of law
6. The success of the modern project is the result of attaining truth through the scientific method that is based on well-established facts and a spirit of inquiry that subject any claim of knowledge to doubt unless it stands to rigorous, empirical, and rational scrutiny
7. On world stage, success is achieved through maximum global cooperation designed to secure that conflicts be resolved in a rational and non-violent fashion
8. The Enlightenment project is under attack around the world by political leaders the like of Trump and Putin and by decisions such as Brexit
9. The attack threatens to replace objective rationality as well as the respect for rules and institutions – the hallmarks of the Enlightenment project – with decisions that have their anchor in the instincts of the common people, the deep-rooted consciousness of nations and the insights of authoritative leaders as better representatives of the people and their spirit
10. The Enlightenment project had been attacked in the past. Now we must fight back to restore its promise.

2. "Flat World" is a term coined by Thomas Friedman in his book *The World Is Flat* (2005), in which he announced the birth of a new era of common geopolitics driven by the information and hi-tech revolution.

3. Brook's article was also titled with, "The Age of Reason."

Brooks' article represents a predominant mindset among the elites of the West. Since the election of Trump, it has been fashionable to say that this is the end of the age of reason. In the US for example the anti-liberal crowd will accept this verdict with an overt joy while liberals will either admit this with pain and an anxiety as to what lies ahead in the future or, as with Brooks, with a call for the restoration of the order of the Enlightenment: a battle cry to restore the old order.

What we will argue here is that a re-examination of the political and geopolitical logic of the Enlightenment is mandatory. A new chapter of the enlightenment needs to be written but one that is fully aware of its own inner fallacies. The version of the enlightenment that took prominence in the second half of the 20th century and then was fast-tracked to new heights with the information revolution has exhausted its creative and progressive powers. A revision is necessary.

The critique of the failures of the Enlightenment has a rich philosophical background that usually appears under the heading of "post-modern" thought. An important and central voice in this school of thought is Michel Foucault. A key concept in his thinking is "the history of the present." In a deep sense, what we will try to do here is to inquire into the logic of "the history of the present." True, most research into the political and geopolitical of the present times focuses on the socioeconomical background: the rise of financial capitalism where profit bottom-line overshadows genuine value-creation, the 2008 crisis and the sky-rocketing inequality gap, the growing discrepancy between the all-inclusive ethical language of the rich and the elites and the dire economic reality of the "production floor" of society. The latter, excluded from financial and political power, rebel through figures like that of Trump against the ruling elite and its language; even so towards the language of "Human Rights" that was set supposedly to serve their cause at the bottom.

The logic of the Enlightenment, if we continue this line of thought, is no longer perceived as a liberating force of defiance against authority, but rather as a political and economic oppressive force that draws its power precisely from the same "Flat Global Logic." Here could figure, for example, equilibrium points of game-theory models that are used to justify states of affairs of blatant inequality as if they were laws of nature; refusing them is to refuse logic (or the very nature of economy).

The Age of Reason: "1984" and the "Newspeak"

We will confront here the dilemma of our times from a new angle: that of the logical-philosophical discussion of analytic philosophy of the 20th century. The central object of inquiry is that of the discussion in Meaning: what can be said about the meaning of the expressions of our language? What analysis or reconstruction is mandatory to secure understanding and preventing failures in communication? This is a discussion whose subjects of inquiry are indeed language and logic – logic appears here in the role of supra-linguistic grammar – but quick to follow is a discussion in truth and facts: for what is factual truth if not the realization of meaning-commitments that are made in language?

This discussion in logic, language, truth, and facts becomes increasingly complex and perplexing the more closely one examines it. It appears on political stage with great force, all the more with the beginning of Trump's tenure. What are facts and what are alternative facts? What is news and what are fake news? Who – in an analogy to the printing of money or the minting of coins – is in a position of authority to "mint"

facts? What meaning-commitment, for example, truly lies behind Trump's famous election promise to build a wall on the Mexico-US border?

It is no wonder, then, that in the months following Trump's election, the book that rose to the top of the sales charts is "1984" by George Orwell. In his masterpiece Orwell introduces the idea of a new language calculus, the "Newspeak." The "Newspeak" is a politically perfect language designed by the ruling party of "Big Brother." Its end-goal is a language whose use is obligatory, so not only will citizens speak Newspeak, but they will also think and act the dictate of the new language. To quote a member of the overseeing "Newspeak" party committee: "only the disciplined mind can see reality." The disciplined mind speaks Newspeak.

A deeper look at the constitutive logic of "Newspeak" must therefore induce with us some discomfort and raise the following question: Is not the language of political correctness, the language of the global and "flat world," more fully compatible with the idea of "Newspeak" than the rolling, instinctive and so often irresponsible language of Trump himself, and in general of the opponents of the "flat logic"?

Here is, in words taken from "1984," an explanation of the rationale behind the "Newspeak" revolution:

So, the revolution will be complete when the language is perfect?

[Yes], the secret is to move from translation to direct thought, to automatic response.⁴

It is well known that in the race between Barack Obama and Hillary Clinton to the Democratic presidential nomination in 2008, it was Clinton who, in a wonderful viral YouTube video that garnered millions of views, was portrayed as Big Brother dictating a perfect language; a language in which the barriers between translation and direct thought and automatic response fall one after the other. The "perfect" language that Clinton speaks in that video is not seen as a liberating language, designed to serve the pressing needs of the people, but as a language of oppression. In that clip, built on an Apple commercial from 1984, the people in prison uniforms are freed from the control of the oppressive, perfect language of Clinton in the role of Big Brother, and we are informed that electing Barak Obama will ensure that 2008 will not become 1984.

So, who is "Big Brother" and what is the new, oppressive speech? Is this really the new speech bureaucracy of political correctness and of the flat logic of the forces of globalization? In the spirit of Karl Marx, according to whom the world is ruled by a "conspiracy without a conspirator," the new speech bureaucracy of political correctness may be perceived as an oppressive apparatus, perhaps without a literal "big brother," but one that is supervised by committees-of-sort of meaning-experts and censors of language; the latter can also be said to be serving economic interests and goals of global elites, businessmen, politicians, perhaps columnists of leading press such as the New York Times, elite Academia, World Bank economists, appointees of international human rights organizations and etc. – the circle of people that we may associate with the prestigious Davos Forum. Alternatively, is the newspeak of more literal "Big Brothers", who take the form of authoritative or authoritarian leaders shaping language and reality, facts and alternative facts, according to their wishes and their local and varying goals – more appropriate as an analogy to Orwell's "1984" prophesy?

4. The question is posed by the protagonist of the book. The colleague answering him is a member of the Newspeak committee. He shares with the protagonist his enthusiasm over the creation of the new dictionary, a new and updated language calculus, that is synced with the most up-to-date science and the spirit of the totalitarian society controlled by Big Brother.

What is now being re-invoked for discussion, therefore, are fundamental questions of language, meaning, truth, and facts – or perhaps the most fundamental question of the very possibility of literal meaning. This time, however, this logical-formal debate takes a dramatic political and geopolitical turn. For example, as soon as Trump was elected, Reince Priebus, the former White House chief of staff, was quick to make the distinction between those whose use of language is literal – so apparently, in his view, the liberal enemy speaks – and those who speak seriously, as his president speaks. Literal speech is one that has a tight, rule-oriented commitment, but is empty and repressive, a bit like a tailor-made tender – so hints Priebus. To speak seriously, on the other hand, may mean to take lightly the logical chains of a commitment to literal meaning and precisely because of that to be able to make serious and responsible use of language, directed at real political action.

The importance of the latter distinction should not be underestimated. It mimics another, incredibly significant distinction, the distinction between the literal and the real, between compliance with literal conceptual definitions to that of the encounter with what is truly real. For those who are familiar with the "The Matrix" trilogy, this difference will surely be reminiscent of the juicy steak that Cypher relishes on though he admittedly knows that it is a produce of the Matrix and not a real steak. The false steak is the literal steak. It complies to perfection with all literal taste definitions that the finest steaks' connoisseurs can provide but it is not a real. Cypher, sealing over the steak dinner a deal of betrayal, sums up this culinary-philosophical discussion with the well-known proclamation: Ignorance is Bliss.

The Age of Reason: Wittgenstein and the Illusion of the Ideal

To delve deeper into the subject matter at hand, we must turn to the philosophy of Ludwig Wittgenstein – perhaps the true hero of 20th century analytic philosophy (Wittgenstein an Austrian in birth who fought bravely on the side of the Central Powers in WWI, worked and died in Cambridge, England, in 1951). At the heart of his work is a heroic struggle against the standard positivism that reigns supreme in the intellectual world of the West. Wittgenstein's discussion is in logic, language, meaning, truth, and facts. At heart, his work is of formal or logical nature, in the best tradition of analytic philosophy.

How, then, can a seemingly formal-technical discussion in logic hold the key to understanding the revolutionary political changes we are now witnessing?

In this sense, however, we must first admit that a logical-philosophical discussion is always present at the background of significant political changes. A logical perplexity seamlessly interwoven into the fabric of the life and politics of an era is destined sooner or later to show its hand. In analogy, we may think of it as a hidden destructive frequency that resonates through a historical era and that can ultimately bring on its demise. Suffice here is to reflect on the mythological story of the discovery of irrational numbers. Why, according to mythology, was the discovery of irrational numbers kept secret by the members of the Pythagorean school? It must be the case that the discovery was experienced as an acute logical-glitch – like the famous “glitch” of the Matrix – that threatens the very foundations of the epistemic structure they were laboring on; a founding element of which is the assumption that measures in our world can be given in terms of relations between natural or whole numbers. The logical breakdown is so severe that according to the mythological story, the Pythagorean who breaks with the group and discloses the kept

secret is punished by the gods in drowning. A discovery seemingly belonging exclusively to the logical-mathematical sphere carries political significance that demands a merciless punishment.

It turns out that this holds true also of the story of the 20th century discussion of logic and its host of constitutive paradoxes, as they resonate in the way of life, practice, and the politics of liberal Western culture. What, then, is the crux of standard positivism and the 20th century philosophy of logic, at which Wittgenstein's criticism is directed?

Well, in a nutshell, the story of logic in the 20th century is the positivist attempt to first subject mathematics and subsequently natural language to a consistent and rigid set of semantic rules. This is sure an oversimplification, and yet we may think of this as an enterprise of formalization designed to subject human praxis, even as far as ethics, to a well-formalized, semantic system of rules. The motivation for this enterprise of “formalized correctness” carried by modern positivism is clear. It is a reformative move of correctness as viewed through the lenses of the “Ideal.” The quest for human communication and practice that rest on solid logical grounds such that they are secured of the imperfections and flaws of natural language and human practice – as these are inherently prone to error.⁵

A well-known historical anecdote, described in beautifully written short book titled, *Wittgenstein's Poker*,⁶ documents an encounter that takes place between Wittgenstein, a formidable intellectual figure in Cambridge before and after the war years (WWII), and the philosopher of science, Sir Karl Popper. At the center of the discussion: Are there indeed major philosophical problems, a claim towards which Wittgenstein's position is categorical: Philosophical problems are nothing but logical confusions – pseudo-problems that arise, in Wittgenstein's phrasing, when language “goes on vacation.” Popper holds the view that philosophical problems, even if not scientific, are still real problems that require a solution or an informative answer. Wittgenstein, on the other hand, thinks of “solving” these problems as an emancipatory activity set to free us of the shackles of the “picture that keeps us captive”; a picture that hinders our ability to see things as they are and act accordingly. The defining moment of the debate revolves around ethics. The positivist act of formalizing both language and practice does not stop short of ethics. Wittgenstein, who once claimed that if ever there was a book of ethics – say, a treatise consisting of well-formalized dictates of ethics – the library that houses the book would go up in fire, challenged Popper to come up with an ethical maxim for him while threateningly waving the charcoal poker of the fireplace. Popper was quick to respond to the challenge and offered the maxim, “Do not threaten visiting lecturers with pokers,” prompting Wittgenstein to leave the room angrily with a door slam. Karl Popper may have shown wit but missed the depth of the discussion and the gist of Wittgenstein's attack on the reign of positivism and the arrogant confidence it exudes in the power of the mechanism of logical formalization that does not stop short even before the sacred gate of ethics.

Here is a key quote from Wittgenstein's "Philosophical Investigations." Its key idea is that in striving for perfection, toward the ideal conditions of correctness of communication, language, and logic, we may lose grip on reality and our ability to describe and shape it in a proper and responsible way:

5. Here too, as in the Pythagorean project, the founding pillars of the logical program are threatened by a series of paradoxes that share the same structural character, from Kurt Gödel's famous Incompleteness Theorem to the Löwenheim-Skolem theorem and to the fundamental paradoxes of set theory such as that of Russell.

6. Wittgenstein's Poker, *The Story of a Ten-Minute Argument Between Two Great Philosophers*, 2001, Authors, David Edmonds, John Eidinow.

The more narrowly we examine actual language, the sharper becomes the conflict between it and our requirement. (For the crystalline purity of logic was, of course, not a result of investigation: it was a requirement.) The conflict becomes intolerable; the requirement is now in danger of becoming empty. – We have got on to slippery ice where there is no friction and so in a certain sense the conditions are ideal, but also, just because of that, we are unable to walk. We want to walk: so, we need friction. Back to the rough ground! ⁷

A new understanding of Wittgenstein's revolutionary ideas and their translation into the logic of our times is an important and necessary challenge. For example, in positivism, a sentence in language can be seen as an expression in quotes such that a removal of the quotes transports us from language to reality: from the sentence to the objective fact it portrays. The translation from linguistic expression to factual reality is supposedly objective or, if we wish, politically neutral. Likewise, this would seem to hold true of an imperative, a command or, say, an election promise. The fundamental intuition is that of language as a mirror-image of reality. The American philosopher Richard Rorty describes in his celebrated book, "Philosophy and the mirror of nature," this conceptual thread as it runs through western philosophy way before modern positivism. However, if we depart from the mirror-image model or the illusion of the automatic translation of symbolic representations into the materials of reality, we will find ourselves stepping into a new vision of the relationships between language and practice, e.g. we will be required to offer a new understanding of how language acquires reality. This time not in the form of direct, supposedly automatic, translation in the spirit of "Newspeak," but as an action that has a creative character, that at the same time is neither distorting nor misleading. This is not a simple challenge. But Wittgenstein in his work paved the essential logical steps required for us to be able to walk in this direction.

The model of positivist or liberal correctness, then, is nothing but an attempt to achieve those "ideal conditions" against which Wittgenstein warns us. They will lead us in the end-limit onto slippery ice and we will not be able to walk. Walking is a metaphor for meaningful communication and action. This is a recurring image in Wittgenstein's thought, according to which in the attainment of the so-called "ideal conditions," then, in the absence of friction, the cog-wheel that is designed to animate the space of meaning and action is unable to perform its task. It will resemble a cogwheel in an "Idle" mode. The new political and geopolitical logic we must seek now is therefore the one that calls "friction" back in. We must now follow the logic of the "rough ground."

The Age of Reason: Political Correctness and the Conditions of Meaning

We are now at the end of an era governed by legal political correctness as a driving force. This is not just about the nature of public and political discourse but also about the way we judge the functioning of systems and organizations, as we assess them against conceived "ideal conditions" – in the drive for perfect compliance or convergence to an ideal endpoint. Think, for instance, of an effective and ideal army in that its soldiers are safe from harm. Such an army will naturally fail the test of its own constitutive identity, which is the protection of civilians. Similarly, an economic organization that sets its goals only around quantified calculation of loss and profit – as its shareholders may think – rather around the overall responsibility before whatever constitutes its identity, e.g. if this was the product it manufactures and sells

7. Paragraph 107 in *Philosophical Investigations*.

to the public. In this context, it is worth considering the words of Toyota's CEO, member of the founding family, who takes command of the company in times of crisis and offers this as concise analysis of what went wrong: "We have transformed from a car-making company to a money-making company." His insight enabled the company to resume its place as the world's leading car manufacturer. There is no doubt that the 2008 economic crisis was characterized by this fundamental confusion, since the distinction between (speculative) profit and (real) value or, in a broader sense, between "success" and real achievement, was completely obliterated. The perfect, literal steak however false, that Cypher relishes on in *The Matrix* in return for betraying his comrades, wins over the real steak of the "rough ground."

A deeper look at the logical structure underpinning the discussion in the "ideal" is warranted here. What we actually have in the "ideal" is a working normative model applicable within a guarded locality in a disguise of universal applicability. The model of western liberal democracy, together with its set of associated values, is a timely example for a working model that claims universality. This in fact is the gist of Fukuyama's thesis of us arriving at the gates of the ultimate political model and hence the end of history. The "ideal," we may sum up, is a local abstraction claiming in an a-priori fashion a universal normative force. This obviously will lend the already practitioners in the guarded locality an unfair advantage in any possible dealings with localities that are now required to subscribe to the "ideal." In Wittgenstein's language, the measuring-rod that purports to be "ideal" or "perfect" is nothing but "private" and as such loses its ability to fulfill its purpose or the use for which it was designed – think of a private clock ticking private time, refusing to negotiate time-determination with the clocks of others. This will not work as base of synchronization within a community.⁸

Here also lies the crux of the postmodern critique of modernity. In Wittgenstein, we can find the logical artillery required to secure this critique from allegations that it inevitably leads to moral relativism or anything-goes type of attitude. The opposite is in fact true. Immanuel Kant is known to testify that he was awakened from his dogmatic slumber by reading David Hume. It is now appropriate to be awakened from a new dogmatic slumber: the picture of reason and rationality as universal super-rigid machines, to borrow a phrasing from Wittgenstein, that demand literal compliance rather than creative translation. In this we revert to the true premise, and promise, of the age of reason: autonomous reason as an emancipatory power that can anchor human praxis in the world. We may add here, on a humorous note, that Kant on the autonomy of reason was replaced in our times with an awe before the idea of the autonomous machine.⁹

Political correctness as a driving force of human practice must be a thing of the past. It sits on an essentially positivist disposition that has lost touch with the historical or material preconditions of meaning. A predetermined, a-priori logical anchoring of meanings must give way to an a-posteriori rediscovery of meanings through the lenses of the changing circumstances where the meanings of our words and deeds must anchor. The formalized correctness of modern positivism, whose banner is modern logic, translated into a culture of doctrinaire legal political correctness. This, as explained, is nothing but the expropriation of western liberal form of life and framing it within a binding, bureaucratic, dogmatic scheme and in the name of universality imposing it on diverse cultures and practices. Again, to go cynical, enemies of

8. For a detailed discussion of the "ideal" measuring-rod, see my paper "The Standard Metre in Paris," *Philosophical Investigations*, vol. 31, 2008.

9. I think, for example, in this context of Elon Musk and his various statements on the subject of AI.

political correctness, will liken the logical predicament described here as that of the community of Zebras imposing their form of life on the community of Lions in the name of moral progress.

Even liberal sacred concepts like “Human Rights” will no longer enjoy political immunity. “Human Rights” can be now re-approached as the product of a local abstraction of a concrete form of life – say, western-liberal communities of relative economic prosperity – that in the name of universal validity gives itself an unfair advantage in interacting economically or otherwise with other communities.¹⁰ The leading slogan of American universities, “diversity is a value,” is telling in this context. It in fact invokes, under the guise of generosity towards the diversity of colors, ethnicities, and lifestyles, a hidden preference for the base color of white. White, supposedly an equal member of the family of colors, is in fact the base color that lies underneath all other colors. The “other” is colored, the “one” that all are measured against is white.

This brings us to the “politics of representation” and its flagship mechanism of “affirmative action” designed to close the gap for the under-represented “colors.” The inherent fallacy of “affirmative action” is that it promotes “professional representatives,” players whose craft is “representation” and not the cause of the discipline they serve. The outcome is counterproductive in that it deepens the gap since it does not promote the true emancipatory powers and talents of the under-represented. In this respect, “affirmative action” is not different from the old colonial practice of sidelining emancipatory leaders of the colonized society for a carefully chosen selection of collaborative representatives. True political leadership of the colonized society is thereby blocked, and the colonial rule can be thus prolonged.

Even the literal understanding of the value of “equality” should now come into question. The philosopher and psychoanalyst Erich Fromm wrote many years ago that the error of our time lies in the way we inadvertently replaced the concept of “equality” with “sameness.” The retirement age for women and men cannot be literally the same, since the material conditions with which men and women, fathers, and mothers, are coping with are different. The true expression of “equality” as it pertains to retirement age for men and women should therefore be not read literally but be indexed, e.g. we may find that 67 in men equals 63 in women. In a research institute for democracy, where sacred practice over discussion roundtable is 3 minutes on the clock speaking-slot, should not equality dictate a generous, additional 1 minute more to a nonnative speaker or a speaker who stutters?¹¹

The pursuit in the name of equality of a common core of identity, a constitutive common denominator, is at the heart of the fallacy we explore here. We have already noted of “diversity is a value” that it presupposes a tacit common denominator. Instead of looking for a common cross-sectional core, we need to think in terms of the completing pieces of a jigsaw picture-puzzle. Pieces of the jigsaw by definition do not share a common core as they instead complete each other to form a meaningful picture. The value of equality is therefore rightfully expressed not in us being subjected to a common core but rather through partnership

10. Just think of a formative concept with which every child in American culture grows up, and that is the concept of “personal space,” an imaginary boundary space drawn around every citizen, the invasion of which is an act that can be defined as violent. Only recently, in remarks leading up to the publication of her book, did Hillary Clinton talk about how Trump, during the main televised confrontation between them, encroached upon her “personal space.” Interestingly, as it happened, Clinton did not find the mental capacity to block by speech or gesturing Trump’s undoubtedly bullying behavior. Yet the very idea of such a “personal immunity space” that prevents friction and collision between people, requires a spacious physical environment. Such a space would not be suitable for societies of families with many children and tribal populations who inevitably live in overcrowding conditions. * The current Corona crisis has again invoked this idea through the demand for maintaining a “social distance” as a real space of immunity that prevents possible viral transmission. The less crowded societies are naturally more protected.

11. No recommendation meant here to formalize the additional 1-minute speaking-time to the nonnative speaker into a binding rule; otherwise, we are back into the vain attempt to formalize praxis to the letter.

in a creation of a picture: a shared project, be it national, ideological, or any other conceivable human project. To resort to philosophy, we may say that all shades of red do not share a common red as they rather complete to create the family of the red color.¹² Equality is in complementary partnership. In being true contributing players, partnering together, each player brings in his or her singular complementary contribution, that we become equal.

The value of equality as expressed today in liberal culture may best be phrased by the oxymoron of “Standard Individualism.” In subscribing to the “standard” we presumably secure the values of “Equality” as well as that of “Human Rights.” However, put in this fashion, it would be hard for the “Individual” not to sense the full restrictive and oppressive character of the “Standard.” The astute Viennese journalist of the early 20th century, Karl Krauss, expressed similar ideas in his columns at a different historical moment, with the disintegration of the bureaucratic order of the Austro-Hungarian Empire. This is what he writes on “Human Rights”: “When there were no human rights, the unique individual had human rights. This was inhuman. Then the value of equality was created, and human rights were taken from the unique individual.”

The question arises as to the extent to which we are now in a similar historical moment, that of the disintegration of the old liberal order and with it the era of political correctness with its hidden bureaucracy of meaning – however abstract and therefore less visible than the old order of the Austro-Hungarian bureaucracy to which Krauss refers.

The Age of Reason: Media, Judgement and the “Liberal Fallacy”

The place and status of the media must also be questioned. Plato famously was apprehensive of the corrupting power of art. In retrospect we can defend Plato's position and say that he feared the corrupting power of bad art. But Plato goes so far as to express the concern that even a wonderful poet like Homer, standing in front of an audience thirsty for his poetic descriptions of Achilles' exploits, may err and think he himself is Achilles or even that he can surpass Achilles. Reflecting on the mega-celebrity status of actors and actresses that overshadows by far that of the protagonists they play, we may find Plato not far from the mark. This may also hold true of the media vis-a-vis the praxis of life and politics that is the subject of their reporting. The media of our times with the reach of power it holds is in danger of falling into the arrogance alluded to by Plato. It may err and regard its protagonists, political leaders, generals, leaders of industry and economy and men and women of action in general, as merely extras in a plot where they are in fact its authors and true protagonists. When the very ethos of action and respect to real-life protagonists is undermined up to ridicule in the name of critical review that the mood of the “production floor” of society may turn against the media and the coverage it offers. The people at the “production floor” that feel exploited and excluded from the socio-economic power game may then turn to irresponsible populist leaders that cynically nourish their rage.

So is the wind of moralistic retrospective judgment that blows through the media and the liberal circles in relation to past heroes. See the commotion surrounding the smashing of the General Robert Lee monument, commander of the army of the American South, the Confederate Army, during the American Civil War.

12. Think in this context of Wittgenstein celebrated concept of “Family Resemblance.”

The same wind is blowing in many other places in our tumultuous world, from the shattering of ancient pagan monuments by ISIS in the Syrian civil war and elsewhere to, in contrast, New York City municipality, which is seriously considering, following a liberal protest, whether the statue of Christopher Columbus, the discoverer of America, should be left standing. Political correctness judges the past in semantic categories that are not materially available to the people and protagonists of the past – it is somewhat like requiring past figures to pay in the currencies of our time. We can safely assume that General Ulysses Grant, General Lee's contemporary who led the fighting against him, would not have joined this righteous protest campaign and would have been happy to see his opponent's statue intact. It is especially ironic that this judgmental state of mind – preoccupied with purifying the past of figures that do not retroactively stand up to the stern criteria of our current lifestyle – is reminiscent of the Soviet *modus operandi*, ridiculed in the West, in which official documents and photographs were cleared of any evidence of the existence of senior officials who had been purged from power positions.

The spirit of judgmental political correctness that has taken over the reading of history is dangerous. More than anything, it causes us to miss the encounter with history as it actually occurred, with its people and its protagonists as well as with the material circumstances they faced. It is a mindset afflicted with a simplistic description of history as if the latter were a chain of unnecessary disasters instigated by irresponsible leaders. The historian becomes a judge and the historical research becomes the gathering of evidence to substantiate the guilt or innocence of the protagonist. Against what, we must ask ourselves, does the standard-setting historian-judge assess and evaluate the actual course of history? He or she can assess it only against an ideal standard, that is, political "ideal conditions," borrowed from today's material circumstances. These take the form of a counter-factual historical trajectory, against which actual history does indeed seem to be one continuous anomaly and its protagonists therefore may be seen as criminals.

This judgmental and moralistic mindset is part of the postcolonial ethos that now dominates the hallways of Western academia and media. At the heart of this mood is a particularly simplistic and critical reading of history and especially of the colonial past of the West, to which in many ways the West owes its current power and status in world affairs. Behind this intellectual state of mind lies the assumption that there is an "ideal" point of reference, sometimes even perhaps in the form of a pre-colonial, natural state, a return to which represents justice; this, in a non-coincidental analogy to an utopian conception of nature and the environment, before the massive human environmental intervention of the Industrial Revolution.¹³

A similar case can be made in relation to the idea of progress and the inadvertent replacement of the concept of technological or structural-political progress with the idea of moral progress. It can be said that for the standard liberal, progress is in the construction of political and social life designed in such a fashion so that the very idea of friction, the coping with the necessity of resolving moral dilemmas, will become a matter of the past. This is a nonsensical idea according to which, complying with the moral imperative is an a priori attempt to construct a structured way of life so that the moral dilemma cannot come into being to begin with. In a crude analogy to simplistic ethics discussions in youth movements: if you are on a plane that must be abandoned with 20 people on board and only 19 parachutes, what should you do?!

13. Discussion of climate and the contribution of human intervention to global warming is definitely a reference point in this space, and therefore there is no wonder that it has become a political issue and the target of attacks by skeptical conservatives, e.g., such as Trump. In Europe, too, it is interesting how skepticism over the European Union's project merges, as it often does, with skepticism over global warming as a result of human activity.

The simplistic liberal thinks of a world and an ideal way of life in which the ethical parachutes are already packed and prepared in advance for all the passengers of the plane.¹⁴

The frustration therefore of the standard liberal is with the very emergence of the moral dilemma. In analogy to a mathematical problem with no solution, the liberal observes the moral dilemma as having no “correct” resolution, but that it could and in fact should have been prevented from coming into being. (e.g. that there should have been 20 parachutes on board!)

However, this may be true that we all prefer having enough ethical parachutes, the moral dilemma will always cross our path. The standard liberal will find in this entanglement an excuse not to act but find fault in a structural malfunction of the socio-political system that is responsible for the dilemma. Fault must be that of past generations or of others; the liberal thereof is excused. To this logical predicament, we better reserve the term: “The Liberal Fallacy.”

The Rough ground: From Literal Repetition to Material Expansion

The logic of “the rough ground,” on contrary, must center on friction and in renewed confrontation with the moral dilemma. The moral dilemma – in the deepest sense any political or geopolitical decision is a dilemma of a moral nature – will not conform to established mold and will therefore constantly require a novel resolution of an expansive nature, in which the concepts and values demonstrated in exemplary past stories are translated and reformulated in the material conditions of the present. This synthetic expansion of the past has a creative and expanding nature and is not a response that is literal, formal, or legal in nature.

The standard or the failed liberal is guided by an image of a consistent world, as if it is structured through a web of rules that cohere in marvelous consistency. But this marvelous consistency of world orders and worldviews is the result of a resolution of those for whom, at the moment of encounter with reality, reality was a web of paradoxical entanglements of rules, values, and facts, colliding and threatening to cancel each other. The well-known quantum physicist Nils Bohr claimed that every encounter with a paradox is an encounter with hope – hope for progress by means of resolution. Not so for the failed liberal. For he or she this excuses their inaction on the merit that there is no course of action that can qualify as right. This in analogy is like those whose court manners are impeccable until they recognize a threat, however slight, on their position and status. In this they feel excused from showing manners, for they feel good manners are a matter of days of calm rather than times of conflict and struggle. The truth is to the contrary, manners and values are tested first and foremost during conflict. “Culture of war,” for example, is not an oxymoron or an internal contradiction – on the contrary, it is the true test of every culture, together with its founding rules and values.

To conclude, we will have to acknowledge that there is no historical point of reference of “natural justice” to which one must return and not a just template that is ready-made to be implemented. But rather a forward movement that reinvents itself time and time again and is guided by past events and sorrows, along with the logic and constraints of today’s “realpolitik” that demand of us a fair and just resolution. We must give up on the logic of a non-temporal, formal response to a template or the logic of repetition: the logic

14. Substitute medical ventilators and in general the saving-life equipment required to treat acute Covid patients for well-packed parachutes and you get the picture of the state of the heated critical debate at the outbreak of Covid-19.

of reverse-engineering the past and supposedly rectifying it of its crimes – an ethos driven by the fear of falling into the tragedies of the past more than the courage to be worthy of its greatness – as a misguided key to the building of the future.

When I discussed all this at a European research institute only recently, one of the quick-witted attendees offered his branding of the system of concepts I used with the phrase: "Bismarck with an iPhone." This is precisely in the sense of an approach to shaping the future that forgoes the erroneous logic of repetition and instead adopts a logic that does not evade the necessity of material friction in the renewed building of the future – in the creative, self-reinventing translation of exemplary values carried out by exemplary protagonists of the past in the material constraints and the technological tools of the present.

It was Noam Chomsky who once said that: "we shouldn't be looking for heroes, we should be looking for good ideas." It hard to think of a better representative of liberal dogmatism, with which we are debating in this paper, than Noam Chomsky. In rebuking Chomsky, I think we could safely acknowledge that there is not a single good idea in human history that was not carried out or exemplified through the life of a hero or a heroine. These are the protagonists that battle through the "rough grounds" of their times and that in standing up to their greatness, we are summoned now by history to carry the baton forward. Since our subject here was the age of reason and its future, I think it would be only appropriate to conclude with the words of a giant protagonist of reason, Sir Isaac Newton, expressing his own debt and owe before the past: "If I have seen further than others, it is by standing upon the shoulders of giants."

* A Coronavirus Summary Note:

I cannot conclude this essay, the main point of which is the understanding that the old liberal order must make way for a new order, without referring to the Corona crisis. This crisis holds an essential mirror up to the old liberal order. We can imagine it as a frequency of a historic disruption, well-calibrated to undermine the old order, as if the latter were a suspension bridge that a storm collapses by activating a unique frequency. When I described the logical cracks opening up in the foundations of the old liberal order, I did not dwell on an implication of the "illusion of the ideal" which concerns a risk-averse mindset. I have lingered long on this aspect of the risk economy of the old liberal order in my book *Logic in Action* (2012).¹⁵ For our purpose here, it is important to understand that the more powerful is the liberal categorical, retrospective judgment – a judgment equipped with post-factum wisdom that is blind to the material conditions of the criticized protagonists – the greater is the systemic weakness to act courageously toward an expansive and non-literal fashioning of the future. The corollary is indeed a mindset of risk aversion that rewards players who do not take risks and punishes the brave ones who do take risks; if you will, it encourages the profiteers of words and of financial, short term bottom-lines rather than the people of action and the value creators. This process, by its very nature, by force of internal inertia, intensifies to the point of inevitable discharge and collapse of the kind we have already encountered in the 2008 crisis. The risk economy to which the Corona crisis has plunged the world will therefore necessitate the construction of a new model, which forgoes the illusion of control in the name of the ideal, and instead foster the creation of a new culture of a shared risk taking, in thought as well as in action.

15. Doron Avital, *Logic in Action*, Kineret Zemorah-Bitan, 2012.

At the time Donald Trump was elected to the presidency on November 2016, I was attending with a few of my colleagues a political seminar on the politics of the Middle East at Jimmy Carter's presidential library in Atlanta. Discussing with the president, who oversaw the great diplomatic and geopolitical feat

of achieving a peace treaty between Egypt and Israel, was an enlightening and instructive experience. On issues of the day, the liberal president was clearly distraught by the surprising turn of events of Hilary losing the election and him needing instead to congratulate Donald Trump on his victory. In the discussion that ensued on diplomacy and geopolitics, I did stress before the president that "declarative diplomacy," as I put it, had run its course. I meant by this that the kind of diplomacy and doing geopolitics that is derived from abstract and a priori principles, must give way, in the spirit of the ideas of this paper, to 21st century type of "realpolitik" – the kind of which I was trying to capture with the phrasing of "Bismarck with an iPhone."

I was stressing the gap between abstractions taken literally, posing as an "ideal," and the real world with its real woes that cry for our attention. The president was intrigued though there was not enough time for us to develop the ideas much further. But this discussion brings home once again the acuteness of the widening gap between the world of verbal possibilities – the verbal announcements – and their translation into the world of action. If not the abstract principles, I was alluding to in the discussion with the president, then we have now the online immediacy of text and in general the inflation of verbal declarative expressions. As you do with inflating the value of a currency by flooding the market with it – this in concrete terms is yet to be seen in our economies – so do the space of verbal communication loses in value with respect to the world of actuality, up to the point where it cannot anymore animate it in a meaningful fashion.

Awareness of this gap between word and deed, between the online immediacy of the text and the space of actuality, is now necessary. Therefore, vigilance regarding dramatic surprises is also necessary. Lack of coordination between, on the one hand, the steering wheels and controllers of systems in the hands of leaders, and on the other hand, the actual movements of vessels, in analogy to the political systems of our world, is a recipe for colossal disasters. Will we now, in the wake of the global crisis of change in world-order, and the acceleration of processes caused by the Corona crisis, be required to face another series of mega-crises?

The great Roman sage Seneca wondered in his book "On the Shortness of Life," "Can anything be more idiotic than certain people who boast of their foresight?" I will not propose, therefore, a forecast for the future, but rather, in Michel Foucault's terminology, as I have tried to do in this paper, offer a penetrating look into the dynamics of the history of the present.

Corona, Science and Regulation: An Economist's View

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This paper discusses the question of the effectiveness and improvement of the work of the regulatory authorities for drugs and vaccines. First, it lays the economic foundations for the pharmaceutical industry, then it presents empirical evidence for the role of regulation in the development of drugs and vaccines, and finally it proposes policy changes.

1. Introduction

These days, humans all over the world are waiting for the scientific breakthrough that will save humanity from the SARS-CoV-2 virus (Severe Acute Respiratory Syndrome Coronavirus 2), which causes a disease known as COVID-19 (World Health Organization, 2020).

This epidemic is affecting the livelihoods of billions of people around the world, many of whom have even deteriorated to life-threatening hunger. As of this writing, there are millions of diagnosed cases of COVID-19 and hundreds of thousands of deaths all over the world, but these numbers are probably much higher, as many countries do not bother to check what illness a person has and what causes the increase in morbidity and mortality.

As of this moment, the damage caused by the pandemic, in terms of morbidity and mortality, do not look so bad. What stands as reference for humanity, however, is the memory of the Spanish flu that raged around the world between January 1918 and December 1920, infecting some 500 million people and killing 50-100 million people (Center of Disease Control and Prevention, 2020); what is also remembered is the Asian flu that spread between 1957 and 1958 and killed between one million and four million people (Department of Health and Social Care [UK], 2020).

The morbidity and severe damages inflicted by past pandemics have led governments around the world to implement closures and to prevent crowding, in order to reduce contact between people and thus reduce the possibility of infection. Thus, the main damages caused by this epidemic are economic, resulting directly from these preventive measures.

This pandemic is expected to decrease world GDP by 5.2% in 2020, and developed economies are

expected to shrink by as much as 7%. In other words, according to estimates from June 2020, the world is expected to lose more than \$4.5 trillion (The World Bank, 2020). Since the end of the pandemic is not in sight and its damage is likely to intensify, the World Bank has defined the economic crisis it is causing as one of the worst crises in decades.

Many scientists around the world are working day and night to find a vaccine, but this is only the first step. The vaccine must be produced in huge quantities, a capability that exists mainly in commercial drug companies, and it must be distributed throughout the globe. Such a vaccine will save the lives of many and the enormous economic damage that we are currently expecting may not materialize.

This paper discusses another step on the path to the long-awaited vaccine – the regulatory phase. Each drug and vaccine undergo prolonged stages of monitoring by government regulatory bodies before being distributed to the public, to check that they are safe to use. Regulatory bodies have often been criticized for the fact that the meticulous monitoring process to which they subject every drug and vaccine prolongs the development, prevents and delays the development of drugs and vaccines and thus causes great harm that even outweighs the benefit of relatively safe drugs and vaccines (Klein, 2000, 2008).

However, there is no denying that knowing that drugs on the market have been supervised, controlled and approved makes us consumers confident when we use a drug and feel quite safe (at least most of us) when we get vaccinated.

This particular time illustrates for us the trade-off between safety and quality and standard of living. On the one hand, every day that the regulator delays the vaccine will result in great economic damage and a huge loss of benefit from the very restrictions that are imposed on us as free people. On the other hand, once an approved vaccine comes out, most of us will feel safe to take it.

Chapter 2 below will outline the economic foundations of the pharmaceutical industry; Chapter 3 will discuss the role of regulation in the process of developing drugs and vaccines; and Chapter 4 summarizes and proposes recommendations for changing the policy of drug and vaccine regulation.

2. Economic Background

The Vaccine Consumer

When a person consumes a drug or vaccine, he gets in a liquid, injection or pill a substance whose composition, effects and damages are unknown to him. In this sense, the person is in a state known as asymmetric information. This is a situation where the drug manufacturer has more information about the product it is selling than the consumer. The healthy person who needs to decide whether to get vaccinated against coronavirus is usually a person who hates risk and therefore has a fear that the vaccine is unsafe and may cause him serious harm. This fear will lead many consumers to refuse to take the vaccine.

A vaccine creates what economists call positive externalities. That is, the vaccinated person is not sick and therefore not contagious. The individual does not comprehend his positive effects on the

whole of society and, therefore, in the absence of strict control, too few people will take the vaccine. Consequently, the potential for illness and infection will remain high. To alleviate this concern, the regulator (for example, the U.S. Food and Drug Administration – FDA) subjects each vaccine to a careful and lengthy control process, to reduce the likelihood that every person attributes to the harm caused by the vaccine, and thus increases the number of people who agree to take it.

The Regulator

The regulator is a public representative. The public is in a state of rational ignorance (Downs, 1957), meaning it does not have the ability, knowledge and time to learn about the true nature of the vaccine. Therefore, it relegates to the regulator the authority to test the true nature of a vaccine and release to market only safe vaccines.

The principal-agent problem (Jensen & Meckling, 1976) exists between the public and the regulator. While the public has an interest in releasing safe vaccines to the market speedily, the regulator also has an interest in maintaining its reputation.

When the regulator needs to decide whether to approve a vaccine or not, it can make two types of mistakes: approve a vaccine that is not one hundred percent safe and effective, or not approve a safe and effective vaccine. The more time the regulator devotes to testing, the more it delays good vaccines but also avoids the approval of vaccines that are not so good.

If it makes a mistake and approves a vaccine that is not completely safe, then it will pay a (personal) price in the form of lawsuits, negative publicity and more. If, however, it makes the mistake of delaying the release of good vaccines, public pressure will be less severe, and so will the chances of lawsuits. This is because, from the public's point of view, there is no vaccine and everything is part of a process that "takes time". Therefore, the regulator prefers not to take unnecessary risks.

The Firms

Creating a new drug is a long and risky process. Often, firms try to develop a drug, investing a lot of money, but the development process fails, and the drug does not make it to the market. What about the good drugs that did make it to the market? These drugs have also undergone a long process of monitoring and licensing, a process that added costs and delays to their production. As a result, the public had not benefited from the drugs for a long time and when these came out, the public paid a lot of money to acquire them since the developing company wanted to take advantage of the relatively short patent time left to rake in profits (for optimal patent time see, e.g., Nordhaus, 1972). However, effective and safe drugs and vaccines are still available to the public.

3. The Pharmaceutical Industry

Research and Development

The pharmaceutical industry is characterized by heavy investment in research and development. The scope of its expenditure on R&D is second only to the computer and electronics industry, and it tops the list of R&D expenditure per employee (Lakdawalla, 2018). When a molecule is discovered that treats a

particular disease, it is registered as a patent. The reason for early registration is the public procedure of testing the drug, which does not allow for the effective safeguarding of trade secrets (Morton & Kyle, 2011). After successful animal experiments, a request is made to the regulator to approve human experiments. Subsequently, three phases of clinical trials in humans are conducted. The first stage is to test the drug on healthy people to make sure it is not dangerous; in the second stage, different doses are tried on sick people; in the third stage, the drug or vaccine is tested on humans when the control group in the experiment is administered a placebo.

About 70% of the drugs or vaccines that make it to the first stage pass the tests and reach the second stage, and about 30%-40% of the drugs and vaccines in the second stage will be deemed safe enough to reach the third stage. Overall, approximately 20%-30% of the drugs and vaccines that started the first phase will complete the third phase and be approved for use (Adams & Brantner, 2006). This process is expected to take 8-10 years and cost about \$500 million (Blume-Kohout & Sood, 2013; Broom, 2020).

Patent rights are usually granted for 15-20 years; however, the developing company can enjoy them only from the moment the product reaches the market, which happens long after the patent rights are granted. When patent rights expire, the developing firm faces competition from firms that specialize in manufacturing drugs that have lost their patent rights (such as the Israeli Teva Company).

Speed of Approval and Development of Drugs and Vaccines

The speed with which the drug or vaccine is released determines the period that the developing company will enjoy the monopoly rights granted to it by the patent protection, and thus affects its profits. To what extent does the speed of approval affect the development of new drugs? In 1992, the U.S. Congress passed a law that allowed the U.S. Food and Drug Administration (FDA) to charge fees from drug manufacturers to fund the approval process of drugs and vaccines (Prescription Drug User Fee Act – PDUFA). As a result of this law, the time for drug and vaccine approval has been significantly shortened (Olson, 2002).

Vernon, Golec, Lutter & Nardinelli (2009) found that shortening the approval time by 10% leads to an increase in the research and development expenses of pharmaceutical companies by 1.4% to 2%, so that the shortening of the approval time following the law increased the companies' research and development expenses in the survey by 5% to 7.2%. The rapid approval of drugs resulted in the saving of 140,000 to 310,000 life years in the decade following the law's approval (Philipson, Berndt, Gottschalk & Sun, 2008).

Beyond the enhanced benefit for consumers who use newer drugs, resulting from improved quality of life, prevention of hospitalizations and longer life expectancy (Lichtenberg, 2007), the higher profits from early entry into the market encourage the development of more drugs and vaccines. Each additional year of patent rights increases the number of drugs entering the market by 0.2% (Gilchrist, 2016).

The speed of approval of new drugs and vaccines also impacts the allocation of resources for research and development. While the path to drug approval, for example cancer prevention or early-stage cancer treatment, is long, drugs designed to treat advanced-stage cancer undergo a rapid approval process.

Since patent time is fixed, companies devote most of their efforts to developing drugs to treat critically ill patients and probably do not spend enough effort on developing drugs to prevent these diseases, leading to the loss of many years of life (Budish, Roin & Williams, 2015). In addition, the long and costly approval process contributes to pharmaceutical companies' concentration on markets where large profits are expected, thus neglecting smaller markets (Dubois, de Mouzon, Scott-Morton & Seabright, 2015).

Speed of Approval and Company Size

When they are set to approve a drug or vaccine, regulators are also affected by the reputation of the company that applied for the regulator's approval for its products. Therefore, older and larger companies enjoy faster approval paths than small companies (Olson, 1997; Thomas, 1990). This contributes to the centralization of the drug and vaccine market and to pushing their prices up. Needless to say, when big profits can be made, these companies do not show too much interest when it comes to social responsibility towards all patients (Leisinger, 2005).

4. Summary and Conclusions

This paper posed the question that we critically face in these days of a global pandemic: is it possible to expedite the arrival of drugs and vaccines to consumers?

Numerous empirical evidence suggests that the long and expensive process of approving incurs a heavy price tag, as it delays the arrival of good products in the market and thus causes a significant loss of years of life and quality of life, it distorts the allocation of resources to R&D and it gives an advantage to large companies, exacerbating market centralization and price increases.

On the other hand, tight regulation increases the benefit to consumers because it makes the medications, vaccines and medical devices that we have relatively safe to use.

Indeed, patients are not resentful, perhaps out of ignorance, at the fact that they are not receiving a drug that is not on the market but could be there. However, we also are not aware of the outcry of those who used the drugs and vaccines and were harmed by them.

Is it possible to reach an ideal world soon, where safe drugs are quickly approved? probably not, but there is certainly room for improvement. Of course, we do not want truly hazardous substances to reach the market, but it is certainly possible to compromise somewhat on the effectiveness tests of treatments (Grennan & Town, 2020; Isakov, Lo & Montazerhodjat, 2019) and move on to learning following approval.

In an age where knowledge is rapidly disseminated among the medical community, it is possible to reach a situation in which the medical community will quickly filter out for itself the best drugs and vaccines. Also, a stricter demand from drug companies for social and moral responsibility backed by appropriate laws will result in their conducting thorough self-checks before launching products to the market, even for fear of huge lawsuits.

Such an improvement in the work of the regulator will result in more people benefiting from better medical services at lower prices.

The tremendous impact of the Coronavirus on the health and lives of many people as well as on the entire economy has led the U.S. Food and Drug Administration to test the safety and efficacy of drugs and vaccines on a very fast track (U.S. Food and Drug Administration, 2020). The question we need to ask is whether we can move closer to a world where all drugs and vaccines undergo a rapid monitoring and control track so that more people enjoy better, more effective and cheaper drugs and vaccines.

It seems that these days of immense economic damage caused by a pandemic are a great time to re-examine the effectiveness of the regulator's work and improve it.

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Heaven Help: Civilian Aviation During the Covid-19 Crisis

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The contribution of civil aviation to human development is evident in all areas of life, so much that in fact it is almost impossible to imagine our world without it. 2019 was a record year for civil aviation, breaking a record in the number of daily flights and passenger traffic. Had it not been for the manufacturing catastrophe in the Boeing 737, it would also have been the safest year for aviation. Civil aviation in Israel is extremely important to the security, cultural ties and the economic strength of the country. The article will briefly review the state of civil aviation in the world and in Israel, argue that the Covid-19 crisis reflects the fragility of Israeli airlines, emphasize the need to assist them in crisis situations like the one we are experiencing in 2020 and stress the actions required by airlines to overcome such a deep crisis.

Civil Aviation in the World and in Israel – Facts and Figures

On August 25th 1919, the first commercial flight took off from London, in an aircraft of an airline that would later be called British Airways. After a short flight, its landing gears rubbed the runway of Paris Airport. It was the first international scheduled commercial flight in the world. On that flight there was one passenger, who paid £1,000 for the ticket, as well as a few goods transported from the British Isles to the mainland. A century later, the International Air Transport Association (IATA) published data that showed that in 2019 alone, there were about 39 million flights worldwide, and global passenger traffic in aviation stood at more than 4.3 billion passengers (a figure that can be properly appreciated if one remembers that the entire world population is estimated at 7.8 billion people).¹ Air freight traffic in that year exceeded 35% of total world trade, and has reached about 60 million tons of cargo, whose value is estimated at \$6 trillion.²

At the end of July 2019, the FlightRadar24 aircraft tracking app recorded more than 225,000 flights in one day, a figure that indicates the busiest day in the history of aviation.³ 2019 was also one of the safest

1. See the IATA report, published in 2019: <https://www.iata.org/contentassets/c81222d96c9a4e0bb4ff6ced0126f0bb/iata-annual-review-2019.pdf>.

2. See the latest report by ATAG: <https://www.atag.org/our-publications/latest-publications.html>.

3. See the report in *Business Insider*: <https://www.businessinsider.com/most-flights-ever-225000-flight-radar24-flight-tracking-2019-7>.

years in international aviation.⁴ According to the annual survey by the Aviation Safety Network (ASN), out of the tens of millions of flights operated worldwide in 2019, 20 fatal air accidents occurred, claiming the lives of 283 people (three accidents out of those 20 were commercial flights in Europe and North America, in which two air crew members and three passengers perished).⁵

Today we can fly from one destination to another across the globe in a few hours, in a passenger jet that cuts the sky at a speed close to the speed of sound. In February 2019, a Boeing Dreamliner passenger plane flying from Los Angeles to London even reached a speed of 1289 km/h, while it was originally designed to fly at a speed of about 900 km/h.⁶ Moreover, technological development has made passenger planes particularly efficient,⁷ and geopolitical stability, especially in the Western world, has helped open the skies around the world and made competition in civil aviation fierce.

The contribution of civil aviation to human development is evident in all areas of life, so much so that it is almost impossible to imagine our world without it. Although we fly from one geographical place to another, we do more than that – we move from one culture to another and come back with ideas and experiences; we leave a country with defined borders and arrive in a country with open borders, and perhaps hope that borders will be removed all over the world; we take off and land, land and take off and bring with us economic opportunities, social ties, new-old foods, human life ingredients that migrate across the globe and enrich the human race.

Meanwhile, civil aviation contributes 3.6% of the world GDP, and this contribution is very diverse and significant. According to the Air Transport Action Group (ATAG), airline companies contribute to the creation of more than 65.5 million jobs worldwide, of which only 15% are actually in aviation services. Most of these jobs are created indirectly in the fields of trade, tourism, transportation, etc., and some even in companies created as a derivative of technological and industrial research and development that originated in the aviation world and migrated to other areas such as medicine, automotive, high-tech and low-tech. This means a multiplier of 6.6 jobs per every employee in an airline company.⁸

Israel has integrated well with the global trend in aviation, and the rate of increase in the number of passengers each year in the last decade has exceeded the world average. The latest statistical yearbook published by the Central Bureau of Statistics (CBS)⁹ shows that in 2018, the number of inbound and outbound flights to and from Israel exceeded 154,000. The number of passengers on these flights exceeded 22 million people, and the amount of cargo was about 350,000 tons. Out of these data, more than 43,000 flights were operated by the three main Israeli airlines – El Al, Arkia and Israir,¹⁰ which transported about

4. If you do not take into account the Air Ethiopia Boeing 737 Max accident, in which 157 passengers were killed, 2019 was one of the safest years for commercial aviation. See the conclusive report by CNBC: <https://www.cnbc.com/2020/01/02/deaths-from-commercial-airplane-crashes-fell-more-than-50percent-in-2019.html>.

5. See the statistical data of 2019 by ASN: https://aviation-safety.net/graphics/infographics/ASN_infographic_2019.jpg.

6. See a detailed report on this subject in the Washington Post: <https://www.washingtonpost.com/weather/2020/02/09/british-air-record-flight-speed-atlantic/>.

7. Only about 2% of CO2 emissions by humanity are caused by commercial flights of passengers and cargo: <https://www.atag.org/our-publications/latest-publications.html>.

8. See the report on the ATAG website: <https://www.atag.org/component/attachments/attachments.html?id=708>.

9. See the Israel statistical yearbook for 2019: <https://www.cbs.gov.il/he/publications/doclib/2019/19.shnatontransportan-droadsafety/diagrams19.pdf> (in Hebrew).

10. There are three commercial airline companies operating in Israel, flying passengers and cargo: El Al, Arkia and Israir. In January 2020, C.A.L applied to the Civil Aviation Authority for a license to fly passengers, while it is permitted to fly only cargo. See the report in *The Marker*: <https://www.themarker.com/consumer/tourism/1.8373971> (in Hebrew).

7 million passengers with the help of a fleet of 56 Israeli passenger planes and three cargo planes, as well as chartered planes.¹¹

IATA and the research company Oxford Economics published a report on civil aviation in Israel at the beginning of 2018. The report shows that civil aviation contributes more than \$27 billion to the Israeli economy, which constitute 6% of GNP and about 265,000 jobs. The commercial aviation industry in Israel directly contributes about \$7.2 billion to GNP, and it employs about 33,700 workers in airlines, airport operating companies, companies that operate on airport grounds (shops, restaurants, etc.), representatives of aircraft manufacturers and service providers in the field of aerial navigation.¹²

Aviation in the World and in Israel During the Covid-19 Crisis – Facts and Possible Solutions

The positive trends in the civil aviation industry in recent years have led aviation organizations around the world to publish optimistic forecasts as to what to aviation in 2020. But then the Covid-19 crisis struck, and the global spread of the disease in the first four months of 2020 prompted the steepest downfall in the history of civil aviation. The number of international commercial flights in April was about 10% of the pre-crisis air traffic and attempts by various countries to bring life back to normal did not help the civil aviation industry to restore normal operation in the summer of 2020.

A report describing the gloomy picture of world civil aviation was published in late April 2020 by the International Civil Aviation Organization (ICAO).¹³ The report shows that in 2020, the estimated decrease in the number of passengers on international flights compared to 2019 will be between 44% and 80%, and the cumulative damage to the aviation industry will be as high as about \$314 billion, which constitute a decrease of about 55% in the airlines' turnover. Consequently, the decline in airport revenues will be 45%, and revenues from tourism around the world will reach only a third of revenues in 2019.

As of early April, 40% of the world's passenger planes – about 10,500 – are grounded. Recently, aircraft parking lots have begun to fill up at all airports, especially in countries where the climate is dry and hot and the cost of parking is high. That is, the characteristics of the climate are essential for maintaining the integrity of the aircrafts and the ability to restore their airworthiness without damaging the planes.

Similarly, the damage to Israeli civil aviation will be significant. IATA estimates that air traffic in Israel will fall by 9 million passengers, a decrease of 40%, hurting the revenues of Israeli airlines by more than \$2 billion, and bringing about the loss of tens of thousands of jobs directly and indirectly.

Understanding the crisis that airlines are facing requires recognition of the economic constraints in which they operate. The economic model of airlines, as evidenced by the data described above, is a mass retail model based primarily on what is commonly called the creation of "size advantages", or Economies of Scale. This means that airlines must fly as many passengers and as much cargo as possible in order to attain purchasing power with which they will receive more convenient and favorable economic terms

11. See the report in *Calcalist*: <https://www.calcalist.co.il/local/articles/0,7340,L-3772463,00.html>.

12. See the IATA report: <https://www.iata.org/en/iata-repository/publications/economic-reports/israel--value-of-aviation/>.

13. See the IACO report: https://www.icao.int/sustainability/Documents/COVID-19/ICAO_Coronavirus_Econ_Impact.pdf. See also the IATA report, published in April 4th 2020: <https://www.iata.org/en/iata-repository/publications/economic-reports/covid-fourth-impact-assessment/>.

from their various suppliers, and streamline their processes in a way that reduces fixed expenses and some variable expenses on passengers.

Thus, in order to compete successfully in the global aviation market, airlines offer tickets at a price that represents a low profit relative to the expenses tied to providing the service. Sometimes they even sell the ticket at a loss to reduce the economic damage from a flight with few passengers, in the hope that they will be able to sell complementary services to the passengers, such as a hotel vacation and car rental, and perhaps even duty-free products.¹⁴ Thus, it turns out that airlines are less sensitive to changes in flight prices, but very sensitive to declining passenger volume, which is why the Covid-19 crisis threatens to push many dozens of airlines to insolvency.¹⁵

For example, the price of a new Boeing 787 is about \$200 million,¹⁶ and its annual operating cost is estimated at tens of millions of dollars,¹⁷ as is its depreciation. Airlines pay for the aircraft by way of taking out a long-term loan, and they repay the loan through the expected cash flow from the sale of airline tickets. Therefore, a decrease in cash flow directly impairs the ability of airlines to meet loan repayments on aircraft. Moreover, a long-term crisis as the one expected now leads to a decline in the market value of the aircraft themselves, which serve as a guarantee for loan repayment.

The American company Delta has a debt of about \$8 billion, its annual revenue is estimated at \$40 billion a year, and its earnings stand at about \$4 billion a year. Thus, it is clear that the cessation of its activities for a few months is dramatic, and that its ability to meet the loan repayments for the purchase of the aircraft is impaired. We are therefore witnessing a collapse in Delta's share price and its market value that has recently fallen by more than 50%, from about \$36 billion prior to the outbreak of the coronavirus pandemic to about \$16 billion at the end of April 2020.

In addition, the uncertainty regarding how long it will take to get out of the Covid-19 crisis makes it difficult for airlines to reduce expenses; this is in contrast to a situation in which an airline proactively decides to reduce its operations. For example, the costs of maintaining the pilots' proficiency are high but are obligatory even if they are furloughed,¹⁸ and so are meeting the loan repayments that financed the purchase of the planes, the cost of parking the planes over time and the cost of maintaining them (since the airline will need them when the crisis is over and therefore is not interested in selling them, apart from the fact it will be difficult to sell for a reasonable price). Indeed, airlines are reducing labor costs,

14. Attention should be paid to a fascinating dynamic economic phenomenon that occurs from the moment an airline offers a commercial passenger flight to the moment when the earning obtained from it can be calculated. The point of equilibrium between the supply curve (S) and the demand curve (D) for each of the flight tickets varies from the moment the sale begins (marketing) to the end (closing the flight in the online systems). We therefore encounter an unavoidable effect of price discrimination, where the airline must adopt a pricing strategy in which the identical products and services that it offers are sold at different prices.

15. See an interesting analysis by Doron Zur on the state of Delta company in the midst of the Covid-19 crisis: <https://www.themarket.com/blogs/dorontsur/BLOG-1.8739960> (in Hebrew).

16. See: <https://www.statista.com/statistics/273941/prices-of-boeing-aircraft-by-type/>.

17. See a paper on Direct Operating Cost (DOC) of various aircraft models, including the Boeing 787: Minwoo, L., Larry K. B. L., Wenbin, S., (2019), "Analysis of Direct Operating Cost of Wide-Body Passenger Aircraft: A Parametric Study Based on Hong Kong", *Chinese Journal of Aeronautics*, Vol. 32, Issue 5, May 2019, pp.1222-1243.

18. A pilot is required to pass a level exam by a civil aviation authority examiner every 6 months; the exam is held at a flight simulator, in which the pilot is tested on performing emergency procedures and malfunctions, use of the aircraft systems, his knowledge of the aircraft literature and his acquaintance with the aviation world at large. In this context, IATA attempts to coordinate between the aviation authorities in different countries to extend the various licenses required of air crews: <https://www.iata.org/en/pressroom/pr/2020-04-27-03/>.

lowering salaries for all employees, halting projects under development and trying to defer payments to suppliers, but these actions have limited effect on their cash flow. Simply put, this is not an industry that can be "turned off" and "turned on" immediately and without damage, and as the current crisis continues, turning on can be costly and time consuming. Indeed, converting some passenger aircraft to cargo aircraft may reduce the damage, given the increase in cargo volume associated with the crisis, such as protective equipment and medical equipment, but we see that this is not a simple procedure.¹⁹

Due to the difficulty of temporary shutdown, the airlines are doing everything in their power to generate traffic, even, as mentioned, at a loss and sometimes to satisfy special demands, some of which come through the political-diplomatic channel. Bucking the trend of the industry, Israir flew more in the first half of 2020 than in the same period last year. The company routinely operates 10-11 aircraft (7 that it owns and another 3-4 on lease), and during the Covid-19 crisis it operated rescue flights of Israelis from Europe, medical cargo flights from the Far East and passenger flights to maintain contact between residents of Eilat and the Southern District with the country's center (mainly for medical procedures). In the first four months of 2020, Israir operated its aircraft at a level of 4,321 flight hours, compared with 4,250 flight hours in the corresponding period last year (a figure that reflects a performance of 101.6%). Out of about 8,000 passengers who passed through Ben Gurion Airport in April, about 2,000 flew with Israir (about 25% of the traffic, compared to the same period last year when Israir occupied 2.5% of all traffic at Ben Gurion Airport). The unusually high numbers are surprising given the circumstances, and they emphasize the need and ability to make quick adjustments under bold management, utilizing cash balances wisely saved for such difficult times and strengthening ties with the company's customers (some flights were at a loss due to Covid-19 restrictions and low occupancy rates), all out of a desire to remain economically vital and important in the Israeli public eye, and to receive recognition for its strategic-political contribution. Creative, quick and courageous thinking puts the company in a stable survival mode, slows down the rate of cash burning and, no less important, gets the company ready for the day after. The honest cooperation and trust relationship between the management and the employees at Israir have created fertile ground for executing a flexible business plan in a dynamic crisis environment, which requires the recruitment of all the manpower left in the company.

Even if we do emerge from the crisis soon, the recovery of the civil aviation industry may be slow, especially in the branch of international flights. We will see passenger planes return to flight without filling all the seats of the aircraft, and without fully covering the flight costs, and the operation of the flights will continue to be complicated for an unknown period of time. Operating an international flight in a

plague-stricken world is a complex endeavor, both in transporting passengers and in the transport of cargo. Flying passengers requires checking them and verifying their health before they board the aircraft, and it is necessary to protect the cabin crew and disinfect the aircraft after each flight, especially if a patient is suspected of being on board. Cargo flying takes the aircraft to different destinations of varying levels of epidemiological risk, and risk factors for infection may migrate from country to country with the airborne goods, spreading the disease.²⁰

19. Despite repurposing aircraft and reassigning personnel, there is a marked deficiency in air cargo capacity. See the IATA publication of this issue: <https://www.iata.org/en/pressroom/pr/2020-04-28-01/>.

20. See the report by Michal Raz Haimovitz that deals with the perspective of Israeli pilots during the crisis: <https://www.globes.co.il/news/article.aspx?did=1001326305> (in Hebrew).

Another step that may help the economic recovery of the industry is the assistance of governments around the world. Unlike other sectors, the aviation sector, by virtue of being a high-risk area in terms of safety, requires close supervision by local and international aviation authorities. The maintenance of the aircraft is required to be meticulous, and maintaining the proficiency of the aircraft crew, and especially the pilots, must be highly professional. This regulatory burden is justified, of course, but it has the potential to add to the operating costs of airlines, and there is a good reason to take this into account in a time of crisis in which the market is not functioning in a way that reflects these costs.²¹

Moreover, the relationship between the airlines and the Israeli governments has always reflected a special situation that justifies government assistance. Israeli airlines employ many air crew members who are part of the Israeli Air Force's combat-ready and professional cadre. Many of them serve in reserve units for many days during each year. This fact serves the Israeli airlines well because they have skilled air crew members, but it also serves the security of the State of Israel as the pilots maintain constant flight capability, with high flexibility, and are ready to be summoned at any time. Moreover, the existence of a vital and active civil aviation industry serves well the unique geopolitical situation in which Israel finds itself. Israeli civil aviation proves time and time again its crucial and unique role in this context: during wartime and military operations, foreign companies rarely fly to Israel, and even stop doing so for long periods, and Israeli airlines maintain air traffic. These include operations to airlift Jews from around the world, airlifting essential cargo in times of crisis, rescuing Israelis from around the world, and so on.

Another step that is important to take in Israel is a structural change of the industry. As explained above, the economic model of all airlines in the world is based on size advantages, so there is good reason to consider positively the merger of the three Israeli airlines, El Al, Israir and Arkia, into one airline that can handle the fierce competition in the field.²² The restriction of competition that is expected from that merger may not harm the ticket prices, especially because of the "open skies" reform, which was deemed a success and led to a sharp increase in the number of weekly flights between Israel and various destinations around the world.²³ It turns out that in addition to the general contribution of civil aviation to our world, as described at the beginning of this paper, there are numerous safety, security, economic and other reasons that justify special government assistance to Israeli airlines during the Covid-19 crisis.

The crisis that the world economy is undergoing as a result of the spread of the coronavirus and the steps required to protect public health may lead to a fundamental change in the business doctrine of companies whose operation requires significant investment in assets, while their resilience depends too much on their positive cash flow capacity. In my opinion, the crisis stresses the need of every business entity, and certainly of airlines, to develop management tools that will enable agile, flexible and adaptable operations, as well as sales strategies that will incorporate the economic risk involved in operating them, so that their profit margins allow for acquired financial durability. A black swan may always appear, only this time it looks like a virus.

21. See the call by IATA and ITF (Transport Workers' Federation) for special government assistance to airlines during the crisis: <https://www.iata.org/en/pressroom/pr/2020-04-27-03/>.

22. See Yoram Gabizon's story in The Marker, about the possibility of merger of the three Israeli airlines: <https://www.the-marker.com/markets/.premium-1.8800812> (in Hebrew).

23. See Eitan Avriel's article in The Marker that opposes the possible merger of the three Israeli airlines: <https://www.the-marker.com/markets/.premium-1.8815249> (in Hebrew). See also Dani Sade's review of the "open skies" policy, 5 years after the reform was implemented: <https://www.ynet.co.il/articles/0,7340,L-5241635,00.html> (in Hebrew).

Concrete and Flowers: The Public Image of Engineer Prof. Rachel Shalon

Sharon Geva

Dr. Sharon Geva is a historian, a lecturer at Kibbutzim College and a teaching fellow at the NCJW Women and Gender Studies program at Tel Aviv University. Her book, *Women in the State of Israel: The Early Years* (Hebrew), was recently published in the Hebrew University Magnes Press, Jerusalem (2020).

This paper tells the story of Rachel Shalon (1904-1988), a civil engineer and the first woman at the Technion to reach the rank of professor, compared to her public image as reflected in the Israeli press. It mainly discusses the immanent tension in this image, in light of Shalon's crossing gender boundaries, as a woman in a profession that is traditionally considered the domain of men, and who worked in a distinctly masculine space. This discussion shows how, ultimately, the appreciation and even the esteem for a woman who was the most senior woman engineer in the early years of the State of Israel actually reinforced and entrenched the patriarchal culture in Israeli society, rather than challenge it.

Introduction

In 1960, Prof. Rachel Shalon was interviewed by *Maariv*, which was then the most popular commercial newspaper in Israel. The interview presented her research and professional achievements in the field of civil engineering as the first woman to reach the rank of professor at the Technion and was the first among the graduates of that institute to be included in its academic staff. Alongside research and teaching, she established and headed the Building Research Station at the Technion. The interviewing journalist was under the impression that she was facing a rather stiff woman. "Concrete is her profession – and, meeting her, one gets the feeling that small particles of the materials she is studying have penetrated her body and soul".¹ At the same time, she reported that Shalon is a "handsome young woman" who "likes beautiful things, and that includes clothes", and cultivates flowers in her backyard.²

1. Ada Cohen, "Mrs. Professor", *Maariv*, 15.7.1960, p. 16.

2. *Ibid.*

This article is one expression of the tension between Shalon's professional identity and her identity as a woman, a key element in her public image, which is at the focus of this paper. On contrast to her profession, which was distinctly masculine,³ and her senior rank in the academic hierarchy, her outer appearance, clothes and flowers received attention. In essence, she was, as the headline of that article put it, "Mrs. Professor". This tendency is also evident in news items and other articles published in the Israeli press about Shalon, in which the work of the most senior and oldest woman engineer in the country was reported, and will be discussed below. Inspired by the motivation underlying research in the history of women,⁴ this paper seeks to raise awareness of the importance of Shalon in the history of this profession in the Jewish community and the State of Israel, not least its place in Israeli history in general.

This tension stems from the traditional division of roles between women and men, a cornerstone of Israeli society.⁵ Although women make up about half of the world's population in general and of most societies in particular, they are considered a minority. The inferiority of the woman in patriarchal culture is inherent: she functions as an "other", as an object, and the boundaries of her activity are delimited to the private space, while the man, the "self", the autonomous subject, operates in the public space.⁶ As a woman who is an engineer, Shalon has crossed gender boundaries. Emphasis on traditional female elements in her life story and work neutralized the threat she posed to this fundament, thus paving the way for her appreciation and esteem. Meanwhile, non-paradoxically, gender boundaries were bolstered rather than cracked.

1. The Tragedy of the Woman Engineer

In the first decade of the State of Israel, most women did not work outside the home. Among those who did, few chose professions that were traditionally considered to be men's professions, which were principally leading and managing or operating machinery, such as driving, watchmaking and engineering. During this period, the proportion of women among all those employed in the economy was between one-fifth and one-quarter. In 1958, the proportion of women who also worked outside the home was 27.3%. About a third of them worked part-time.⁷ Most worked in a traditional female profession such as nanny and kindergarten teacher, schoolteacher and nurse, hairdresser and beautician. A few were doctors and engineers.⁸

In a series of investigative articles conducted by the journalist Tikva Weinstock in 1960 on the subject of women in the liberal professions, it was found that in theory all those were open to women, but in practice only a few women worked in a profession that was not traditional, and persevered in it. The gap between the declaration of equal opportunities in the labor market and reality was an expression of the general gap between the declaration of equality in the State of Israel, as formulated in the Declaration of

3. Dafna Yizraeli, "The Gendered Workplace", *Sex, Gender and Politics*, Tel Aviv: HaKibbutz Hameuhad, 1999, pp. 167-215 (in Hebrew).

4. Dvora Bernstein, "The Study of Women in Israeli Historiography: Starting Points, New Directions and Emerging Insights", in Margalit Shilo, in Margalit Shilo, Ruth Karak, Galit Hazan-Rokem (eds.), *The New Hebrew Women: Women in Zionism and the Jewish Pre-State Community from the Perspective of Gender*, Jerusalem: Yad Ben Zvi, 2001, pp. 7-25 (in Hebrew).

5. Dafna Yizraeli, Ariella Friedman et al., *Sex, Gender and Politics*, Tel Aviv: HaKibbutz Hameuhad, 1999, pp. 9-18 (in Hebrew).

6. Simone de Beauvoir, *The Second Sex*, Tel Aviv: Babel, 2001, pp. 9-27 (in Hebrew).

7. "Work", *Statistical Yearbook of Israel 4*, The Central Bureau of Statistics, Jerusalem: Government Press, 1952, p. 77 (in Hebrew); "Work: Manpower, Employment and Unemployment", *ibid.* 6, 1954, p. 116 (in Hebrew); "The Population (Ages 14 and Up) By Workforce, Religion and Sex", *ibid.* 10, 1958, pp. 292-293 (in Hebrew).

8. Lilia Basevich, *If Only an Echo...*, Tel Aviv: HaKibbutz Hameuhad, 1981, pp. 101-102 (in Hebrew); "A Small Number of Professions for the Girl to Choose", *Haaretz*, 30.12.1957, p. 3 (in Hebrew).

Independence,⁹ and the status of women in Israel in actuality. At that time, women were not equal, neither legally nor socially.¹⁰ It was also found that even when the proportion of women in a particular profession was high, for example in teaching, most of them filled lower ranks.¹¹

The same was true in the field of engineering. The proportion of engineers among members of the Association of Engineers and Architects did not exceed 3%. The main difficulty was dealing with the attitude of men, peers and superiors, towards women in the profession, and women's having to prove their abilities to them repeatedly. Weinstock called it "the tragedy of the woman engineer".¹² The struggle of each and every female engineer was not a general struggle for the position of women as women in the profession but was divided into separate struggles that each engineer had to repeatedly conducted by herself. These also contributed to the divisions among women and further established the dominance of men in this field. In the background, the solitude of women in male professions also emerged, and it was exacerbated by men in these professions, who bolstered their status in a "members-only club".

As part of the series of articles, Uriel Shalon (Friedland), then chairman of the Engineers Association and director of the "Shemen" factory,¹³ who was presented as an "authority" on the subject, was also interviewed. He said that "there are many outstanding women engineers in the profession". The journalist commented that "It is not for nothing that he thinks so: his wife is Rachel Shalon, the professor in the faculty of building [sic], head of the Building Research Station and president of the International Organization for Laboratories and Materials, the engineer who reached the highest level in Israel, which only a few men achieve".¹⁴ Rachel Shalon was not interviewed for that article.

Whatever the reason for her absence among the interviewees for the article, retrospectively, this is one instance of noting Shalon's marital status, including the professional status of her spouse.¹⁵ As the years passed and as she progressed in work and academic rank, this detail was mentioned again and again. For example, in a review of the Torch-Lighting Ceremony at the 32nd Independence Day, Shalon was chosen to light a torch. She was introduced as a "civil engineer and professor at the Technion", an "honorary citizen of the city of Haifa" and as married to Uriel Shalon, an engineer and CEO of "Shemen", also an honorary citizen of Haifa. Her professional achievements, in the academy and outside it, were also detailed.¹⁶ Years later, a street in the city of Haifa was named after him.

2. A Woman and a Scientist Alike

The series of articles on women in the labor market was exceptional given the regular news items and articles published in the press about women who were employed in what were traditionally considered men's occupations. This series of articles was an investigation aimed at finding out the reasons for the

9. "The Declaration of Independence of the State of Israel", State of Israel: The Temporary Government, Official Bulletin no. 1, Tel Aviv, 14.5.1948, www.knesset.gov.il/docs/heb/megilat.htm (in Hebrew).

10. See, for example, Ariella Friedman, "On Feminism, Femininity and Women Power in Israel", Dafna Yizraeli, Ariella Friedman et al., *Sex, Gender and Politics*, Tel Aviv: HaKibbutz Hameuhad, 1999, pp. 19-47 (in Hebrew).

11. Tikva Weinstock, "All Honorable Is the Daughter of the King – Inside?", *Maariv*, 31.8.1960 (in Hebrew).

12. Tikva Weinstock, "Numerus Clausus for Women in Medicine School", *Maariv*, 5.9.1950, p. 7 (in Hebrew).

13. "Shemen – An Industrial Pioneer in Israel", *Davar*, 23.12.1960, p. 30 (in Hebrew).

14. Weinstock, "Numerus Clausus".

15. "Last Column: Rilam to Be Headed by a Woman", *LaMerhav*, 20.7.1960, p. 2 (in Hebrew).

16. "Prof. Rachel Shalon the First Engineer", *Maariv*, 17.4.1980, p. 19.

women's generally unfavorable position in the labor market. In general, articles and news stories about women in male professions have portrayed the stories of their lives and work and presented them as unique, always while emphasizing the feminine features in their biographies and characters. The displays of appreciation were accompanied by an evaluation of their functioning at home, and traditional female traits in their personalities or details in their external appearance were highlighted. This was also the case in articles about the engineer Shalon; for example, when it is told that she "embodies in her personality the fusion of a woman and a scientist alike".¹⁷ This fusion was both metaphorical and real: thus, "on her desk in the office one can find in one corner – a slab of concrete, and in the other corner – a vase with pretty flowers".¹⁸

Another article about Shalon began with a description of her appearance: "Her hair is brown-black, intertwined with silver threads, her eyes are brown, soft and wide open". Dressed elegantly, her voice is quiet and she "looks much younger than her age". The journalist called her "the great lady of the Technion" and noted that the professor is not as tough as she might seem. She further noted that in the end, "Rachel Shalon is basically a teacher".¹⁹ While it is not inconceivable that the intention was to underscore the fact that Shalon taught many male and female students, this reference assigned her, even if inadvertently, to a distinctly female profession and thus strengthened her identity as a woman in the eyes of the readership.

Rachel Shalon, nee Znanmirowska, was born in Poland on the eve of Passover 1904, the daughter of Gittel and Hanoach, a lumber merchant, and grew up in Kalisz. She recounted that from a very early age, her father taught her, as well as the rest of her brothers and sisters, to become independent. Her life story, as she outlined it, shows that determination and striving to achieve the goals she set for herself characterized her since her youth. An example of this is when she was determined to learn Hebrew even though her father forbade it because it was a sacred language, or when she decided at the age of fifteen to attend a Jewish school in Warsaw, since she could not bear the manifestations of antisemitism in the private school where she studied. Her parents refused, as they did not want her to leave home, and she went on a hunger strike. She eventually moved to her aunt's home in Warsaw. After graduating from high school with honors in mathematics, she studied chemical engineering at the Warsaw Polytechnic. In 1925, because of instances of antisemitism, she decided to continue her studies in the Czech Republic. Meanwhile, she joined a group of Jewish students who went on a tour of Palestine-Israel, where the Hebrew University was just opened. Following the tour, she decided to stay in the Eretz Israel, much to the chagrin of her parents who informed her that they would stop supporting her financially.²⁰

In Israel, she continued her studies at the Technion in the field of civil engineering, during which she worked in the laboratories of the Nesher cement factory. In 1930 she graduated from the Technion and married. A year later she joined the Technion faculty, where she served as Vice President for Research, Vice President for Academic Affairs and Dean of the School of Graduate Studies. Thus, she was the

17. "Concrete – and Pretty Flowers", *Maariv*, 19.7.1960, p. 3.

18. *Ibid.*

19. Sonia Daitz-Lazar, "Rachel Shalon's Concrete and Blocks", *Days and Nights Magazine, Maariv*, 13.8.1971, pp. 28-29.

20. *Ibid.*, p. 28.

first of all the Technion graduates, men and women, to reach the rank of full professor.²¹ In the early 1950s, the Technion established the Building Research Station, which conducted research on construction management and its adjustment to climatic conditions in Israel.²² These were the years of the great aliyah (immigration wave), during which the Jewish population in the country was doubled again, construction was accelerated and immediate housing solutions were required.²³

The articles on Shalon show that the source of her motivation to study engineering was not only the landscape of her childhood and adolescence and personal interest but also the changes that took place in women's status that occurred during with her life as a young woman. She said: "The period of my youth was the period of the liberation of women. Equal-rights laws have already been enforced in several countries and there has been an awakening and a desire to discover and know. Engineering interested me perhaps because that profession was attractive for being so uncommon among women".²⁴ The 1920s were the time of the first wave of feminism, which was mainly manifested in the suffragist struggle. This was also the case in Israel, so at the end of a nine-year struggle (1917-1926), women in the Jewish community in Eretz Israel were given the right to vote.²⁵

The life of equality that Shalon led in her private home, let alone her partner's attitude toward her professional and academic achievements, were a sign of the time. Shalon herself had no doubt that

It is impossible for a wife to pursue a real career without an understanding husband, but although many husbands declare support for women's equal rights, they oppose them when it comes to their lives. People ask why women do not reach the top more often, even when their talents and abilities are obvious and unquestionable. Maybe it's because for a woman, there is no other woman to lean on. It may be a joke, but without an accommodating husband, the wife is torn apart and the conflict prevents the freedom and concentration necessary for professional advancement.²⁶

These remarks indicate an awareness of gender boundaries as well as of a gap between the egalitarian rhetoric "without gender difference", in the words of the Declaration of Independence, and the reality of women's lives in Israel – not only as citizens but also in the workplaces. It was also clear to her that housework was the lot of women and solutions would be found through other women who would do these chores for them – maids or caregivers. It can be assumed that this is how the Shalon household was

21. *Ibid.*, p. 29.

22. "The National Institute for Building Research: The History of the Institute", Technion website, <https://nbri.net.technion.ac.il/korotamahon/> (accessed 12.4.2020). Over the years, Shalon published many studies in Construction, among which the book *Cementing Materials* (Tel Aviv: Midot, 1964), and studies conducted in the Technion's Building Research Station, including *Inspection of Concrete in Buildings* (1954), *The Effect of Room Height in Residential Building in Terms of Climate, Architecture and Economy* (1962), *A Report on an Investigation of Ground Sand* (1965) and *Plastic Cracking in Cast Concrete in Warm Climates* (1970) (in Hebrew).

23. Moshe Sikron, "The Mass Aliyah: Its Extent, Characteristics and Effects on the Make-Up of Israel's Population", in Mordechai Naor (ed.), *Immigrants and Transit Camps: 1948-1952*, Jerusalem: Yad Yitzhak Ben Zvi, 1988, pp. 31-52.

24. Cohen, "Mrs. Professor".

25. Margalit Shilo, *The Struggle for the Vote: The Women of the Pre-State Community and Suffrage*, Jerusalem: Yad Yitzhak Ben Zvi, 2013 (in Hebrew).

26. Daitz-Lazar, "Rachel Shalon's Concrete and Blocks", p. 29.

run. Shalon expressed similar ideas at an event on women in science organized by the Women Workers' Council; while a man can invest all his time and energy in research, a woman is required to simultaneously carry out the housework, and this dual commitment has both a physical and mental cost.²⁷

3. The First Woman Engineer

The tension between Shalon's professional identity and her gender affiliation was at the root of her public image. The way to ease this tension was to emphasize the traditionally feminine features in her character – in her appearance and personality. These repeatedly reminded the public that although she was a senior and renowned engineer, a professor at the Technion, her identity as a woman was not compromised. At the same time, efforts to normalize her crossing the gender boundaries also worked in the opposite direction and reaffirmed those same boundaries, while again stressing the anomaly of Shalon's career.

Shalon, whether consciously or not, did not resign to it. She did not see herself as an exception, for example when she said: "I have no shadow of a doubt that women can succeed in this profession just like men".²⁸ In 1957, she received the rank of professor; in 1965, she was appointed rector of the Technion.²⁹ At that time, the proportion of women among all engineering students at the Technion was about 8%. She said, "I have closer and more intimate ties with the female students; they also turn to me with personal problems, as a woman speaks to another".³⁰ There is no doubt that the very presence of a woman among the senior academic staff served as an incentive for young women who chose to study at the institute, and certainly provided support during their studies, and it seems that they saw her, one way or another, as a role model.

Shalon identified the main source of the reinforcement of gender boundaries in Israeli society, which was expressed first and foremost in the assigning of women, at a very young age, to tracks that fundamentally revolve around caregiving and service – at home and in educational institutions. "Take toys, for example [...] From the beginning we give the doll to the girl and the building blocks to the boy. If the building blocks were given to the girl, she would probably be able to build those blocks as successfully as the boy". The attitude towards girls at school also confirms the practice of tracking: "There is a prejudice that women are not qualified for mathematics. This results in different attitudes towards girl and boy students", she claimed.³¹ What she said in 1960 is consistent with the findings and conclusions of researchers in the field of education, both regarding the tracking of girls and young women into traditional female professions and regarding their mathematical skills.³²

27. "Women Scientists Describe Their Lives", *Haaretz*, 3.11.1960, p. 4 (in Hebrew).

28. Cohen, "Mrs. Professor".

29. "Appointments of the Technion Academic Staff", *HaBoker*, 5.5.1957, p. 5 (in Hebrew); Zvi Tal, "Prof. Rachel Shalon Will Be Appointed Technion Rector", *Herut*, 3.6.1965, p. 4 (in Hebrew).

30. Cohen, "Mrs. Professor".

31. "Women Scientists Describe Their Lives", *Haaretz*.

32. Shoshana Ben-Zvi-Mayer, Rachel Hertz-Lazarotivz, Marilyn P. Sapir, "Teachers and Teaching Trainees – On Classifying Boys and Girls as Outstanding Students", *Studies in Education* 53-54 (1990), pp. 71-88 (in Hebrew); Fadia Nassr-Abu Alhijja, "Disparity of Achievements: Intercultural and Gender Differences in Mathematical Grades", in Yossi Shavit, Yariv Feniger, Rinat Arbiv-Elyashiv (eds.), *Chance for Change? Current Theory and Research of Equal Opportunities in Education*, Tel Aviv: Mofet, 2017, pp. 200-228 (in Hebrew).

Studying Shalon's work shows that she was marked as a groundbreaking woman – one of a kind. Although she seems to have been the first woman engineer in the history of the yishuv (Jewish community) and the State of Israel, over the years she was not defined as such. At the same time, there is no doubt that she saw herself as such: first and not last, one who would be followed by more women. On another occasion she noted that "our natural goal should be – 50% women in the technological professions, like our ratio in the general population".³³ Shalon passed away in 1988; this goal has not yet been achieved.³⁴

33. Tal Tzabar-Nativ, "Women Only 9% in Engineering Professions", *Davar*, 27.10.1975, p. 9 (in Hebrew).

34. In the 1999-2000 academic year, the proportion of women students of engineering was 25%, and in the 2016-2017 academic year it was 29%. Miri Alon, Anna Litvak et al., *High Education 2016: Statistical 168*, the Central Bureau of Statistics, 2018, p. 6 (in Hebrew). In the 2017-2018 academic year, the proportion of women students among all the students at the Technion was 36.7%. Ayelet Tal, *Women and Men at the Technion: Students and Staff Members, 2018*, Concise Annual Report, the Technion website, p. 3, <https://women.technion.ac.il>. About 10% of all full professors were women. *Ibid.*, p. 7.

The Technological Revolutions of Money: How We Learned to Count and Love the State

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The development of money has been associated since its beginnings with technological revolutions. The writing and seal revolution in antiquity gave rise to the hard currency, the print revolution gave rise to paper money, the digital revolution created digital money, and perhaps cryptocurrencies, the consequence of the blockchain revolution, are a new development in the history of money. Each of these stages is a revolution in itself, and they have not only augmented trade but also general literacy, shaped the phenomenon of the state and generated profound changes in the individual consciousness and in social relations. Cryptocurrencies, whose prototype is Bitcoin, are a new phenomenon, and it is not yet clear if they are a new revolution in the history of money and how they will change it.

On November 5th 2002, the Austrian mint issued about 15,000 silver coins called "Maria Theresa Thaler", packed them nicely and sent them to banks and other customers around the world – in Saudi Arabia, Argentina, USA, Ethiopia and more. In 2017 the mint launched a special edition of the coin to mark the 300th anniversary of the birth of the empress who first issued it. One of the most advanced nations in the world, a euro-zone member, still has been minting real silver coins used as common currency continuously since 1741 to this day. While it runs an economy with the most novel digital money, it still provides money in its earliest form – the hard currency.

Two thousand five hundred years stand between the first currency and our digital world. Two thousand five hundred years during which money became the main artery of the economy, society and the state. Or in the words of Liza Minnelli in the memorable film Cabaret: "money makes the world go 'round". Where did the coin even come from? And how, thousands of years later, was it transformed from the undisputed ruler of money to its anachronistic expression?

Money and technology have always gone hand in hand. The Industrial Revolution of the early 19th century

relied on new trading opportunities created when the money market became more agile and sophisticated, and therefore encouraging the use of innovative technologies to increase production. To the same extent, technological changes have revolutionized the field of money. The interrelationship between technology and money has existed throughout human history and has influenced human relationships. Below I will describe how technological revolutions have brought about revolutions in the field of money – from the invention of the currency to bitcoin – and how the money revolutions have affected human consciousness.

The Currency Revolution

Like many other things in human history, the birth of money is the result of an evolutionary process. The bitter debates that the relevant experts conduct about the question of the source of money (exchange, debt, or temple work) seem to laymen to be fussy narcissistic studies.¹ But sometimes the storm slips out of the teacup, as it did, for example, during the Occupy Wall Street protest that broke out following the 2008 financial crisis against Wall Street and its bailout by the Obama administration. The protest rekindled the debate over the sources of money and attracted public attention outside the walls of the academy.² But one thing brings all the scholars into unequivocal agreement – the invention of the coin was the first great revolution of money.

Until the invention of the currency, people traded in various ways. Sometimes they exchanged with one other the goods they desired directly – a sheep for a cow, milk for a cucumber. Sometimes commodities, such as cloths, seashells, and jewelry, were allotted for exchange purposes only and these became "means of exchange". Precious metals – gold, silver and copper – were also used as a kind of commodity intended for exchange (and partly for tools and jewelry). The Bible tells of Abraham – that is, the 15th-20th centuries BCE – who purchased the Cave of the Patriarchs for four hundred shekels of (the metal) silver,³ while the Greek philosopher Heraclitus, who lived between the 6th and 5th centuries BCE, already referred to gold as the most precious, noble and esteemed metal and wrote that "All things are an exchange for fire, and fire for all things, as goods for gold and gold for goods".⁴ Metals, chiefly gold, have become, indeed, a preferred means of exchange until well into the late modern era. The metal was durable, easy to carry, it offered considerable value, and on top of that it was liquefiable and therefore easy to distribute (unlike a cow or wood, for example), yet it was a commodity, a trade good, and to paraphrase Heraclitus, 19th-century Karl Marx would call it "the commodity of all commodities". In ancient times, the value of every means of exchange – cattle, cloth, shells, grain or gold – was determined ad hoc when the transaction was made, and each transaction stood on its own. Like any commodity, gold, the "super commodity", had to be examined in each separate case – to weigh it and check its purity with a touchstone, and only then could a deal be made.

1. The narrative of exchange was introduced by Adam Smith, the father of the classical liberal school of economics, in his book *The Wealth of Nations*, published toward the end of the 18th century, in the first volume, Chapter 4. See also Carl Menger, *On the Origins of Money*, 1892. This theory sees money as a "bottom-up" evolution, from direct exchange to complex exchange. In contrast to it, an institutional concept has emerged that sees money as an expression of debt/credit controlled by state authority. See Georg Friedrich Knapp, *State Theory of Money*, 1905. A third, lesser-known view holds that money is primarily a computational system born out of the need to determine the value of sacrifices in temples.

2. The debate erupted when David Graeber, an anthropologist and one of the leaders of the protest movement, published a book claiming that the source of money is debt. See: David Graeber, *Debt. The First 5000 Years*, 2012. Alongside positive and even praising reviews, mainstream economists of the classical school countered him. See, e.g., George Selgin, *The Myth of the Myth of Barter*, Cato Institute, 2016.

3. Genesis, 23:14-15.

4. Heraclitus, "B90", in *The Cosmic Fragments*, ed. Geoffrey S. Kirk, Cambridge: Cambridge University Press, 1978 (1962), 345-348.

All this changed as soon as someone took the prevalent technology at the time and with a slight change of its designation created the first coin. The seal – a stone or metal engraved with specific marks and paintings that can be recurrently stamped on pottery or metal – has been used as a means of identification and security since the fourth millennium BCE, when writing began. The seal was proof of the identity of the sender on documents, or as imprints on vessels that attested to the origin of the wine, oil or any other product that was in them, and together with the writing revolution it created a system of laws and certificates. In a brilliant move, the ruler of Lydia, a small Greek city-state on the shores of Asia Minor, nowadays Turkey, between the 6th and 5th centuries BCE, a disk made of an alloy of gold and silver on which a seal is stamped. The disc was not used to sign letters, laws, contracts or tools of any kind. It was unique and existed in and for itself; it was the first coin. From now on, one could bring metals to a certain state-owned workshop, where they were made into an alloy of a determinate ratio of gold and silver, cast into seal molds, and were handed to the owner as identical coins, the seal on which indicates that the state supervised their production process and guarantees their worth.

The coin was different from all the previous means of exchange. Coins facilitated trade significantly. There was no longer a need to weigh, measure and evaluate every transaction, and it was enough to count the coins. The revolution was enormous, and in less than a century the use of coins was widespread in every corner of ancient Greece. Aristophanes' parodic play "The Birds" (414 BCE) tells of a poor farmer who comes to the big city and after selling his wares carries the tiny silver coins in his mouth.⁵ Whether it was the ridicule of the use of money, or whether carrying money in one's mouth was a common practice, the play illustrates the extent of the use of coins that included even the poorest of people and the remotest of villages.

The invention of the coin created, for the first time, a uniform standard that everyone used, and thus brought about a tremendous revolution in the everyday life of humankind.⁶ Trade has become simple and accessible to many –rich and poor – and in many ways the coin gave rise to "democratization". In what way? Firstly, it created impersonalization. That is, instead of the obvious possibility of identifying between the means of exchange and its owner, even after the transfer of ownership has taken place, now since all coins are identical, it is no longer possible to identify a coin's previous owner from the moment it changed hands. Secondly, because of the possibility of dividing it into small units of low value, the coin introduced the use of metal as a means of exchange also to the common people. And thirdly, a point worthy of special attention is the fact that the use of coins has expanded literacy. Aristophanes' poor peasant did not think of becoming literate, but he did know well how to sell his wares, calculate their value and count the coins he held in his mouth. Therefore, even though writing was invented before it, the coin preceded it by centuries in promoting literacy among the general public.⁷

The coin revolution also profoundly affected the formation of the state. When the state issued the coin, it became the sole and ultimate designator of its value and was thus involved in every transaction conducted by means of the coin. Subsequently, all of Greece's city-states followed suit, especially Athens, and as the

5. Aristophanes, *The Birds*, trans. G. Theodoridis, 2005. <https://bacchicstage.wordpress.com/aristophanes/birds/>.

6. David M. Schaps, *The Invention of Coinage and the Monetization of Ancient Greece*, Ann Arbor: University of Michigan Press, 2004.

7. Literacy, which in Hebrew originates from the word meaning "bible" or "theory", has been used in recent decades to designate a variety of reading, communication and analysis skills such as technological literacy, digital literacy, medical literacy and more. "Numerical literacy", the currently accepted term for the ability to count and calculate, developed together and in parallel with literacy in its simple sense of reading letters.

use of the coin expanded, so did the state's presence in every transaction. The pervasion of the state into the daily lives of every individual brought about a profound change in the consciousness of the people, and even the common masses, who were usually associated with their direct master, were henceforth aware of the existence of the state in their lives. The impersonalization of the individual holding the coin created a personalization of the state, which made sure to display its gods and symbols on the coins. The Roman Empire further developed the use of the coins, and imprinted the faces of emperors on them, making them one of the most powerful instruments in its control over distant lands. Evidence of this can be found in the Midrash Genesis Rabba, compiled circa 6th-4th centuries AD, which interprets God's promise to Abraham, "and I will make of you a great nation", thus: "that his reputation will spread throughout the world... and what is his reputation? An old man and an old woman here, and a lad and a maiden there".⁸ Reputation (Hebrew: *monitin*), which shares a common root with the word money, is used here for both coin, renown and influence.

Combining a seemingly simple technological method – imprinting – with the writing revolution, produced the coin. The coin was a revolution in itself and has since persisted throughout human history. It spread all over the world wherever the white man's foot stepped and became the ultimate form of payment to the very heart of modernity.⁹ The coin is the result of technological revolutions – the writing and the seal – and when the coin was created, it revolutionized social relations and shaped the phenomenon of the state that has existed to this day. It can be stated, therefore, that the birth of the coin was one of the greatest revolutions of humankind that set the course of history. This was a huge event that changed social systems beyond recognition.

The Print Revolution

What does a person in 13th century Florence do he is afraid to walk around in the streets with silver and gold coins, or struggles to carry them because of their weight? He deposits them in for safekeeping at a Medici family bank or any other bank, in exchange for a certificate. He buys something, and in return passes the certificate with his signature, which is passed on to the next seller and so on, until someone in the chain decides to go to the Medici Bank and withdraw the gold. In the meantime, the Medici Bank can lend the gold deposited with it for safekeeping with someone else, by issuing a certificate. The borrower also purchases by means of the certificate, and so on and so forth. Although the original amount of gold has not changed, based on it, deposits and loans have increased. But how many certificates, personally signed and handwritten, can be issued?

And then appeared Johannes Gutenberg and published the first printed book – the first print edition of the Holy (Christian) Bible, kicking off the print revolution. It was a huge one; suddenly, texts could be produced quickly, cheaply and in vast quantities. Reading materials were available and made accessible to the general public. Literacy has gone beyond the strict confines of the scholarly elite, mostly within the church, and has become the domain of a bourgeois and well-established educated class. This revolution paved the way for modernity – for the Protestant religious revolution, for the growth of the bourgeoisie, for

8. *Genesis Rabbah*, 39:11.

9. On the spread of the coin in antiquity around the Mediterranean, see Elliott C.P., "The Role of Money in the Economies of Ancient Greece and Rome", in: Battilossi S., Cassis Y., Yago K. (eds.), *Handbook of the History of Money and Currency*, Singapore: Springer, 2020. https://doi.org/10.1007/978-981-13-0596-2_46.

the scientific revolution, and more. And of course – for the money revolution.¹⁰

Simply put – the printing press enabled the issuance of certificates identical to one another in great numbers. And since the same certificate can be duplicated dozens and even hundreds of times, the volume of loans can be increased. It took some more time for states, which were in the process of increasing centralization, to adopt the method, take it over, and make a clear distinction between a bank "promissory note", a certificate of agreement between the bank and a lender/borrower, and the banknotes the states issue. The states demanded a monopoly on the issuance of very specific certificates: these are not bonds that explicitly state who the partners in the certificate are – the borrower and the lender – but uniform, anonymous bills, stamped with value and the name of the state. A person holding this bill, whoever he may be, owns a certain amount of gold deposited in the vaults of the state treasury. Unlike the named and identifiable "banknote", the state bill is anonymous and completely uniform. It is the money, and this time "paper money".

Unlike metal coins, and even manual certificates, bills can be printed indefinitely – more and more money, lots of money! There is no doubt that the shift to paper money has been one of the factors that has caused the fluctuations between inflation and recession that have characterized the economy since the Industrial Revolution some two hundred years ago. At first, the connection between paper money and the gold in the vaults caused confusion and bewilderment. An immortal episode in Goethe's play *Faust*, from the early 19th century, describes a cunning policy adopted by Mephistopheles, the devil, who paid all the debts of the kingdom after the war without spending a single ounce of gold. The explanation given to the astonished emperor is that a promissory note was issued against the gold, and it was distributed to the masses as payment. The emperor suspects that his signature may have been forged, but not – “Remember, Sire, yourself it was last night / That signed the note / ... / These did you make, then thousand-fold last night / Conjurers multiplied what you did write”; but not only that, “And that straightway the good might come to all, / We stamped at once the series, large and small; / Tens, twenties, thirties, hundreds, all are there. / You cannot think how glad the people were”.¹¹ The emperor is appalled, for the amount of gold is so small compared to the amount of paper printed in his name, and he still wonders how the people believe this paper is gold. The feeling of insecurity in relation to paper money has dissipated over the years, and today paper money is perceived as tangible and real.

For about two hundred years, the world has shifted between gold and paper, that is, between periods in which the issuance of paper money is restricted to the limited amount of gold, and periods in which paper money is printed regardless of gold or other assets, but rather in the amount the state wants. In 1971, the relationship between money and gold finally ended, and since then money has existed solely as paper, without any precious metal or other asset backing it. It is just plain worthless paper or metal, just a sign created by the state. Although the seal on the ancient Greek coin, too, signified the coin itself and not something external, like a certificate or commodity, but the value referred to by the seal was the metal from which the coin was made. Now, however, the sign stands by itself – it is all about a relationship of exchange and debt, and it has no external value other than the very fact that the state has set it. This type of money

10. The first modern paper money was issued by a printing machine in Massachusetts in 1693. On the relation between the printing press and paper money, see Balkun, Mary McAleer, "The Print Revolution and Paper Money", in *The Routledge Companion to Literature and Economics*, ed. Matt Seybold and Michelle Chihara, Abingdon: Routledge, 17 Sep 2018. See also Goldberg, Dror, "The Massachusetts Paper Money of 1690", *The Journal of Economic History* (2009), 1092-1106..

11. Johann Wolfgang von Goethe, *Faust*, lines 6066-6076.

is called "fiat money".¹² The dollar, the euro, the shekel - every coin you name – is created out of nothing in the central bank, the "money factory" of the state, and it is replicated by it and by the banks. The power of the state has reached an all-time high.

Either way, the process that has taken place since the invention of the coin is repeated – standardizing and facilitating trade, expanding the literacy of all users, and of course their anonymity while the issuing state is identified and empowered. Money, indeed, has become one of the most important factors in the growth of the modern state.

The Digital Revolution

The digital revolution penetrated the money market around the middle of the 20th century, and it was again a technological revolution with distinct literacy implications, which influenced the movements of money. This has far-reaching effects on all aspects of money, but we will focus here on the "form of money", like dealing with coins and paper money. In 1958, the first credit card was issued and was immediately a success, and what matters for us here is the fact that a person pays for their purchases with a digital card instead of a personal check or bills. At first, it was just a credit card, i.e. the payment was recorded at the time of the transaction but was collected from the payer and deposited with the payee at later dates. Subsequently, additional payment methods were created (debit, prepayment, etc.), all of which are made using a digital card.¹³

Thus, we have a real revolution in the experience of using money. Until that point, it was possible to "feel" money, because the metal coin was a hard and clear object that contained within it the value of the metal itself, and the paper banknotes with the uniform value printed on them could be counted. The physicality of the two forms of payment was expressed in Hebrew by the phonetic monikers loosely translated as "ringers" and "rustlers". The magnetic card diminished the physical experience that lends numbers concreteness, when it created a sensory disconnect with the sum. Counting bills and coins in a wallet gives a person an instant sense of what one has and what one hasn't, while "swiping" a credit card dissolves that feeling. Once again, people were required to increase their calculating skills and the sophistication of their literacy. Moreover, since almost all digital cards are credit cards, users were required to consider time almost daily. Thus, the digital card created another stage of abstraction, which created and required a very advanced and sophisticated numerical literacy, to the point of creating difficulties for many users.

The encounter between buyer and seller has also changed. It is immediate – payment in exchange for goods – but unlike cash that completes the transaction instantly, with a credit card the transaction ends for each participant separately after each of them has gone their separate ways. The amount will be collected from the buyer's account according to their agreement with the credit company and will be deposited in the seller's account according to their agreement with the credit company.

Ostensibly, the digital revolution in the form of money is a linear continuation of previous revolutions,

12. The meaning of the word *fiat* in Latin is "*let it be done*". See Foster, Ralph T., *Fiat Paper Money – The History and Evolution of Our Currency*, Berkeley, California: Foster Publishing, 2010.

13. Evans, David & Schmalensee, Richard, "Paying with Plastic: The Digital Revolution", in *Buying and Borrowing*, MIT Press, 2004; Guseva, Alya, and Akos Rona-Tas, "Money Talks, Plastic Money Tattles: THE NEW SOCIABILITY OF MONEY", in *Money Talks: Explaining How Money Really Works*, Nina Bandelj et al. (eds.), Princeton: Princeton University Press, 2017, pp. 201-214.

but in fact it has brought about some significant twists and turns. It opens with the fact that the card is a money transfer device, and it is not the money itself. And yet, it is gradually becoming the main form of payment, and the "rustlers" and "ringers" are about to disappear from the landscape. At this stage, "money" is computer bits and numbers flickering on a screen. Hence, the encounter with money has become more and more abstract, and it is no longer counted – but rather the sums are calculated. The "form of payment" remained only a private instrument, in the hands of banks and credit card companies, while the money issued by the state is completely abstract, and soon the latter will not even bother to use the government printer's plates.

There is no doubt that digital cards are changing the connection that coins and banknotes have created between the individual and society and the state. While the previous means strengthened the presence of the state, the digital cards increase the presence of the bank. In addition, the card soon played a role in dissolving political and economic borders, as credit cards could be used in foreign countries. In this case, even the currency conversion is embodied in the payments. The seller receives the payment in his country's currency at the time guaranteed to him under the agreement, while the buyer pays at the time set with him in the currency of his country. Thus, a short exchange operation is performed that includes components that require complex literacy – calculation over time (actual payment is made in the future and includes interest), over space (payment is made in another country), and with conversion calculations (payment is made in a different currency). To some extent, the magnetic card has been used as a cross-border private payment method, embodying state-issued money.

But the wheel turned more radically. Despite the deep alienation between the buyer and the seller, to the point of complete indifference on the part of the seller to the currency in which the actual transaction takes place, the impersonality and anonymity that deepened, as the form of money became more standard and abstract, began to disappear. This time, a personal connection exists between the cardholder and the company that gave her the card. And unlike a coin or banknote that do not leave a mark or trace relating to you – a "swiping" of the card tells things about you that even you did not know. Unlike identical state coins and bills for all users without distinction between rich and poor, regardless of their income and wealth, the cards became outward feature identifiers. Your level of credit is displayed on the card – platinum, gold, silver, each company and its image-bolstering ways – and when it is taken out of the wallet, your status is declared to the entire world. Companies even print on the card the club to which you belong, and even a picture to your liking. The privatization of the ways that money is used has created personalization in your presentation outwardly, and in knowledge about you inwardly. In the past, once you made a deal there were no traces left (not always, but roughly); now, the traces remain even after you have forgotten. Identification interests the private market because it allows it to track your preferences and influence your purchases.

The digitization that intensified with the advent of the home computer into common use, the smartphone, and the Internet's takeover of all areas of life, gradually obviated the use of banknotes, and the relationship between the individual and money has continued to change. Private bank account management has gone digital and the state, as mentioned, has not been left behind either. Today, most of the money that the state issues is channeled to the public by digital means only, without the need for printing. All over the world, including in Israel, there is a growing trend to abolish paper money, not to mention coins, and move to a "digital wallet". More than being cheap to issue, the importance of digital money for the state is in

increasing its oversight. On the one hand, digital money makes it difficult to counterfeit, steal and cheat and even trade in drugs, arms and people; on the other hand, it makes every man and woman transparent. The standardization of form – the coin and the paper – has disappeared, and with it the anonymity they have afforded. The bits on the computer are just numbers, but they tell everything about you.

The freedom that digital money gives to carry out operations at tremendous speed, to travel, buy and purchase, has an inherent, stronger control of the state, and no less – of the banks. The degree of sophistication is increasing, and the ordinary person must chase the train and quickly acquire the literacy required to do so. The gap between the literacy needed to deal with the world of money and a person's ability to acquire it is deepening.

Ultimately, digital money and the form of payment that accompanies it continued the abstraction and expansion of literacy outlined by previous revolutions, but also introduced a twist. The physical experience of numbers was converted into a constant computational experience of sums, and the standardization of form and number was converted into digital expressions of quantities. The anonymity of the individual alongside of the constant presence of the state was transformed into the personalization and full transparency of the individual, while removing the state from his daily money experience.

The Blockchain Revolution

As if that were not enough, a new factor has recently introduced itself, which gives the impression that something unprecedented is happening – the blockchain revolution. Blockchain, many believe, is causing a revolution in the field of money by creating cryptocurrencies, the best known of which is its first application, Bitcoin.

In short: a blockchain is a series of blocks chained to each other in sophisticated, internal, computational methods that cannot be disassembled. This technology creates a high, almost hermetic level of security. Based on it, an anonymous person or group – not known to this day – created a currency called "bitcoin" that became a prototype for cryptocurrencies, i.e. – secure and encrypted currencies. This strange currency caused buyer hysteria, and was purchased in vast amounts, its value skyrocketed, and then plummeted, and now it is traded in varying fluctuations. So far for technology. And what does it do to money? It should be remembered that this technology is still nascent, and everything we speculate about it is completely tentative.

Proponents of bitcoin believe that it is causing an unparalleled revolution and is an alternative to the money we know, whose creation and management are concentrated in the hands of the state and the banks.¹⁴ Firstly, it is money born "from below", without any backing by a state, and as such is private money for all intents and purposes. Secondly, there is no longer any need for banks as intermediaries, since direct transactions can be made. That is, it is essentially decentralized money. Bitcoin is the money of tomorrow, they argue, depriving the state and the banks of their power. In addition, it fulfills an important function of money, because its transfer is faster than any form of transfer that has been used so far, and therefore

14. Baldwin, J., "In Digital We Trust: Bitcoin Discourse, Digital Currencies, and Decentralized Network Fetishism. *Palgrave Commun* 4, 14 (2018). <https://doi.org/10.1057/s41599-018-0065-0>; Griffin Daughtry, "The Ideological Origins of Bitcoin", FEE 26.6.2019 <https://fee.org/articles/the-ideological-origins-of-bitcoin/>.

it contributes to the acceleration of economic activity. Because of all these, its proponents claim, bitcoin is different from any other digital financial activity, since it is completely anonymous, and the identity of the owner remains unknown during the entire transaction. In this sense, despite its being digital, bitcoin takes us back to the anonymous stages, i.e. coin and paper money. Moreover, each bitcoin is unique – it is a singular blockchain unlike any other. That is, the owner of a bitcoin is the owner of a specific bitcoin currency, unlike the owners of 5 million shekels that sit in a bank, which have no identity of their own. Thus, despite its pure digitality, bitcoin is real.

Paul Krugman, a Nobel laureate in economics, who conducts a crusade against bitcoin and other cryptocurrencies, claims that bitcoin takes us back 300 years, to the golden age.¹⁵ Why? Because all bitcoins were created at once and therefore their quantity is limited, unlike paper money whose quantity is regulated by decisions of the central bank. The great absurdity that Krugman points out, along with other bitcoin opponents, is the fact that in order to extract the bitcoins that still exist in the database, an action known by both bitcoin proponents and opponents as "mining", requires extensive computer work that consumes enormous amounts of energy. Huge computer farms whose entire purpose is the mining of bitcoins have been set up in windswept frozen regions, to maintain the low temperature of the equipment and use natural energy. The same energy that can be used for real things that contribute to humanity's well-being, is used to create "nothing". There is no doubt that blockchain is a technological revolution – big or small. Just as the capabilities of the first huge IBM computer from the 1940s do not come close to the capabilities of the simplest of smartphones, so the production of blockchain will change and the amount of energy it consumes will plummet. Krugman believes that technology will stay with us, and it is still difficult to know what its real effects will be on money. Either way, states and banks are beginning to embrace the world of cryptocurrency for its benefits, and even “domesticate” bitcoin and the like, by taxing and registering. And in other words – the characteristic of decentralization is expected to disappear. In conclusion, Krugman does not see cryptocurrencies as a threat to the current economic system, which is based on states and banks. Where they will take us – it is hard to know.

Summary

The coin revolution took place about 2000-2500 years after the seal and script were invented, and it is a combination of the two. Since money took the form of a coins, it has ruled the world for about 2000 years. Then paper money emerged, about 300 years after the print revolution, and gradually took the place of the coin, and only in 1971 was the process of detachment from the coin completed, when paper money finally became fiat money with no value of its own, like metal. A few decades after the first computer was born, digital money has developed, threatening to completely eradicate the remnants of coins and banknotes, and it already faces a new challenge, the result of the blockchain revolution – cryptocurrencies.

All these revolutions, without exception, are about literacy – seal and writing, print, computer and blockchain. But the interesting thing is that the new form of money created as a result of each of them accelerated the literacy process throughout society. The distribution of reading and writing among the various sections of the population was immeasurably more limited than the ability to buy, sell, lend and

15. Paul Krugman, "Transaction Costs and Tether - Why I'm a Crypto Skeptic", *New York Times*, July 13th 2018.

borrow, calculate sums and convert money. This is true of the writing-seal-coin revolution and the print-paper money revolution. In the 20th and 21st centuries the picture is different. Literacy is the domain of almost the entire Western population, while dealing with developments in the field of money is not a simple challenge for the ordinary person.

All these revolutions were also part of the formation of the state and the place of the individual in it. The unification of money, and the legitimation given by the state to every coin, bound every individual and every transaction with the state, thus creating an anonymous society united through the state and through the shared trust in it. Then again, the revolutions of the 20th century have come and changed the picture. Anonymity is being replaced by transparency, and banks are an important component alongside the state, sometimes even above it, in identifying money. Blockchain seeks to offer a different take, in which the user's anonymity is maintained, but the coins themselves are not uniform: each coin has a name, has an address, and is owned by someone, just like a dog, a cat or an armchair. It also seeks to transfer the center of money production from the state to society.

Where will the new revolutions, which may eventually be revealed as one revolution, take us? Will the new money deviate from the path paved by the coin and the paper money? Judging by the increasing rate of revolutions, we may come to know it still in our day.

Technology, Sexuality and Online Sexual Therapy

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It is well known that healthy sexuality is an inseparable part of physical and mental health. Sexual dysfunction is, among others, a source of psychological distress, anxiety, depression, and has adverse effects on body image, confidence and self-value. Certainly, it is destructive to intimacy and often causes substantial difficulties in everyday functioning. The purpose of this article is to generally delineate the evolution of online sex therapy. The article begins with a discussion about the internet's influence on intimate relationships and about sexual behavior. I then briefly explain the fundamentals of sex therapy and conclude by presenting an initial study case of online sex therapy.

Technology, intimacy and sexuality

In the past decade, the use of technology for sexual purposes has expanded dramatically. For example, watching sexual contents online has risen in the past ten years at such high rates, that studies looking into the general growth of people using the internet for this purpose across the world have become meaningless for comprehending the phenomenon. Moreover, the financial press, including the British Daily Mail, reports that these days, when people are confined to their homes due to the outbreak of COVID-19, online purchase of sex toys across the world has risen. Updated data as of the beginning of April 2020 point to a growth of 135% in the purchasing of sex toys in Canada, 75% in the U.S., 60% in Italy and 40% in France.

Certainly, a degree in psychology is unnecessary for understanding that the fact that we are locked in our homes, listening to the media report the numbers of sick and dead, increases anxiety and stress and leads many of us, male and female alike, to porn websites in search of relaxation and stress alleviation. Furthermore, the internet is also a source of information on safe sexual behavior - from

Corona contagion as well. Researchers from Columbia University and Washington University claim that although it is known that the virus is transmitted via sneezing, coughing, respiratory secretions and contact with infected surfaces, there is no evidence that it may be caught via vaginal or anal sex. Of course, oral sex, or a kiss, which happens naturally during intimate relations, may definitely cause infection. Therefore, the Israeli Society for Sexual Medicine's guidelines state that sexual contact with regular rather than random partners, under the limitations of oral avoidance, may be considered safe.

Another matter that should be kept in mind, is that until the outbreak of the Coronavirus pandemic, the internet served as a means that connected between people for the purpose of initiating long term relationships, as well as occasional sexual encounters. Familiar websites such as OkCupid and Jdate brought together many couples who may never would have gotten acquainted without the internet. Applications like Tinder and Grindr allowed many others to connect for the mutual purpose of having sex.

Sociologically and psychologically speaking, it appears that the important thing is that technology is changing the way we relate to each other. Since the global distribution of the internet, studies investigating the way it influences human behavior in sexual and intimate contexts have been initiated. Initial studies in the field have taught us that people who contact others via the internet feel less inhibited in their behavior and expression than they do when physically communicating face to face (Cooper, A., & Sportolari, L., 1997). As early as the beginning of the internet era, over half of compulsive internet users said they flirted online, 42% of them admitted to having an online affair and more than a third said they find sexual satisfaction when exposed to sexual contents online (Greenfield, D. N., 1999).

With time it began to dawn on us that excessive use of the internet as a means for connecting with potential partners, as well as a means for satisfying sexual urges, might in fact harm sexuality and sexual functioning, also posing a threat to relationships. A research examining the impact of both male and female addiction to cybersex on relationships and the nuclear family has shown that cybersex was a central factor in the decision to break up relationships (Schneider, J. P., 2000, 2003). Moreover, men who were involved in online sexual activity reported it had a negative influence on their sexuality in their non-online relationships (Cooper, A., Galbreath, N., & Becker, M. A., 2004). Online affairs that do not include actual encounters is also not free of consequences. A study of online affairs found that the range of emotions experienced by online adulterers negatively affected their official relationships (Whitty, M. T., 2005), if nothing else, due to the secrecy that envelopes online conduct in such contexts (Cooper, A., Delmonico, D. L., & Burg, R., 1999).

A decade after the internet burst into our lives, Henline and Harris conducted a study about a broad range of technologies, which demonstrated their pros and cons regarding relationships (Henline, B. H., & Harris, S. M., 2006). The study found that messaging using technology creates difficulties in understanding the true intentions of the message, among other reasons because it lacks components such as intonation and context, and therefore, that it disrupts communication patterns between couples. In addition, the potential accessibility of alternative partners on mobile phones, which are mostly private media to which spouses are not exposed, raises the likelihood that the existing relationship will be neglected and experienced as suffocating.

Furthermore, many studies show that an increased use of technology in occupational contexts leads to a series of interruptions to everyday family life. Mobile phones, laptops with Wi-Fi etc., allow the employer to contact employees anytime, anywhere, and draw their attention to work-related issues, for example, while checking out emails from home. Thus, the work-life balance, which is essential to the quality and scope of couple's intimate free time, is disturbed. It is notable that such disruptions occur also beyond the context of work, when friends and family might interrupt the flow of intimacy between couples as well.

Back to the positive contribution of technology to our intimate lives. It is important to keep in mind that technology allows us to keep in touch with our partners, by messaging or emailing during the busy workday. Since our PC and smartphone are with us all day long, couples can share voice and visual files, such as photos and videoclips, which may improve the quality of their relationship in sexual contexts as well. In addition, when our lives are managed online, there is a lower chance we will forget important date such as anniversaries and birthdays.

It is important to keep in mind that the internet allows us also to communicate sexually, via online games or multi-player games. This possibility opens couples to a sphere in between "talking" and "doing", with the potent of evoking sexual arousal between them. These and other examples of momentarily focused communication may compensate for the little time left for intimacy, after time consuming activities such as childcare, caring for older parents, etc., consume the little energy and free time couples have together (Hertlein, K. M., 2004).

Geographical distance between couples is another issue whose negative implications are moderated by technology. In an era of global business contacts, international careers and open skies, couples share experiences in quality video chats from anywhere in the world. Those who are not in a relationship and wish to get to know locals when visiting a foreign country can do so using applications that connect between people based on geographical radius, for random sexual encounters as well as for expanding one's acquaintances. If we take into account that a visit to a foreign country allows us to meet people who do not affect our personal life spheres – as they do not know our friends, our family, or our colleagues – the concerns that accompany the beginning of intimate relations are significantly mitigated. This is all the more crucial when referring to people's ability to express their sexuality without the unique risks that apply to the city and country where they live: Same sex attraction – gay and lesbian relations – may be forbidden in one's culture of origin, and therefore may be realized far from overseeing eyes.

Beyond the aforementioned, one of the contributions of technology which we have yet to discuss is the change in the way relationships are perceived in modern society. We are witnessing the structuring of new patterns of intimacy, added to mainstream ones. The openness and accessibility that the internet offers contributed to the growth of phenomena like swingers and polyamory. Quite a few couples around the world feel that intimacy with another couple enriches the sex they have with a steady partner, and that emotional relationships with people outside the official relationship may in turn empower it. On the other hand, it appears there are those who feel comfortable with the slow development of intimacy, and technology comes to their aid by preserving the dynamics of emotional relationships without the frustration that stems from delaying physical intimacy in the first stages of a relationship.

Sex therapy and online sex therapy

Sex therapy has, for several decades now, won recognition in the medical sphere for its clinical importance. Indeed, there is a generation that still has its doubts regarding technologically supported sex therapy, however, research shows that technology allows many to obtain appropriate help and achieve substantial improvement in many aspects of their sexual behavior. The mere fact that we turn to the internet in many contexts of our lives, may also assist people who cope with sexual dysfunction and seek answers online to understand what they are going through and especially to discover they are not the only ones dealing with such difficulties and that they can find treatment that may improve their lives.

In Israel, sex therapists are certified by the Israeli Society of Sex Therapy or by the Israeli Society for Sexual Medicine. Sex therapists are clinical professionals such as social workers, psychologists or physicians, who underwent comprehensive training in the field of sex therapy after specializing in their own field. These certified experts have skills, knowledge and experience in varied therapeutic work, and they are able to treat sexual dysfunctions as well as the secondary issues cause by them. Of course, the reverse option exists as well, and these therapists have the professional ability to treat mental and psychological problems which cause sexual dysfunctions, and which stem from other issues.

We may say that treating sexual dysfunctions calls for a systematic approach whose reference to man's sexual behavior is a result of several integrative factors that affect him. Sexual dysfunction is typically classified into two types of causes – organic and inorganic.

Organic causes include biological aspects, such as the secretion paths of hormones which partly contribute to sexual function or dysfunction, and physiological aspects, which are related to the structure and function of the sexual organs.¹ The internet is a source of information which allows people to acknowledge that biological and physiological issues influence sexual functioning. There are websites online which render medical information accessible to all, and among them are quite a few that provide information about a diversity of symptoms related to various sexual dysfunctions of physical background. Although these sites cannot serve as a tool for self-diagnosis, they do contain a lot of information, which may direct readers to a general understanding of the biological and physiological factors which impact them and suggest turning to the family physician or a urologist who specialize in sexual dysfunctions.

The internet can aid people with inorganic causes for sexual dysfunction in a similar process that leads to the identification of biological and physiological causes. In such cases, people who look for information online may realize that the assistance they need is not within the expertise of their family doctor or a urologist but call for a therapist from the field of psychotherapy. Inorganic causes include psychological factors which have to do with an individual's personality,² inter-personal factors which

1. Men, for example, may deal with sexual dysfunction based on a host of physiological causes. The most common are: 1. Injury to the arteries or veins as a result of diabetes or alcoholism. 2. Damage to the nervus system. 3. Hormonal changes such as a decrease in the free testosterone level or the functioning of the thyroid gland, or a rise in prolactin (common in men over the age of 45). 4. Smoking, drug use, certain medications and obesity. 5. Advanced age which influences the quality and duration of the erection. In the case of women having difficulties to orgasm, the common physical causes may be: 1. SSRI antidepressants. 2. Multiple sclerosis or diabetes. 3. Injury to the lower spine.

2. Sexual dysfunction of psychological causes may stem, among others, from difficulties in forging relationships and intimacy, depression and performance anxiety, life crises in various ages, hardships at work, disease or loss of a family member and more. Likewise, sexual violence or sexual harassment may impact sexual functioning.

have to do with their partners,³ social factors which have to do with their family and close social circles,⁴ and cultural factors.⁵ Along with the development of technology and clinical expertise, it was made evident that technology in sex therapy allows us to make use of several advantages in the therapeutic process, but also made it clear that it is not free of disadvantages that should be taken into account by sexologists (Hertlein, G. R. Weeks, & N. Gambescia, 2003).

The internet offers patients an outlook on the training and experience of therapists before they are approached, and perhaps also the possibility to read recommendations about them - keeping in mind that approaching a sex therapist may be an intimate matter that patients may not care to share with their friends and therefore about which they cannot ask for recommendations. Likewise, when the therapist is not close to a patient's social circles, rather than exposing oneself, anonymity may be preserved, and patients do not have to risk encountering a family member or a friend on their way to the clinic. Patients who are especially concerned with physically arriving at their therapist's clinic, or who do not trust the ethics of psychotherapists and therefore seek to avoid any leak of intimate information regarding their therapeutic relationship, may seek clinical assistance via online sessions. Although online sex therapy may present a clinical challenge which therapists must take into account, it still offers patients the ability to look online into the above noted causes for sexual dysfunction.

Online sex therapy: Aya's case

Case description: Aya (alias), is a 27 years old unmarried accountant, who turned to me for online treatment due to anorgasmia, following a brief medical inquiry that pointed to the absence of organic causes for her complaints. Aya describes herself as a person who likes to be in control over her life. She is very successful in her job and professionally appreciated by her colleagues. She works until late in the evening, and when she gets back home, she is usually tired and has no desire to go out or hang out.

Aya told me she has a loving and supportive relationship. She and her partner have good communication, they are open towards each other, talk about problems and solve them, and they don't feel tensions and anger accumulating between them. She says they are thinking about getting married, but in the background Aya's inability to reach orgasm is no doubt disturbing and troubling them and they would both like to dedicate themselves to therapy to solve the problem.

The clinical process: Much like the traditional psychotherapeutic process which takes place face to face in the clinic, the online sessions are held weekly, mostly at the same hour, on the same day. I sat in my clinic and Aya was asked to be at home, in a comfortable, private room, which will allow her to be isolated from her surroundings and concentrate on the process without external interferences.

3. Sexual relations are first and foremost relationships. Conflict between partners, power struggles, affairs unknown or unconsented to by one of the partners, gaps in sexual needs and in sexual behavior, may all affect sexual functioning.

4. The Israeli family, as opposed to the situation in other countries in the western world, is a dominant factor in individual's lives. Israelis ascribe significant value to family relations, and therefore a family's critical view on sexual relations, gender tendencies, affairs etc., may have negative implications on sexual functioning of both men and women.

5. Needless to say, Israeli society is a melting pot of cultures which have come together from across the world, some of which still consecrate patriarchal perceptions which may cause sexual dysfunction among both sexes. Also noteworthy is the fact that an extended military service is compulsory in Israel, and it may significantly and profoundly affect sexual behavior, mainly among men.

I made it clear to Aya that online therapy binds the therapists to the same rules of ethics which apply in the traditional treatment in the clinic, and that of course, the sessions are not photographed nor taped or saved. Breaching the rules of ethics exposes therapists to grave legal sanctions, and a therapist that chooses to, can also do so by photographing and taping the clinic using hidden technologies, therefore the course of thinking in this respect is identical.

The online medium did not prevent Aya from expressing her thoughts authentically. She was very open and direct, and I was impressed that to a certain extent, the dynamics of the beginning of a therapeutic process were similar to those which take place in the clinic. In the first two online sessions I talked with Aya about her sexual background, her childhood and her relationship.

Aya grew as the eldest child in a home where both parents were busy with their careers. Aya remembers her parents' relationship as proper rather than warm or physical, and that her parents never spoke with her and her two smaller brothers about sex. Aya remembers that when she went on dates with boys, she received messages from her parents saying she should be careful lest they take advantage of her. In addition, in one of the online sessions Aya recalled that she used to masturbate quite a bit when she was a child, but once her mother saw her doing so and yelled at her to stop.

Aya said that her sexual development was regular, she did not experience traumatic sexual encounters and the first time she had sex, which was during her military service, was a meaningless experience.

A comprehensive inquiry supplied that Aya had never experienced an orgasm during sex, nor masturbation, manual stimulation, oral sex, and even not in fantasies or erotic dreams. Likewise, in the two first sessions it was brought up that Aya does not feel comfortable sharing with her partner what might stimulate her, and that she is flooded by overpowering sensations like "a hair-raising wave", when she is extremely stimulated.

The third online session took place in the presence of Aya's partner alone, whom I had also asked to be in a comfortable room with privacy and without external interferences that may draw his attention away. I clarified to Aya's partner that online therapy is bound by the same rules of ethics that apply in traditional therapy, and I was impressed that he deemed the clarification was acceptable and that he felt comfortable to freely express his feelings.

In our conversation I had the impression that Aya and her partner's body image is healthy, and that their relationship is positive and open, that they like touching each other and are attracted to each other. Aya's partner stated that he is prepared to commit himself to a therapeutic process that will assist Aya to try and cope with what disturbs her sexually. However, I came to understand that the problem led a decrease in the frequency of their sexual relations, while Aya's partner is usually the one to initiate sex, and that during sex, over motivation on his side leads him to often ask her how she is, and if she is getting closer to "it". This raised the clinical importance of acknowledging that Aya's orgasm is not her partner's responsibility, and that its absence does not stem from causes that are his fault.

The fourth online session was held in the presence of both Aya and her partner. The challenge in the personal sessions was amplified when both partners were sitting in front of the screen. On the one hand, the broad screen which allowed me a view of their body language, made it hard to read their

facial expressions; on the other hand, the close up view pushed information that may have attested to the dynamics between them out of the frame.

In the session, we noted that questioning Aya during sex about her state stresses and frustrates her. I tried to lead Aya and her partner to an understanding that the fact that both of them are focused on Aya's "performance", or sexual functioning, hampers her ability to concentrate on her pleasure and for it to build up to an orgasm. This is even more relevant considering Aya's description of the strong sexual stimulation she feels during sex, which would almost amount to an orgasm before losing out to her difficulties to concentrate and a feeling of detachment from pleasure.

Furthermore, Aya appreciated that an orgasm is a very pleasurable experience and there was a sense of expectation which made it hard for her to realize the physical potential. Aya imagined that experiencing an orgasm would be accompanied by a complete loss of control over her body, a sensation she feared. Aya finds it important to always and in every situation be "proper" and to maintain an orderly and organized front. She was afraid of the orgasmic image she had created.

In light of this, at the end of the fourth session I asked the couple to cease having full intercourse and concentrate on touch exercises in order to improve their sexual openness and create a behavioral environment in which intimate communication came without expectations, and so that they could learn to experience sex solely as a physical experience - not necessarily as a prelude to orgasm.

The next online sessions were dedicated to talking about the week that has passed and about their ability to follow my guidelines. It may be said that these sessions were indeed open and sincere, but lacked a deep emotional involvement, and therefore the difficulties of online therapy did not create a special challenge. In the seventh session Aya reported that she can orgasm following focused manual stimulation but said that the orgasm came after prolonged stimulation. At this stage, when the sexual communication between them was calm and the sexual experience more relaxed, I guided the couple to combine manual masturbation during sex while maintaining concentration. After another two sessions it was evident that the process was beginning to bear fruit, as the couple reported that they succeeded in having sex during which they both orgasmed.

Discussion: As a therapist with three decades of experience in maternity hospitals, I must admit that online therapy posed substantial challenges, and that I struggled to adapt to online therapy and to the clinical experience as it is reflected through the screen and sounded through the speakers. At the hospital and in the clinic, I was used to sense my patients face to face. Every experienced clinician – in any field – is acquainted and familiar with the experience of reading beyond what the patient is saying: from changes in the position of their body throughout the session, from perceiving their body language, their changing intonation, eye movements, the shade of their skin. All these and other indications are important tools for the psychotherapist.

Indeed, healthy sexual functioning at this stage may be considered clinical success, and although it should of course be preserved and the sexual experienced should be allowed to develop into deeper levels of the relationship, I am uncertain whether we may learn from this case about the likelihood of success for any case and any individual. Online sex therapy may enable us to deal with various issues of sexual dysfunction, but it seems to me that for many of us, depending on the individual and the case,

it may be more of a gateway to therapy that will quickly proceed from the internet to the clinic.

However, I do understand and acknowledge the fact that I, too, like many other therapists, am expected to adapt to reality along with its technological changes, and to discover the advantages of new therapeutic processes. As technology advances, professionals in the field of sex therapy and couples therapy will find themselves facing new challenges. Cultural, social, economic and of course, psychological trends will be translated in the clinic in a diversity of ways.

Just like technology changes the culture and society in which we live, it changes us and our patients as well. Therefore, we must adapt our support to the way our patients might receive it. For example, the time stress which characterizes the lives of many young people in Israel and world-wide may prevent them from being able to dedicate themselves to clinical therapy (it is enough if we consider the burden of transportation and the time it takes to reach the clinic). It is our ethical duty to accustom ourselves to the clinical needs of patients and to their lifestyle in an age of advance technology.

The importance of developing creative approaches accommodated to the needs of patients as individuals and as partners, requires devoting the research to the task. While most studies about technologies in the context of relationships and sexuality have focused on the frequency and nature of technological communication, future research should concentrate on developing additional ways of employing the advancement of technology to improve sexual functioning within relationships, and especially to investigate how we as therapists may adapt online therapy and better the therapeutic competence through this means.

We are doubtlessly facing a new era. An era in which Coronavirus projects onto the human species and human sexuality, and a world in which virtual technology affects every aspect of our lives, including anything that has to do with psychotherapy in general and sex therapy in particular. I anticipate that progress will improve the world of psychotherapy and will increase the effectiveness of the therapeutic processes. However, traditional therapy which attributes meaning to familiarity, to contact, to being able to smell each another and look one another in the eyes - not through a screen - will never lose its uniqueness, its therapeutic power and its significance for every human relationship.

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Engineering Education in the 21st Century

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The 21st century, and especially the current period that is pushing forward processes and technologies of remote learning, requires a change of approach in engineering studies. To remain relevant and preserve its hegemony, every academic institution must advance from traditional-disciplinary frontal learning toward integrated horizontal and vertical digital education, micro-degrees, training outside the confines of the academy, personal-oriented learning and life-long educational guidance.

Introduction and General Background

Innovation driven by scientific and technological advancement is a key component in the economic and social advancement of any modern country in the 21st century. This engine of growth and its role in society is largely the result of changes in recent decades, which were based on the fusion of science and engineering into “engineering sciences” within universities and colleges, and it is reflected in engineering education, research and academic-industrial relations. Against this background, engineers took on professional and managerial leadership roles in the national innovation sector in general and in industry in particular.

The 21st century has brought and still brings tremendous changes in science and technology, such as the information revolution, social networks and more, which have a profound impact on human society in general and engineering studies in particular. A good example of this is the interaction between the life sciences and engineering, based on massive computing power. This change requires an approach

that involves skills to bridge over processes that occur simultaneously over a vast range of orders of magnitude, from the molecular level to the macro level – a range of nine orders of magnitude. These transformations require a thorough understanding of chemical, biological, and physical processes, combined with advanced computing tools to quantify these processes themselves and to serve the connecting models across those wide ranges of orders of magnitude. All of these are the basis for generic technologies, which should be integrated in all engineering disciplines. In addition, this situation is also a driving force that blurs the boundaries between the various engineering disciplines, as is also the case in the scientific disciplines. All these lead to the need for a multidisciplinary education of the modern engineer. Also, most of the world's leading technology companies, such as Facebook and Google, Uber and Apple, are successful not only because of technology but also thanks to the ability to bridge science and technology, on the one hand, and social and economic needs, on the other hand. At the launch of the first iPhone, Steve Jobs explained that technological breakthroughs are not only accomplished by engineers. They require original thinking, vision and a broad education in the arts and humanities.

In light of all of the above, the need arises to re-examine the training of the modern engineer and, as a result, the paths of action in academia in general and in universities and colleges in particular, which play a key role in training engineers to take leadership positions and realize scientific and technological advances. In recent years, elite universities around the world have invested a great deal of time and resources in rethinking and changing the training and teaching of studies generally, including engineering studies. An important motive for these moves is the gap between the technological and information revolution that are changing all areas of life, on the one hand, and the fact that teaching and learning methods have not changed significantly in centuries, on the other hand. There is a growing understanding that the current situation is not sustainable, and even if there is still no new model that is consensual or a “magic solution”, new models should be sought, developed and tried.

Elements in the Education of the Modern Engineer: Knowledge, Skills and the Real World

The traditional education of engineers has been based on the understanding that training in academic institutions is designed to impart the foundational knowledge required, while abilities and skills needed for the engineer's work, such as design and entrepreneurship, will be acquired over time after graduation. The revolutions of the 21st century are changing this approach, and by this we mean mainly the enormous revolution in information and its availability, and the fourth industrial revolution, driven not only by new technologies but also and especially by multidisciplinary thinking and the integration of technologies alongside very strong interactions with society and the economy. Against this background, the goals in the training of modern engineers are not only to impart knowledge that they will need for their first job, but mainly to give them foundational knowledge, self-learning ability and skills that will enable them to develop, advance and “stay afloat” in a changing and uncertain world throughout their professional careers. All of this requires a transition from teaching-based training to education-based training, where students are at the center. The intention here is to let

the graduates also build capacities for the implementation of knowledge and continuous self-learning of new knowledge in a complex world, where technological advancement requires multidisciplinary thinking and understanding of economic and social forces. This is the toolbox that the academy is committed to providing to engineering graduates. We do not necessarily intend, nor think it is possible, that the graduates be experts in all of these, but rather that they have an understanding of their own significance and are able to continue to develop themselves, especially when it comes to design thinking and entrepreneurial culture.

To impart all of these, engineers' academic training programs must pay attention to three important elements, which sometimes are at odds among and within them. The balance between them can vary from institution to institution, in order to develop engineers with different profiles according to the vision and goals of the institution and the needs of the economy at large.

These elements include three main areas:

- Disciplinary versus multidisciplinary in-depth study: The need for in-depth study of lateral fields, including digital education, analytics and data in all engineering disciplines. There is, of course, additional multidisciplinary components worth considering, related to the social sciences and humanities. However, it is important not to give up on engineers who have disciplinary depth: quantum computers, for example, will only be developed by those with profound scientific/engineering knowledge. The model for balancing these is known as the T model, where the horizontal bar represents the expansion and the vertical one the disciplinary specialization.
- Acquiring knowledge versus acquiring skills: Coherent and documented knowledge (as opposed to knowledge that requires learning of innovative approaches, ways of thinking and deep principles) can also be acquired through diverse and customized learning methods, not necessarily in a standard academic setting, whereas providing essential skills requires education in a methodical environment, and in one that allows to gain experience, similar to that method of advanced studies for higher degrees, components of which should also be integrated in undergraduate studies. In this context, there is no substitute for training within an academic institution, while as for imparting specific knowledge, there are currently alternatives that do not require institutionalized studying in academia. The list of skills is long and can be classified into three types: (1) cognitive skills (mainly core academic skills); (2) deep, broad and systemic thinking skills; (3) interpersonal skills, social and ideational sensitivities. In the discussions and surveys held at the Engineering Education Forum at the Neaman Institute, the more important skills that should be prioritized in the academic education of engineers were defined: self-learning, critical thinking, creativity, complex problem solving, teamwork, internationalism and communication.
- Campus learning versus field experience: There is a need to reinforce the understanding that engineering education does not only take place within the walls of academia and classrooms, so another element should be introduced - collaboration with industry, based on innovative models, especially in promoting education for essential skills as part of industry training; alternatively, on-campus experience under the joint supervision of industry experts and academic staff.

Career-Long Learning and Micro-Degrees

Recently, unfortunately, more people are saying that universities and the academic degrees they award are becoming less relevant. For example, in August 2020, Google launched a new project called Google Career Certificates, in which it offers professional courses that train, in a period of about six months, workers for in-demand high-tech jobs. Those who sign up for the courses are also guaranteed a connection to top U.S. employers, recruiting for positions related to the field of study. Google has not specified how much the new courses will cost, but a similar program it already offers on the Coursera online learning platform for training IT support personnel costs \$49 a month. For the same price, six months of study will cost close to \$300, less than the amount that university students spend on books during just one semester. Google has introduced three training paths: data analyst, project manager and designer.

Of course, this training by Google cannot be a serious substitute for training an engineer, but it is a flashing warning sign for higher education institutions that must prepare for a fundamental change in the structure and content of the degrees they award, as described above. Although in recent years there has been no decrease in the number and quality of students enrolled in engineering studies in Israel, we must start thinking and long-term planning, otherwise we may lose some of the hegemony of universities and colleges in training engineers. Also, the rapid change of the world in general, and the technological world in particular, means that some of the training students receive during their degree becomes irrelevant after a few years – and we need to move on to the model, described below, which includes studies throughout their careers.

This field is therefore both a challenge for academia in our time and an opportunity for the development of a new model of academic activity that will be attractive, more focused on connection with business, public and industrial organizations, and will fill a newly-formed gap. This issue came to the fore in the discussions of the 21st Century Engineering Education Forum at the Neaman Institute, where there was a clear call from the industry for cooperation with academia on these issues.

In academia, there is a new thinking toward micro-degree programs, which are short and focused programs, each with its own value, where a combination of several micro-degrees together can award a full degree. This course of action, which is encouraged by the CHE and PBC, is particularly suitable for studies towards a master's degree, and is in fact a combination of certificate studies with academic degree studies. A micro-degree scheme as part of postgraduate studies allows both flexibility and adaptation to general economic and personal needs as well as control over the quality of studies. The promotion of such a model allows entry into new areas that are not currently being developed, and therefore can accommodate innovation and access to new audiences of unique consumers, at the individual and organizational level.

Another model for a micro-degree can be based on studies of 10-50 credit points, and it can be shared by more than one academic institution. The micro-degree can have the character of a disciplinary, vertical learning, or horizontal and more appropriate to the changing world of work. These are high-level academic studies, which do not necessarily lead to a degree but are valuable in the eyes of employers. These can be degrees based on hybrid training mechanisms, combining online courses

with frontal courses or online courses with final projects, in collaboration with companies interested in the subject.

Many models and programs are now being developed outside of academic settings as well, and although they do not confer an academic degree, they carry certification by other schemes, such as open badges and micro-credentials.

This mode of study will be liked by students and benefit them, the institutions of higher education and industry in the State of Israel, which of course must be involved in the process. Such a revolutionary move must be undertaken with caution and begin with limited pilots in parallel with existing engineering degrees. In our opinion, the result of this change can lead to the creation of a better student and a better citizen for the benefit of the State of Israel.

Innovative Learning

The Lecturer's Role

The Internet revolution has made knowledge accessible to all, so that getting to a physical space just to acquire knowledge is becoming less and less relevant. It raises the questions: what is the role of the lecturer in the new world? And why should a student come to class? In many ways, the revolution reinforces the importance of the lecturer, who will also expand his or her role as a facilitator, to enable students to examine the vast knowledge that exists critically and analytically and provide them with a broad thinking framework and context. The digital tools and their widespread use during the Corona pandemic illustrate the potential for reducing class time spent on imparting knowledge, to enable the lecturer to serve as a mentor, curator of knowledge, discussion facilitator and more. This is the added value of education in an academic institution compared to other frameworks based solely on digital learning.

Digital Tools and Personalized Learning

In the discourse on the integration of digital tools in teaching, a dichotomous perception is often expressed, of teaching that takes place “either” frontally “or” online. However, this is actually a spectrum, and there are models that offer both –frontal and online. Notable models are Hybrid Learning, Blended Learning and the Flipped Classroom model. Such models are designed to enable learners to deal independently and at a pace that suits them with some of the course content, thus promoting customized learning, which allows for greater flexibility in the learning process and makes the classroom session more meaningful. Classroom time is devoted to delving into the material, discussion, analysis, group work, Project Based Learning (PBL), and game-based learning.

Digital Tools and Continuing Education

Digital learning enables the development of many and varied models for lifelong learning, in the form of micro-master modules, nanodegrees, specializations and the like. It enables modular learning that will accompany engineers throughout their lives, depending on their professional development and aspirations to advance in their jobs and specializations. Consideration should be given to extending

the mission of academic institutions also to educating engineers during their professional lives, after completing their bachelor's degree, in a system that is flexible and accessible, in structured and continuous programs, unlike the current approach in various continuing education units that are based on casual programs. This course of action reflects the commitment of the academic institution to its graduates throughout their lives and not just during their degree studies, and it is currently evolving in leading institutions abroad, under various names such as "60 Years Curriculum" at Harvard University, "Life Long Education" at Georgia Tech and "Agile Continuous Education" at MIT.

Fitting the Physical Space

Innovative pedagogies also require fitting of the physical space in which studying takes place. Lecture halls of 300 students, for example, are not suitable for group work or project-based learning. Technological aspects such as the availability of a wireless network, screens for teamwork and more are also conditions for supporting innovative pedagogies. To this end, a thinking group called MIT 2030 has been established at MIT with the aim of assisting the institution in thinking about adapting and renewing its physical spaces to the institution's changing needs.

Summary and Outlook: Implementing the Changes in Israel

In order to promote only some of the ideas and moves for innovation in engineering education in Israel on a large scale and at the required speed, the cooperation of CHE and PBC is required, which will create the infrastructure for the implementation of these changes throughout the academic system. This envelope is also supposed to develop ways of jointly gaining insights and lessons, to create an educational synergy of all the institutions in Israel. Recommendations in this spirit were formulated at the Engineering Education Forum in collaboration with CHE-PBC, and steps were proposed in two time frames:

- In the short term: Publishing calls for pilot applications in diverse fields such as models for education, structuring and acquisition of essential skills including soft skills, industrial experience as part of the curriculum, techniques for effective and experiential teaching, career-long learning and multidisciplinary learning.
- In the medium term: It has been proposed that CHE will allow autonomy for institutions to run one pilot program for each degree per institution.

In order to leverage the insights in the short and medium term, it was proposed to establish a joint framework for CHE-PBC with the 21st Century Engineering Education Forum, which could formulate recommendations based on a solid background of monitoring and testing new models the field. Among other issues, it is proposed that the joint framework address the following areas:

- Examination of the needs of industry and academia, including the figure of the engineer in

industry and the needs of academia in terms of graduate students

- Suitability to the profile of high-school graduates
- Looking into worldwide implementations and examining their suitability for Israel
- Formulation of practical recommendations for changes required both in institutions, in the CHE and in government ministries
- Examination of various engineering degrees (engineer, graduate in engineering sciences, etc.)
- Examination of the status of the master's degree and an accelerated master's program (for example, an engineer will study directly to a master's degree in four years, and graduates in engineering sciences will study for three years).

Critical Thinking and Creativity in Engineering Education

Gabi Shafat

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It is doubtful whether a substantial portion of the subjects taught nowadays in the various engineering disciplines will remain relevant a few years from now. Academic courses in the engineering and technological fields age at an accelerated pace, hence B.A. graduates in these fields must undergo further training to prepare for the rapid technological changes that are expected to take place in their fields of practice in the near and far future. Beyond classic engineering competencies, students must acquire additional skills, such as self-learning capabilities, critical thinking and creative thinking.

Thinking is conducted using concepts. Various fields of study investigate the origin of concepts and their evolution. These produce theories which emphasize the possibility that concepts evolve spontaneously in the framework of social dynamics, and that individuals acquire them as part of the socialization and educational processes; or, to the contrary, the possibility that concepts manifest psycho-biological processes that take place within the individual and then undergo contextual and formative alterations under the social forces. It seems that almost every approach seeking the origin of concepts and the way they evolve, touches upon the stress between the individual and society, acknowledging the dynamic dialectical process in which concepts are objects of thinking as well as characteristics of society, as well as their impact on all spheres of human activity.

However, as opposed to the humanities' and social sciences' pursuit of the characteristics of human thinking, academic training in the technological professions does not include such requirements. Of course we all classify, arrange, compare, assume and execute, use analogies, conclude, decide, activate, manage, and partake in numerous other activities classified as thinking, however we do not think of thinking, even when completing the requirements for a B.A. degree in engineering.

This is of utmost importance, since we tend to prefer conclusions that in a sense are predetermined (Nisbett & Ross, 1980), and since evidence from research suggests that logical inference is not a universal trait and that it differs across cultures (Peng, Ames & Knowles, 2001). If we are indeed susceptible to bias and are affected socially and culturally, we must teach "thinking" as a fundamental subject, particularly in the various branches of engineering. The purpose of teaching "thinking" is not to teach one how to think, but how to think correctly, or, metaphorically, how to think broadly, vertically and sideways, not only deeply.

My experience in technological pedagogy in the academy has taught me that students do not naturally tend to develop cognizant rules of rational approach in the fields whose skills they acquire. If we wish to promote effective thinking among learners, we cannot assume that this goal may be implemented spontaneously or as a random outcome of attempts to achieve other goals; we must clearly delineate the characteristics of effective thinking and examine the chances of bringing about a change in thinking via educational efforts (Glaser, 1985). The two important objectives in this context are critical thinking skills and creative thinking skills, which I intend to discuss.

1. Critical Thinking and Creative Thinking

Theories about critical thinking are many and varied: Some emphasize the cognitive processes that take place within the thinking individual and therefore view critical thinking as the ability to perform conceptual compositions that are flexible and multi-faceted rather than fixated. Scholars in this field point, amongst others, to the importance of developing logical competencies and of practicing conceptual composition of strategies that increase the probability of a desired outcome (Halpern, 1996), as well as to the development of the capability to discern plausible thinking patterns and accurately phrase the arguments that underline them (Simon & Kaplan, 1989). In contrast, other approaches concentrate on the social context in whose framework thinking processes take form and place (Evers, 2007). Among these are theories which tie critical thinking to the estimation and reasoning of practical requirements (Hynes & Bennett, 2004), while others focus on problem solving as a typical outcome of criticism (Lenburg, 1997).

The profusion of definitions for critical thinking does not make it easier for those who wish to devise an academic curriculum for training engineers in the field. Attempts to find a definition which will enable the formulation of a pedagogic foundation that will be accepted by both aforementioned schools abound (Beyer, 1989). I suggest introducing students of technological disciplines to five features of critical thinking:

- Determining the credibility of a source of information and assessing the information's level of accuracy.
- Distinguishing between and classifying various components of information (factors, assumptions, conclusions, contexts, causes, outcomes etc.).
- Identifying assumptions (implicit and instilled), classifying them and assessing their likelihood.

- Examining the logical validity of arguments and identifying logical failures.
- Assessing the arbitrariness of an argument.

I think that training which places these five competencies as the objectives of an academic course, must take place along with an attempt to promote humanistic values. The nurturing of critical thinking may entail the risk of turning skepticism into nihilism. Acceptance of new opinions and undermining the status of conventional knowledge may also impact students' attitude towards the validity of conventional values (Goldman, 1984). Moreover, the question whether to include issues of social-political controversy is not embraced among various academic circles (Scriven, 1984).

In my view, traits such as independent thinking, empathy, curiosity and intellectual modesty, courage, integrity and perseverance, must be part of the classroom discourse lest we encourage, through critical thinking, arrogance, vanity, righteousness and so on. Such a combination will allow the cultivation of young people who think about the goals they set for themselves, ask questions, form independent opinions and reach conclusions as to the means they deem worthy for achieving their goals (Paul, 1995).

Let us now turn to creative thinking. Of course, the research field which aims to uncover the secrets of creative thinking, is too, lacking in consensus, if only for the disciplinary variations between scholars in the field. Some claim that creative thinking has to do with cognitive competencies (Guilford, 1959), such as the ability to produce new information when facing a familiar stimulus (King & Pope, 1999), while others assert that creativity is a matter of identifying multiple plausible connections between pieces of information (Cornell & Franklin, 1997). Au contraire, other scholars argue a strong connection between one's personality and their creative ability (Furnham & Bachtiar, 2008), therefore mind-expanding courses in humanities and the social sciences may contribute to the training of engineers.

There are also those who purport that "night owls" are more creative than "early birds" in indices of originality, processing abilities, flow of ideas and flexibility of mind (Giampietro & Cavallera, 2007). Researchers claim that this stems from the owls' ability to adapt to an irregular lifestyle: "nocturnal types frequently find themselves in unusual situations, which develop both the desire and the capacity for an unorthodox approach towards finding original, alternative solutions when solving problems". The standard definition of creativity comprises two essential components: originality and effectiveness, meaning innovation which leads to a valuable action (Runco and Jaeger, 2012).

In light of such definitions, I propose viewing creative thinking as comprising three components: knowledge – meaning the anthology of information and skills acquired by an individual; intelligence – that is the ability to apply skills to fields of knowledge; and imagination – which is to me the most important part - the ability to move beyond knowledge and intelligence to produce something new, something that has not been done before.

2. Thinking Competencies in The Training of Engineers

It is now evident that critical thinking and creative thinking are essential competencies for engineers,

as they may be active participants in two types of intellectual processes which characterize the world of technology; "When reasoning fails, imagination saves you; when intuition fails, reason saves you" (Crane, 1983): A convergent process dominated by critical thinking, which allows us to efficiently respond to a given question, reaching one correct answer; and a divergent process dominated by creative thinking, which allows us to formulate diverse answers to a given question and then consequently evoke new questions following the answers we have found. The character of engineering demands that the engineer apply a convergent intellectual process when seeking to solve problems using existing technological means, but calls for divergent thinking when seeking to create new technologies.

Curricula in institutions of technical training do not encourage students to apply diverse thinking competencies (Smith, 2006), though their importance is evident. For example, when students are asked to solve a problem, they immediately seek solutions, while the correct approach to the problem is to first review its phrasing, see whether it may be put in another way, or whether perhaps a similar problem, whose solution is known, may lead to the solution. Checking and doubting premises is something that many students dislike, preferring to take things at face value. In many cases, premises should be doubted and their accuracy verified (Altchuler, 1964). Therefore, training and practicing problem solving was found to improve both critical thinking as well as creative thinking (Reese et al., 1976).

There are three approaches to teaching and learning critical and creative thinking skills: 1) thinking competencies taught as a separate discipline or course, isolated from any field of study. In this path, students apply separate thinking skills for different subjects and situations. 2) The illustrative approach, which integrates questions and/or challenging activities in the framework of teaching a specific subject, without impacting the teaching of thinking skills in the field. 3) Integrating thinking skills with the study of a specific subject, shown by research to be the most effective way to teach and improve thinking skills (O'Brien, 2005).

A study conducted among 514 B.A. students in non-scientific/engineering fields, whose curricula integrated critical and creative thinking, has demonstrated significant improvement in students' thinking processes (Lawson, 2001). Researchers argue that such a study is extensive enough to promote the adoption of such curricula, so that students could boast better thinking competencies. Thinking skills should not be taught as a separate course, but rather integrated within the curriculum. It is crucial to identify students' individual level and to obtain accurate information about their level of thinking before planning curricula that integrate thinking skills.

Conclusions and Recommendations

These days, encouraging creativity and thinking cannot be overrated, and there must be a place for them in students' training and assessment processes in academic institutions that train engineers. Students must undergo compulsory courses in these subjects in the course of their B.A. studies, despite the difficulties in determining the contents for such courses.

In my view it is important that we integrate such content within courses that are considered core curricula for the training of engineers. Students may even be trained to rethink professional fields of

knowledge which they have already mastered. This is the type of criticism and creativity that can be taught and developed throughout the course of B.A. studies via a cognizant assimilation into teaching and learning processes, since the acquisition of criticism and creativity is not a process that takes one semester, but rather a long term endeavor.

Pedagogy that aims also to improve thinking skills requires dedicating a longer time for the preparation of courses. It is harder to plan and limits the amount of content taught. Moreover, teachers can no longer just pass on knowledge; they become academic coaches of sorts, who seek to aid students in fulfilling their potential. In our society, the college experience should comprise opportunities to uncover individual potential and attain higher levels of self-expression. The change, therefore, may come from faculty members who are willing to nurture such growth within and without the classroom. The learning environment as it is reflected in the classroom and in the campus, the relationship between the students and the administrative systems – all contribute to the completion of the educational task.

Accordingly, it is preferable to avoid extreme statements such as "I am going to teach you creative thinking", which may repel students. Introducing novelties that cannot be found in mainstream literature, or updated technological innovations – presenting logical, physical, technological and mathematical challenges – is an option. However, questions such as "how would you describe the next step?" or "How do you think the man who developed this technology thought?" encourage them to think about the failure that would have prevented the development of the technologies we present to them.

Most of the information taught at some point in the course of a B.A. education is eventually forgotten, and another part of it is rendered irrelevant due to technological advances. In contrast, thinking skills endure through time, and may improve and evolve along with the career. The question is, then, why do we bother teaching a critical mass of content and sticking to a rigid syllabus? The warranted conclusion is that we should set more meaningful goals when planning the curriculum, one of which is the betterment of students' thinking competencies. This is relevant also for the assessment of students' achievements in the course of their studies. If teaching sanctifies the memorization of the study material, the exams too will be superficial; however, if teaching and exams focus on understanding and reward students in their grades for giving expression to their critical and creative competencies, thinking skills will form an essential part of the academic training process.

I think it is important to encourage courses that integrate several disciplines of engineering (industrial, electrical, mechanical, computer, biomedical). The links between the disciplines and the ideational and practical interaction between them are a rich source of encouragement for critical and creative thinking. Interdisciplinarity may aid us – lecturers and teaching and research faculty – to become innovative and inventive engineering professionals. To qualify this, I will say that it is important that the problems we put before our students at first be limited to one discipline; however, with time, they must expand and embrace more and more fields of study. Thus, we will lead students beyond mere acquisition of thought to actual thinking, independent thinking, rather than the acquisition of somebody else's thoughts.

The last of this paper is dedicated to the students. Creative students are, first and foremost, knowledgeable students who are diligent in their chosen course of study. Creativity and criticism may evolve along the course of academic studies, but they will fail to turn up in the absence of complete

proficiency. However, if an idea comes up in your mind in the course of your studies – don't kill it, give it time, allow it to sink and then, perhaps, to grow. Sometimes new ideas are so fragile and small, that in our rigid criticism and fixation upon prior knowledge, we rule them out immediately. We should do the opposite. An idea might seem silly but is not necessarily so. Ideas should be written down because they tend to suddenly disappear. Ideas should be collected and then returned to at later stages. If you decide to develop an idea and come to a dead end, take time-out, move on to the incubation phase and let it mature in your mind. If you decide to realize an idea when you feel you have a right answer, do not be frightened by resistance, fight for your opinions, remember that you too might object to other people's new ideas. Fundamentally, man is a creative creature that lives in an environment that warrants creativity.

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Philosophy of Digital Technology

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Galit Wellner, Ph.D., is a senior lecturer at the NB School of Design Haifa, Israel. She is also an adjunct professor at Tel Aviv University. She studies digital technologies and their inter-relations with humans, and she is an active member of the Postphenomenology Community that studies philosophy of technology. She published several peer-reviewed articles and book chapters. Her book *A Postphenomenological Inquiry of Cellphones: Genealogies, Meanings and Becoming* was published in 2015 by Lexington Books.

In the 1980s a new philosophy has emerged, focused on technology. Today, philosophy of technology is an established field of research, covering a variety of technologies and a wide range of questions. Focusing on everyday experiences, this paper briefly describes a branch of philosophy of technology known as postphenomenology, which integrates phenomenology and pragmatism to examine our practical relations with technologies, and through technologies – with the world. The paper reviews some of the relations we have with technologies, especially the permutations developed for digital technologies, in which the intentionality might be reversed, so that technology directs its users.

Why Philosophy of Technology?

Philosophy of technology is a relatively new field. Until the 1980s, it did not exist as such. Why did it emerge at that period? One possible explanation is that the personal computer entered our homes during this time and since then it has become evident that we are surrounded by technologies. If philosophy is an attempt to understand the world and the human being, then technology requires a philosophy to explain it. Most of our fields of knowledge already have "their philosophies", e.g. philosophy of mathematics, of medicine, and of religion (all can be found in the Stanford Encyclopedia of Philosophy), all analyzing important aspects of our lives. So, if we develop the philosophy of art, language or law, why not embrace philosophy of technology?

Some scholars regard philosophy of technology as a subset to that of science. Indeed, from a historical perspective, philosophy of science preceded and was the origin for the philosophy of technology. However, an examination of the early sciences, at least in their Western version, reveals that technology predated science and enabled it (Heidegger, 1977; Ihde, 2011). Thus, Robert Boyle could not have studied the vacuum without the technology of the air pump. Likewise, James Watt invented the technology of

the steam engine a century before the development of the scientific formula of thermodynamics that explained how the engine worked. Moreover, it turned out that philosophy of science is more indebted to questions like how knowledge is produced. By contrast, philosophy of technology poses a different set of questions related directly to everyday life. Through such examinations, it develops its ethical, epistemological and metaphysical arguments.

Today, some forty years after its inception, philosophy of technology is a diverse field of research, covering a variety of technologies – including robots, medical devices, cellphones, emails, baby toys, street benches, bridges, to name just a few. No less diverse is the range of questions in which philosophers of technology are interested, e.g. the shape of everyday experience, the ethical implications of using some technologies, the political consequences of certain developments, how a profession changes its best practices with the introduction of a new technology, etc. These questions cover the lifecycle of technology, beginning with the invention of new technologies, through their usage patterns, and eventually the consequences of such uses on the world and society. Although such questions make philosophy of technology a perfect candidate for the curricula of engineering studies, its entry path into the faculties of engineering in Israel is slow, twisted, and not without challenges.

Whereas the importance of inventing new technologies is unquestionable, the experiences they produce remains secondary, and at best, appear mostly in monetization discussions. This essay concerns everyday experiences of technologies in and of themselves. It may, however, lead to the development of new technologies and the amelioration of existing ones.

Postphenomenology

Focusing on everyday experiences, in this essay I shall limit myself to a branch of philosophy of technology known as postphenomenology. As its name indicates, the theory is based on phenomenology, a philosophy that studies our experience in the world. Phenomenology is interested in humans and their environment. Although some of its major developments occur in the midst of the industrial revolution toward the end of the 19th century (e.g. Husserl), phenomenology hardly refers to technologies. Technology thus becomes "the elephant in the room" for this theory. *Post*-phenomenology offers the next step. Unlike *post*-modernism that sometimes goes against modernism, postphenomenology remains committed to phenomenology. The "post" prefix operates similarly to its functioning in the word "postdoc"; there is not necessarily a contradiction, but more likely a continuation and further development.

Postphenomenology also integrates Pragmatism, another theory that emerged in late 19th century, in order to provide an emphasis on practice rather than representation (Ihde, 2009). Eventually, pragmatism adds to the postphenomenological analysis on social and societal levels (Rosenberger, 2017; Botin, 2020). The result is a rich theory that examines our practical relations with technologies, and through technologies – with the world.

The combination of phenomenology and pragmatism lies at the foundation of postphenomenology, as formed by Don Ihde. He first published the basic principles back in 1979 in *Technics and Praxis* (Ihde, 1979), thereby making it the first book in philosophy of technology in North America. More details were worked out in his seminal book *Technology and the Lifeworld: From Garden to Earth* (Ihde, 1990).

Relations

One of the powerful tools provided by postphenomenology is the systematic analysis of the structure of relations we have with technologies. If classical phenomenology is interested in the duo "I-world", postphenomenology puts the technology in-between, thereby creating the formula: "I-technology-world". This formula represents the basic condition according to which our experiences are always-already mediated by the presence of technology. Technology can be as simple as a shirt. Wearing a rugged gray T-shirt causes me to move differently compared to my movement when wearing a formal white-collar shirt. Even in their absence, technologies mediate the world for us, as evidenced by anyone who's lost her cellphone: Without the cellphone, a tree in the street becomes observable and requires taking a photo; or perhaps a thought pops into one's head, of calling a colleague or a friend, but the desire to call them is hampered by the absence of the cellphone.

The formula of I-technology-world does not mean that our relations to technology are limited to one kind or a single "essence" (cf. Heidegger, 1977). There can be many essences and types of relations. Thus, transportation technologies can help us move faster in the world as in the case of bicycles or airplanes; media technologies can inform us how the prime minister looks like even if we have never seen him or her face to face; some technologies like an ATM or Alexa can conduct a dialog with us; and technologies can simply remain in the background as in the case of the air conditioner.

The diverse relations are represented by the I-technology-world formula as permutations that are produced with the addition of an arrow, parentheses and dashes. The arrow represents an action or a direction of action (in phenomenological terminology – intentionality); the parentheses indicate that two ingredients function as one unit, or if it is a single unit – a withdrawal to the background, pushing the ingredient out of the scope of attention; and the dash signifies a simple connection of working together. Let's illustrate how the formula represents various relations we have with technologies, as Ihde (1990) originally formulated:

The first type of relations is **embodiment relations** in which we experience a given technology as part of our body scheme. When I drive my car, I experience the world as if my body and the car's body are a single unit. When I park the car, I know how much I can drive backwards before hitting the wall or the car that parks behind me. And when I drive in narrow streets, I "sense" where the assemblage of me and my car can pass. The postphenomenological formula looks like this:

$$(I - \text{technology}) \rightarrow \text{world}$$

Embodiment relations go beyond the situation where technology becomes part of our body scheme and they also deal with situations in which technologies extend our bodily capabilities and our senses. With technologies like the hammer we can hit a nail with greater force. With technologies like eyeglasses we can see more details. Similarly, the cellphone extends our hearing capabilities to distances beyond human hearing, even to the other side of the globe (see Wellner, 2016).

The second type is **hermeneutic relations** in which the user experiences the world and the technology as a single unit. While in embodiment relations "I" and "technology" are experienced as a merged unit, here the "technology" and the "world" function as a combo. When a technology is experienced as part of the environment, it tells us something about that environment. These relations often involve media

that is read and interpreted, and hence the term “hermeneutic relations.” The postphenomenological scheme represents this relation as:

$$I \rightarrow (\text{technology} - \text{world})$$

Think of a watch. We can have embodiment relations with it and feel it as part of our wrist. However, this description does not reveal much about the meaning of the watch. It functions like a bracelet. We need to refer to the “text” it displays, i.e. the hour, whether displayed in analog or digital form. The “text” is understood as part of the world that is “out there” waiting for us to become meaningful. Thus, in hermeneutic relations technology provides meaning to the world. Technology is that through which we read the world and interpret it.

The next postphenomenological relation is **alterity relations** in which the technology is experienced as a quasi-other. Classic examples are children’s dolls and ATMs with which the users maintain a certain dialogue. In these relations, the world withdraws to the background, and so in this formula the "world" component is within the parentheses:

$$I \rightarrow \text{technology} (- \text{world})$$

The smartphone's personal assistants like Siri function as a quasi-other of a new degree, as they answer us and attempt to provide meaningful information. Instead of gazing at the other's face, we look at the screen and listen to the voices. The screen now functions as a "talking head" or in postphenomenological terminology – as a quasi-face (Wellner, 2014)

The fourth type of postphenomenological relations is **background relations**, where the technology operates in the background, unnoticed, like air-conditioning and lights in a room. While in alterity relations the "world" is in parentheses in order to show that it occupies the background, here the "technology" is in parentheses for the same reason. The postphenomenological formula is:

$$I \rightarrow (\text{technology} -) \text{world}$$

The four types of relations that Ihde maps are a-historical, meaning they have been existing in our interactions with the early tools of prehistory, with the modern machines of the industrial revolution, all the way to the contemporary digital technologies like the cellphone.

It is important to acknowledge that a given technology can maintain with its users more than one type of relations. For example, the cellphone extends our seeing and hearing senses when we conduct a video-call; interprets the world when it reports the weather at the location of our interlocutor; serves as a quasi-other when giving us instructions on how to reconnect in case of network failure; and withdraws to the background as long as the conversation continues with no interruptions or faults (Wellner, 2016).

Postphenomenology of Digital Technologies

The four basic relations that Ihde sketches are just the beginning. They do not form a closed list. Additional permutations can and should be elaborated to model our relations with contemporary technologies. Peter-Paul Verbeek (2008) develops some new relations to Ihde’s list in order to represent

additional ways in which technologies interact with their users. He shows how technologies do more than mediating the world. They also direct their users. To represent such relations, Verbeek replaces the dash with a slash or an arrow. Thus, embodiment relations are radicalized into “hybrid relations” where the user cannot separate herself from the technology. This happens, for example, in the case of medical technologies like transplanted pacemakers or pills that become an integral part of the user’s body. After taking an antidepressant pill, the user experiences the world differently, and cannot separate the pill from the body. The permutation in the postphenomenological formula is:

$$(I / \text{technology}) \rightarrow \text{world}$$

Verbeek also suggests a radicalization of the hermeneutic relations into what he terms composite relations. This type of relations is necessary to model a situation in which technologies exceed the mere representation of the world, as thermometers and weather forecast apps do. Composite relations model how technologies “construct reality” as in the case of navigation apps that shape the traffic and affect it via their recommendations to the drivers. It is represented in the formula by adding an arrow between "technology" and "world":

$$I \rightarrow (\text{technology} \rightarrow \text{world})$$

The second arrow denotes that technology is now loaded with intentionality, as it can direct the world into a certain direction. Using a navigation app transforms not only the user experience (as modeled by the "classical" hermeneutic relations), but also the world in the form of different traffic patterns. This permutation can represent how a navigation app directs drivers to a certain route, thereby creating new traffic jams, or even simply routing the traffic through the narrow streets of a quiet neighborhood, thereby changing its atmosphere. Here intentionality is no longer attributed solely to the human user. It becomes “composite.”

In his extensions to the postphenomenological formula, Verbeek does not refer to digital technologies as a game-changer. Instead he targets extending the postphenomenological formula to new directions, exemplifying them with works of art. Today with the fast pace of introducing new digital technologies, we can provide more and more examples of Verbeek’s hybrid and composite relations.

New technologies and usage modes open up possibilities to additional permutations of the postphenomenological formula. Some AI algorithms alter the users’ behavior and direct it in surprising ways so that the arrow of intentionality is reversed. It points *to* the "I" and not originates *from* the "I":

$$I \leftarrow \text{technology} \rightarrow \text{world}$$

This permutation models how drivers obey the navigation app, sometimes without realizing where it leads them. Such users can find themselves going in circles due to a bug. Consequently, the app changes the drivers’ behavior as well as the traffic patterns (Wellner, 2020). Furthermore, AI algorithms change the world in ways that are sometimes beyond the control of their developers. For example, algo-trading technologies operate in the stock markets at a fast pace and make decisions at a rate that is beyond human management (see Wellner, 2018).

As new technologies are developed, we create new permutations in the formula to represent them and think through the formula of the new relations discovered. It is important to remember that there is no

single relation that fits all technologies. There is a variety of relations that change in various contexts of use, historical background, and local cultures.

What's next?

This essay provides a very short introduction to postphenomenology as one of the major branches of contemporary philosophy of technology. While positioned as a philosophy of technology, this theory maintains an interdisciplinary approach in two senses. On the one hand, it is not limited to philosophy and combines insights from other domains of knowledge such as anthropology, sociology, earth sciences, nursing, to name a few. On the other hand, committed to its pragmatic roots, the theory attempts to be relevant to a variety of disciplines. Thus, it analyzes medical image interpretation (Hasse, 2008), cancer screening (Forss, 2012), space photography (Rosenberger, 2013), robot design (Besmer, 2015), augmented reality glasses (Liberati & Nagataki, 2015), self-tracking bracelets (Van den Eede, 2015), and more.

These case studies have led to the integration of philosophy of technology, postphenomenology included, into design, research, development and assessment processes. Postphenomenologists contribute concepts to these processes, thereby clarifying situations and offering new directions. For example, employing the concepts of embodiment and quasi-otherness to robot development may reveal a challenge of determining the proper distance the robot should keep from its human users. Likewise, the concepts of hermeneutic relations and composite intentionality reveal how augmented reality glasses not only provide information but also shape the user's worldview and behavior. Integrating postphenomenology into R&D processes will not explain to the designers *how* to better design but rather assist them in asking *why*. Put differently, it will not explain the empirical aspects of reality. Rather, it will make visible many aspects of reality and provide the concepts to better understand them. Without the conceptual framework, the descriptions are useless

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The Story of the Clock: How It Was Discovered that that the Earth's rotation Slows

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Abstract: This short paper presents the story of the discovery of the deceleration of the earth. The main problem in astronomy was finding the location of celestial bodies at a given time, and for that a clock was required. But can one tell if the clock does not drift? It is never possible to know with certainty that any model perfectly describes reality. 19th century astronomers could not know that the errors in their results were due to their clock being given to drift and not because the theory of relativity had not yet been invented. The issue of the Earth's deceleration has been studied for years, and it took astronomers nearly 200 years of thorough work to find that the Earth does slow down, and their clock is inaccurate.

In recent years, a debate has grown on the issue of the necessity of scientific theories. On the one hand, some argue that causal theories are outdated, and that statistical models and learning networks are enough to provide accurate predictions about the future. On the other hand, there are those who support the approach that scientific causal theories are necessary, despite the success of computerized statistical approaches.

In this paper I will present a historical story, which I believe supports the latter position, according to which causal theories are necessary. Without causal theories, and by statistical calculations alone, it is not possible to break through the initial research framework and arrive at new explanations and theories. To convince you, the readers, that despite the expectation that neural networks solve everything, the chances of that happening are slim.

A clock is a necessary tool for science. This is a claim that is very difficult to argue with. Any tool for measuring time is necessary because a central part of the role of science is to produce predictions (and retrodictions). We want to know from the current state of affairs what that state will be in the future, and what it was in the past. Physics is an obvious example. By reducing reality to a small number of

measurable parameters¹ we can find equations that link these parameters and describe their evolution over time. But physics is a clear example. We make Predictions in every field. A chemist, for example, would want to know, when he puts reactants in the flask, what the products will be and how fast the reaction will happen; a biologist would want to know what, from the current state of affairs, will happen in the future, and what has happened in the past; an electrical engineer will want to know the current flowing through a circuit as a function of time... it seems that making predictions is one of the most important tasks of science. In other words: a large part of the functions we deal with in science depend on time t , which somehow needs to be measured.

Take, for example, physical time, and gravity theory as an example within an example. This is the t in equations, the independent variable. This t is the concept that engineers have encountered countless times in their lives, in every equation of physics or electricity or chemistry. The time represented by the letter t in the equations is a purely abstract concept. It assumes that you have an a priori accurate clock as a condition of the theory's existence and its development in general. This is before you even start planning your experiment. It is not a clock. This concept is not a concrete object. The concept of physical time can be expressed in some metaphysical theoretical schemes – for example, Newtonian time versus relativistic time.² The time t is a metaphysical concept.

To create a clock, a physical object, we must do two things. The first is to choose a uniform phenomenon in the natural world – it can be a cyclical phenomenon, such as the movement of the sun in the sky, or the moon, or the stars, or the number of oscillations of a cesium atom, or the oscillations of a pendulum... It could also be a non-cyclical phenomenon, such as sand spilling from a particular container, or the half-life of some radioactive material.

The second thing we need is to set a unit of time,³ for example, the second. The unit of time is what connects the abstract concept of time to the phenomenon used to measure time. It turns the elected phenomenon into a clock. In fact, cyclical phenomena are preferred as a clock precisely because they offer a “natural” unit of time. One of the necessary requirements for a unit of time is that it remain constant – that it does not stretch or shrink as time goes on, that it remain suitable for abstract time. We have no problem with the clock being inaccurate here and there, as long as we know exactly how to calibrate it from periodically, when the errors become unbearable and interfere with our ability to measure. But the unit of time must remain consistent (like other units in science) – a second is a second, today and tomorrow. Paradoxically as it sounds, we demand that the value of the second remain constant in time.

Okay, so we have a clock, and we are eager to do some science. But how do we know our clock does not “drift”? How do we know our unit of time is fixed? That it does not stretch (slow down) or contract

1. Take, for example, the theory of gravity: mass, location and time (in the form of speed), and that is all, more or less. Those three parameters are a reduction of the infinite riches of reality to three numbers only, while neglecting all the other intrinsic and extrinsic properties of the objects, to explain a specific phenomenon.

2. Newtonian time is defined as a uniform time that advances at the same rate for all observers. Einsteinian time changes in different rates for different observers, depending on the relative velocity between them. The difference between them is discernible only at relatively high speeds. Reality matches the Einsteinian (relativistic) time, but in velocities that are low relative to the speed of light, the Newtonian time yields the same result exactly (the difference between them is much below the threshold of our observation, and less than the Planck constant).

3. The unit does not have to be the second – it could be the minute or the hour or the day. The rest of the units could be determined by a division of the primary unit to as many parts as we wish. Precisely as with other physical magnitudes, the unit is arbitrarily defined. Interestingly, the Babylonians chose the sexagesimal system rather than the decimal one when it comes to time.

(goes faster) occasionally? We calibrate it with another clock, of course. But what clock? Until the 20th century, the answer was “turn to astronomers”. The astronomers were responsible for determining the unit of time and maintaining the “super clock,” relative to which other clocks are calibrated.

Defining the astronomical unit of time can be done in several ways: for example, the movement of the moon in its orbit can define the month, the movement of the Earth around the sun can define the year, and so on. Until the beginning of the 20th century, it was customary to define the unit of time by the **sidereal time**. This is the time of the Earth's rotation around its axis, in one day. The method is relatively simple: look at one of the stars, the ones that are so far away that they do not move relative to us practically, and when it returns to the exact same spot in the sky, exactly one day has elapsed. The rest of the time units can be produced by dividing or multiplying the day as we wish. The rotation of the Earth was chosen because it was the most consistent, and the easiest to measure. Over time, it became known that the Earth's axis of rotation is subject to nutation and precession,⁴ but as mentioned above, if we know how our clock drifts, we can “fix” it, and that is exactly what was done: scientists learned what the nutation and precession of the Earth are, and included them in the calculations.

Astronomy is also a science, and so predictions are derived from it. For example, we want to know where the planets, sun and moon will be in the sky at a given time. This problem is called the ephemeris problem. Before the invention of GPS this was a particularly important problem because it was the only way to determine your location in the middle of the sea. Before GPS, navigation was done with the help of celestial bodies, but predicting their location as dependent on time is an even older problem than navigation. It can be said with almost absolute confidence that from the moment Homo sapiens raised his head and looked at the sky calmly, he was interested in the motion of the planets and stars, the moon and the sun. In fact, the ephemeris problem is perhaps the oldest and most productive scientific problem the ever existed. It can be said with much confidence that Newton invented physics for this problem, and many parts of mathematics were devised to solve this problem: where are the celestial bodies located as a function of time?

But hey, just one moment! There is a serious loop here. Let us look, for example, at one problem – the moon. We want to know where the moon is at any time that we choose in the future. But the theory of lunar motion is complicated; it includes the effect of the sun on the moon and the Earth and the orbits of both.⁵ But the bigger problem is that there may be other factors that we have not yet discovered and taken into consideration. Maybe there is an asteroid or planet we do not know about yet? Today we have almost complete knowledge of the objects in the solar system that are large enough to affect the motion of the moon, but one or two centuries ago, new objects were still being discovered. Therefore, now the relevant problem for us is this: if the Earth slows down (or accelerates) its rotation over time, and the day stretches a little, how do we know if the errors in our observations are a result of the drifting clock (the Earth slowing down, or our unit of time stretches) or a consequence of the gravity model of the moon (the model is incomplete, effective factors are missing, there are effects that we neglected, etc.)? In short, how do we know that the clock is the problem rather than the equations or missing data that we failed to

4. The Earth's rotation axis is subject to nutations and precessions and it is not stationary in space.

5. In gravity, a problem of more than two bodies is not accurately solvable, only numerically, which is fine because if we have sufficient computing power, we can solve the problem with as much accuracy as we want. Astronomers at that time, however, astronomers did not have computers, and even easy calculations by today's standards demanded great effort and time.

consider?

Here we see an interesting example of the importance of theory. Up until Newton, the models of celestial motion were statistical in nature. The ancients used observational values to determine coefficients and to extrapolate into the future. But after Newton, astronomers already had a general causal theory, Newton's universal gravitational theory, which works wherever there is mass, be it the moon or the pencil that just fell from my desk. They are all explained by the same theory. There is a cause (mass), and a result (force), and a precise connection between them – an exact formula. True, when it comes to reality there are more than two players in a particular problem, and the equations become so complicated that we do not have an exact solution, but it is possible to build approximate solutions, and calculate them with increasing precision, so it is only a problem of computational power. In other words, there are ways to build a model and calculate the effect of mass distribution on forces (Newton's laws), and subsequently we can predict the location of all celestial bodies. Below we will see how scientists were able to understand that the Earth is slowing down, and we will describe the process.

Confidence in the Theory

Our story begins with the moon – the object closest to us, whose observations are most accurate and numerous, it moves fast, and we also have ancient observations of it that we can use.⁶ The moon is also important for navigation. The problem of the moon is different from the problem of the other planets. Due to the distance of the Earth and moon from the sun, the moon and the Earth can be treated as a system of two bodies with a complete solution, while combining the influence of the sun as a perturbation.⁷ A problem of more than two bodies in Newton's theory of gravity cannot be precisely solved, as stated, but with a suitable mathematical mechanism it is possible to develop an infinite series as the solution to the problem, and find the coefficients of the terms to any desired order, that is, to any desired precision. It should be noted, though, that this may seem like a problem, but the purpose of science is not to find simple and beautiful formulas but to solve scientific problems, and in our case, it is the location of celestial bodies depending on time. It does not matter if your solution is a short and easily workable formula or a tedious series that requires many calculations.

It was only after Leonhard Euler developed in 1739 his trigonometric functions and their differential and integral calculus that it was possible to begin building good models for problems of three bodies.⁸ The first theory of the moon⁹ that used Euler's techniques was his own (1746), and immediately after him two mathematicians named Clairaut and d'Alembert also developed different theories. All these theories were translated into tables, which predicted the position of the moon at any given time.¹⁰ The tables were compared to the findings in observatories, and their accuracy was examined. All the tables had inaccuracies of course – real scientists know that their models are just an approximation of the very

6. Lunar eclipses were documented by astronomers in antiquity with very good accuracy. It is easy enough to see eclipses and they always aroused curiosity.

7. A relatively small disturbance.

8. Generally, the differential equations can be formulated and solved with an approximate series.

9. Newton had a model of the moon's motion, but it used geometry and was not convenient to work with.

10. As mentioned above, the location of celestial bodies at a given time had great pragmatic and economic importance.

complex reality – but what was interesting was that all the tables had the same inaccuracy. That is, three different paths to solving the same problem led to the same error (Wilson 2010). The conclusion, then, is that this is not a calculation error, but something fundamental that is missing in the model of the moon. The three mathematicians' suggestions for solving the problem were different: Clairaut thought that Newton's universal law of gravity should be corrected, by adding a term that depends on the distance to the fourth in the denominator, for cases of relatively short distances by astronomical standards, like the moon. Euler thought that perhaps Newton's law should be amended when it comes to relatively long distances, while d'Alembert did not think that an amendment to Newton's inverted quadratic law was required. After these great mathematicians tested the theory, and developed the second-order solution, they concluded that Newton's law requires no correction.

The theories of all three yielded results with an accuracy of 3-5 arc minutes.¹¹ Over the years, others came who used their solutions to develop the series and find more and more terms of increasing order, and thus more and more accurate tables were obtained, but common to all these tables was that the methods used to construct them relied on observations to determine the coefficients. The more observations were used, the better the accuracy of the theories, but only for a relatively short time. The approximation diverged rapidly from the phenomena, and thus more and more new observations were required.

Laplace's Project – A Theory of the Moon That Depends Only on Newton's Universal Law of Gravity

When Pierre-Simon Laplace set out to construct a theory of the moon (1798), he was looking up to the outstanding accuracy of his predecessors. Unlike them, Laplace added factors to the Moon-Earth-Sun model, effective factors because of the gravity they generate, to create a theory that is wholly dependent on Newton's universal law of gravity. For example, Laplace added equations that represent the fact that the Earth is not a perfect sphere but an ellipsoid. He also managed to explain a phenomenon that puzzled his predecessors; it seems that the moon has been accelerating slowly and gradually since antiquity. This phenomenon was named "the secular acceleration of the moon", and no one had an explanation for it. Laplace has shown that the Earth's orbit around the sun changes over the years, in a way that fully explains the acceleration of the moon.¹² In fact, Laplace himself also neglected part of the explanation, as it later became clear that the change in the Earth's orbit does not fully explain the acceleration of the moon. Still, Laplace believed that soon enough, a model for lunar motion would be built that would rely solely on the theory and accurately predict the position of the moon only based on Newton's law of gravity. Once such a model would be built, there would no longer be a need to reuse the observations to update the terms in the approximate series; it would be enough to take the position and velocity of the moon once as a starting condition, and from that moment the solution will give the future position of the moon forever and accurately and without the need to change coefficients or develop more terms in

11. The fractions of the arc are measured in minutes and seconds, and it is not surprising, given the relation between the Earth's rotation and time measurement.

12. The only thing that provides a complete explanation of the acceleration of the moon is the deceleration of the Earth's rotation, as was found out later on.

endless series. Laplace, who effected great influence, offered the French Academy of Sciences in 1820 to award a prize for whoever succeeded in constructing more accurate theory and tables than what existed, and based on gravity alone. Two proposals were submitted. The first by Damoiseau (1768-1846), and the second by Giovanni Plana (1781-1864) and Francesco Carlini (1783-1862), all senior observatory directors in France. Both proposals used Laplace's new techniques. Still, their models were large and difficult to implement, requiring lengthy calculations and development into series of increasing orders of magnitude, and they yielded consistent errors.

The Pursuit of a Causal Explanation – What is the Source of Errors in the Moon's Location?

As the years went by, more scientists joined the project, proposing additions and corrections to the model, and creating their own tables. Over time, and after various debates and proposals, one model was agreed upon. The errors have been corrected, and all the factors in the solar system that can significantly affect the Earth-Moon-Sun system were considered. At this point, the observations, measurements and telescope technology also improved, and as a result the accuracy of the tables improved remarkably. But still, despite everything, there remained two anomalies that are not explained by gravity.

The first anomaly was the secular acceleration of the moon. In 1853, Adams showed that Laplace's model could explain only half of the observed acceleration (Adams 1853); the second half remained unexplained. That is, the change in the Earth's orbit does not account for all the acceleration of the moon.

The second anomaly was discovered by Newcomb in the 1860s. Newcomb has discovered that in addition to the slow acceleration, lunar motion is also subject to short-term oscillations. That is, sometimes the moon accelerated and sometimes it slowed, at intervals of decades and even centuries. Newton's theory failed to explain these two anomalies.

At this point, two astronomers independently proposed an explanation for the anomaly. Delaunay (1859, 1866) and Ferrel (1864) suggested that changes in the Earth's rate of rotation were responsible for the anomaly. Still, it took almost 100 years to prove this hypothesis. During the second half of the 19th century, the subject was studied by two astronomers, Newcomb himself (1896) and Ginzell (1899). But both were unable to prove anything, though, because the information was insufficient. In 1903 Newcomb, a senior and renowned astronomer, decided that the reasons for these changes were unknown and there was no evidence of a change in the Earth's motion; further research is needed.

Only after the astronomers ruled out all other possibilities (Brown 1910), the way paved to a complete proof. Among the possibilities examined were the effect of Jupiter on the movement of the moon, the existence of asteroids in the appropriate places, the ellipsoid shape of the sun itself, a possible magnetic attraction between the Earth and the moon, an unknown motion of the moon's axis of rotation and more. Finally, the point had come where all other possibilities were ruled out and enough accurate observational information was accumulated to check the motion of celestial bodies farther from the moon, i.e. the planets and the sun.

The method now was to compare the motion of the other planets, the sun (actually it is the motion of the Earth that is interpreted as the motion of the sun), the moon, and later even the moons of Jupiter. By considering the appropriate factor, which depends on the cycle time of the observed object, it was possible to check whether the observed changes in the motion of the moon also appear in the motion of the other celestial bodies. The logic was this: if the changes in the motion of the moon were indeed caused by the changes in the rate of motion of the Earth, we should see the same changes in all the other observations as well. Although the changes in the moon are most noticeable because of its high rotational speed, a close examination will show the same phenomenon everywhere, if it was indeed caused by changes in the rotation of the Earth. In the first stage it is not even necessary to demonstrate a full correlation. Suffice it to show that the minimum and maximum of errors in all the tables of all the relevant celestial bodies are obtained at the same time. Note that such an exercise was not possible before, because each model of each of the objects had errors resulting from problems in the model itself; it was necessary to wait for these models to reach completeness, meaning that all the causal factors within the model would be identified. For example, if one wants to compare the errors in the moon model to the errors in Mercury model, one must offset from the moon's errors the relative part caused by the change of Earth's orbit around the sun, and from Mercury's error its strange perihelion motion.¹³ That is, before astronomers went on to compare the errors of all models in relation to reality, they had to offset from each model the errors that were relevant only to itself. In other words, each model had to reach relative completeness before the models could be compared.

In 1914, Brown (1914) presented a diagram comparing the moon to the sun. The diagram shows that the oscillations and anomalies of Mercury and of the moon are quite similar, when considering the different orders of magnitude. Brown himself thought that this was due to changes in the sun's magnetic field and did not attribute this to changes in the Earth's motion.

In 1915, Glauert studied the relationship between the moon, the sun (actually the motion of the Earth), Mercury and Venus, and although a clear correlation could already be seen in his work, he decided that the information was insufficient and that further research was needed.

In 1925, Innes wrote a short paper on the subject, comparing the moon, Mercury, the sun, and Jupiter. By this point another troublesome problem had already been solved – Mercury's perihelion. This anomaly, of this star's orbit, also bothered astronomers for many years, and its solution finally came in the form of Einstein's general relativity theory (1917). This theory is an improvement on Newton's gravity theory, and it leads to greater accuracy of the models. After solving this problem, and after it was clear that even a new and more accurate theory of gravity does not solve the anomaly in lunar motion, Innes came to the conclusion that the anomalies in lunar motion are due to changes in the Earth's motion. A year later, in 1926, Spencer Jones came to the same conclusion by comparing the motion of various celestial bodies. At this point it was clear to everyone that the problem was not in Newton's theory, nor in erroneous observations, but that the Earth was probably changing the rate of its rotation.

13. Perihelion is the point on the elliptical orbit in which the object is closest to the sun, and that point kept moving for the observers. This another famous problem that will not be discussed here. It was solved only after the formulation of General Relativity Theory by Albert Einstein in 1917. In fact, the solution of the problem was one of the confirmations that Einstein proposed to his theory.

Conclusions

The result of the proof provided by Jones and his predecessors was that astronomy needed a new clock. Since antiquity, astronomers have been dependent on the daily motion of the stars in the sky (a consequence of the Earth's rotation) for the purpose of measuring time. At that stage, they knew that this movement was not uniform, meaning that their clock was moving at an uneven and unpredictable pace. In a first attempt to restore logical consistency to their science, astronomers invented the ephemeral time. That is, they used the ephemeris itself – the location of the rest of the celestial bodies – as a clock. The idea was this: they invested so much work in their models and in solving the Ephemeris problem, that the problem was solved with outstanding accuracy. Although the locations of the other celestial bodies were also subject to changes, at least in their case the changes and their causes were known and therefore could have been taken into account. Thus, the length of the year 1900 was determined as the unit of time definition, and to compare the subsequent year to 1900, a calculation was required that took the solution “back in time”. It was several more decades before the atomic clock was invented, which was accurate and consistent enough to be used to define the unit of time, and it was finally possible to stop using the celestial bodies to define the unit of time.

The most important conclusion here is that without causal theories, astronomers could not offset the errors of each of the models, to compare the errors (after the offset) and show that what was left, was consistent with the observations, thereby proving that the problem was actually the Earth's rotation. Without the Newtonian theory it would have been impossible to construct a separate model for each celestial body, and to find all the causes and factors that influence this model, and to recognize that the problem is in the clock. A statistical model alone would not distinguish the errors in the lunar orbit caused by factors related to the Earth-Moon-Sun system from the errors caused by the deceleration of the clock (Earth's rotation speed), so such a model could not at all compare the errors of all the different models, and locate the problem outside the framework explained by the Newtonian or relativistic theory of gravity.¹⁴ Only a causal theory could find all the gravitational causes affecting each model of each celestial body, offset them, and compare only what is left.

14. Apart from the case of Mercury's perihelion, the Newtonian gravity theory provides almost identical predictions about Einstein's Relativity Theory, with a level of accuracy that is relevant to the problem.

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