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Time=Money[1]: The Notion of the *Ideal* Applied to Physics

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ABSTRACT: This paper is about the possibility of using the notion of the Ideal in physics, this on top of its known role in communications, education, and economy. Present day fashion is to import concepts and methods from the natural sciences into the humanities. However as human culture covers all human knowledge, this one-way approach demands critique. Not only by arguing about the limitations of this fashion, but by investigating the reverse. To what extent can we apply ideas and models from the humanities into natural science? Below, I argue that the notion of the Ideal can be made operational by stipulating that time as measure of the Ideal change, is on par with money as measure of the Ideal value.

KEYWORDS: Ideal, Ilyenkov, Marx, Money, Change, Value, Time, Physics.

Science (and I think this applies to all kinds of research and scholarship) produces ignorance, possibly at a faster rate than it produces knowledge.
(Firestein 2012, 28)

Introduction

In this paper I try to make a small inroad into the question of the extent to which we can expand Evald Vassilievich Ilyenkov's (1924–1979) discussion of the Ideal, exemplified by the notion of value and its expression in a universal equivalent, called money, to other fields. Ewald Ilyenkov can

1. The beauty of the internet is that you can try to find (perceived) sources of aphorisms. Often *time is money* is attributed to the pre-industrial Benjamin Franklin, who wrote his in 1748 essay "Advice to a Young Tradesman." However, Plutarch, referencing to Antiphon (500 BCE), describes time as "the most costly outlay"—the earliest recorded version of *time is money*. This shows that the 'neutral' third party in exchange is an evergreen conversation piece (Chayka 2017). Below, this 'neutral' third party, 'money' is discussed in its form as a universal equivalent, a state it only reaches in a full commodity production environment. An environment in which the 'neutral' third party 'time' became a measure.

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be seen as the most important post-Stalinist Soviet Marxist philosopher. According to Ilyenkov the Ideal is a social and, following Spinoza, a material attribute of the thinking brain; thinking is like walking, an attribute of the human body. "The 'Ideal' here is understood in its entirety, as complete totality of possible interpretations—those already known and those yet to be invented." "This is why we must define the category of the 'Ideal' in its universal form rather than through reference to its particular varieties, just like the concept 'matter' is not disclosed through enumerating currently known conceptions of 'matter' in the natural sciences" (Ilyenkov 2014, 26). The Ideal is a notion which represents human experience and asks for a framework to employ it in inter-human communication and social intercourse. Ideals are products of human social-historical development. In a way one can say that an Ideal presents itself 'naturally' and asks for a representation form in human communication. Consequently, it is a dynamic expression of thinking in the human process of understanding nature, including the self. Ilyenkov famously extended Marx's notion of the Ideal in Marx's analysis of the capital mode of production. In this paper I try to expand the notion of the Ideal to physics.

Understanding the world is not a simple linear process. What we know and comprehend is closely related to what we don't know. In Hegelian terms one can say that the known demands the existence of the unknown in the form of the not-yet known.

First, I will start with the notion of the unknown. Subsequently, I provide a short overview of Ilyenkov's thinking, as I read it. Then we will dig deeper into the notion *time* as measure of change, including the notion of a *clock,* a device that 'ticks' equal amounts of *time* in a linear fashion.

I then try to merge the discussions and suggest that change is an Ideal in the Ilyenkovian sense, and (physical clock) time a universal equivalent like money. Hence, I will deal in particular with the issue of the extent to which time can be considered as only a measure and not as a physical notion and the remarkable fact that, in general relativity theory, the notion *time* conflates in space-time with gravity, which suggests that here time is tied to physical reality.

Part one

0) The unknown

The quip at the heading of this paper by the neuroscientist Stuart Firestein, covers the essence of the human endeavour to understand the world we are living in, including ourselves. We experience nature, we design and execute experiments, and we formulate theories and models to grasp what is happening. In this process we have two strands: a) theories and beliefs (gut feelings) that help us to understand how we arrived, where we are in the world, and what we think that this situation means, and b) theories whose goal is to map repetitive observations into models that enable us to predict based on the 'reasonable' presumption that the experienced regularities comprise a continuous 'undercurrent'.[2] Both are essential, as an understanding of where we are and refer to our place in nature and society, whilst predicting enables us to actively change our lives. This boils down to Marx's dictum that we don't have to stop at interpreting the world, but must go on and change it.[3] Physics is a prime example of a field whose fundamental goal is to be prescient by understanding the dynamics of things, whereby typically remaining in the 'smooth' realm, firmly established in calculus.[4] Abrupt changes are still subject to research, such as in catastrophe theory or the discussion on the perceived so-called collapse of the wave-function in quantum mechanics.

The observation of Firestein that our ignorance grows faster than our knowledge and understanding can be best illustrated in the following small story.

Take a meadow with grass and a pole, somewhere in the grass. A cow is tied to the pole with a rope of length R. The cow walks around grazing and producing nice milk. Her knowledge is given by the surface of the circle to be grazed. The unknown is given by the other side of the circumference of the circle. Everything beyond the reach of the rope is *terra incognita*. After a while the farmer makes the rope longer because everything is grazed and known. With a longer rope, the circumference also becomes longer ($2\pi R$). So, if the rope becomes twice as long, the circumference, i.e., the boundary with the unknown, becomes twice as long. If we take a sphere, the border with the unknown (the surface of the sphere) even becomes quadratically larger ($4\pi R^2$). And if we consider four-dimensional space-time as a hypersphere, we even deal with R^3. Now it so happens, at a certain length of

2. Obviously, in real life such smooth developments are scarce. Unfortunately, we don't yet have methods to deal with haphazard frivolous events such as falling in love or radioactive decay, other than statistics (cf. the Tinder app).

3. This—revolutionary—changing of the world is an example of a non-smooth transition and is the essence of the debate between revolutionary Marxists and social democrats.

4. The informed reader will immediately offer the rebuttal: and what about phase transitions and quantity-quality transitions? Indeed, here we have a problem, see Kircz and Van der Linden 2022.

rope, the cow reaches a patch without grass, but with clover. This change of fodder influences the flavour of the milk the cow produces and the farmer ponders what is happening.

This pictorial example is a one-to-one representation of practising science. We (mammals such as cows) produce an excellent theory (the milk) for human well-being. But slowly we reach the limits of this theory and are confronted with problems. We are crossing a border and the unknown grows larger and larger. Still, we try to digest this situation by doing as we did before. But then, we cross from the known grass to the unknown clover and our (mental) metabolism changes; a new theory has to be born. Obviously, we try to integrate the old and the new, but then we realise that grass-milk is not exactly clover-milk, which then immediately leads to a new product in the supermarket. The above pictorial metaphor is what happens with theories and the emergence of scientific revolutions, leading to novel models and theories.[5]

The unknown is also well-known in e.g., financial budgets where it is listed as unforeseen costs or contingency expenses.[6] The human endeavor of prodding the unknown is an attempt in understanding the infinity of nature.[7]

1) Human models and materialism

Nouns and verbs are words humans use for more or less well-defined notions. By naming something we map the mental ‘picture’ onto an exchangeable object, a word, with a common societal meaning. The words get ‘a life’ of their own. Words can relate to material objects, a bike, but equally well to useful general notions, like energy, love, nationalism, etc. that fuel our communications and knowledge development. In this paper I

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5. Here we enter the discussion of the Kuhnian suggestion of paradigm shifts and their dynamics. For an excellent study of the notion of scientific revolutions see J.B. Cohen 1985.
6. A popular aphorism is by the notorious, twice US secretary of defense, Donald Rumsfeld, during the Iraq invasion in 2003, about ‘known unknowns’ and ‘unknown unknowns.’ Misty notions that darkened his claims about the existence of ‘Weapons of Mass Destruction.’ But for example, within standard cosmology theories we have to postulate Dark Matter (known unknowns), whilst the appearance of Darth Vader remains an unknown unknown. Rumsfeld’s categorization is empty rhetoric.
7. As Lenin correctly stipulates: “The electron is as *inexhaustible* as the atom, nature is infinite, but it infinitely exists. And it is this sole categorical, this sole unconditional recognition of nature’s existence outside the mind and perception of man that distinguishes dialectical materialism from relativist agnosticism and idealism” (Lenin [1908] 1968, 262).

develop the notion of models within the framework of the materialist notion of the Ideal, the notion of activity of the human body, as analysed by Marx and furthered by Ilyenkov's notion of the Ideal.

Below, after reviewing Ilyenkov, only those aspects that are important to our discussion on extending the concept of the Ideal to natural sciences will be discussed.[8]

How do we develop a materialistic epistemology? After all, in a materialist worldview, we humans are the product of a world that existed before our coming into being as well as after the human species perishes due to (induced) natural disasters or by wilful human activity such as nuclear war.

At this point it is already important to note that 'nature', seen as the totality of all that exists, gave rise to humans, but like with the dinosaurs this was not on purpose. And like the dinosaurs, humanity can 'evaporate' and novel forms of life will develop.[9]

In other words, our present discussions on ecology and eco-socialism, as an answer to pollution and climate catastrophe, deals with the survival of our species only. It goes without saying that this consequentially includes the survival of a plethora of other species, which together compose the human habitat or biosphere. This holds, even if we take a Spinozist pantheistic standpoint, as God can decide—or nature just happen to reach

8. Ilyenkov's most relevant works in English are his *Dialectical Logic: Essays on Its History and Theory* (Ilyenkov 2008), and *Dialectics of the Ideal*. There are various versions of the latter. The best know version is the shortened version published as E.V. Ilyenkov, 'The Concept of the Ideal.' In *Philosophy in the USSR, Problems of Dialectical Materialism* (Robert Daglish, tr) (Ilyenkov [1974] 1977).
Only in 2009 was a complete version published (Ilyenkov 2009) of which a translation is published as (Ilyenkov 2014). Comparing both versions, we see that the shortening mainly pertains to polemics with among others, I.S. Narsky and D.I. Dubrovsky, against their mechanical positions that "the ideal is a purely individual phenomenon, realized by means of a certain type of cerebral neurodynamic process" (2014, 27) instead of a socio-historical understanding. The translator of the 2009 version explains the differences in his introduction (Levant 2014, 3–24).

9. See for an interesting discussion Reiner Grundmann: "I maintain that nature is always in 'balance with itself.' Take the example of a river in which, due to pollution (detergents), no fish can survive. But instead of fish, other animals and plants (for example, algae) are flourishing" (Grundmann 1991, 113). Think also about F. Engels's remark in his 'introduction' in *Dialectics of Nature*: "[. . .] and to pass away before animals with a brain capable of thought are developed from their midst, and for a short span of time find conditions suitable for life, only to be exterminated later without mercy—we have the certainty that matter remains eternally the same in all its transformations, that none of its attributes can ever be lost, and therefore, also, that with the same iron necessity that it will exterminate on the earth its highest creation, the thinking mind, it must somewhere else and at another time again produce it" (Engels [1873–1882] 2010, 335).

a point—that humankind can go astray and evolution has to start anew. Apart from catastrophes such as impacts of asteroids, we deal with the understanding and conservation of the direct human environment: the biosphere.[10]

The whole of human history is a story of the development of our species; the ever-increasing understanding of our metabolism with non-human nature to guarantee procreation. This development is a kind of 'learning on the job,' of how the limits of our habitat foster our species. Accruing knowledge of the world (nature) in order to understand its operations (including our being) is the basis of science in all fields. Science should enable the development of our species in conformity with nature's incredibly complicated dynamics, instead of suppressing and brutally exploiting nature; this against the fatal fallacies of the Bible.[11]

Given the limits of human life as part of nature's offspring, the question is always: how do we develop mental models of nature and refine, discard, or supplant them in the course of human (scientific) progress; this within the framework that mental models are an evolutionary result of nature and are therefore human-centred. Our semantics and models pertain to our species only! If other species exist that are able to 'think' and 'reflect' there is no reason why they should frame nature the same way we do.

In this paper, the word science must be seen as the human process of systematically accruing knowledge (facts, regularities) which is confronted with interpretations (theories), experimentations and has the capacity to predict.

Humans have a specific set of senses, partly or completely different from other earth dwellers. Hence, it is imperative that human sensory 'registrations' of nature are the fundamental input to human understanding and theory building. However, the issue is if, when, and how these sensory registrations are understood and become part of a (historically contingent) human understanding of nature. This entails a long process of developing an ever more comprehensive human social activity. The dynamics of sensory experiences in human activity are socialised in the notion change,

10. The term biosphere was coined by the Russian geochemist Vernadsky (1863–1945) (Vernadsky 1998). This is a precursor of Lovelock's *Gaia* concept (Lovelock 1979).

11. "Then God said, 'Let us make mankind in our image, in our likeness, so that they may rule over the fish in the sea and the birds in the sky, over the livestock and all the wild animals, and over all the creatures that move along the ground'." (Genesis 26) and "So God created mankind in his own image, in the image of God he created them; male and female he created them" (Genesis 27). Genesis https://www.biblica.com/bible/.

which I will call an 'Ideal' (see further below) and is projected (or mapped, or materialized, or casted) into models: mental tools.

Within the set of possible senses, for human experience duration and extension are fundamental. To make these tools operational we name categories like heat, colour, smell, space, and time. We also introduce units to coordinate them, like degrees, milligrams stuff per centilitre water, etc. to capture measurement results and exchange them with each other as common ground for communication and social activity. They are a simple immediate given, as we can count our steps as well our heartbeat. Some of these coordinates are so close to our experiences that we can hardly do without them and, hence, Kant postulates space and time even as necessary. However, we slowly learn that there are more human experiences such as electric and magnetic activities in the human body. Our metabolism is pure chemistry and chemical elements and the reactions between them are driven by electromagnetic fields.[12] Our immediate reflex is to describe these new notions in terms of space and time, which gives an extra emphasis on space and time as (for 'the time' being) primary notions. All such notions are mental bootstraps to pull ourselves from a certain level of ignorance to a next level of knowledge. This is also the case with the elusive notion of 'energy,' which can be formally defined in physics.[13] Much easier to grasp are the notions duration and extension, which are metaphorically used in many situations in which we try to grasp change.

The above is an attempt to prepare the reader to the suggestion that we have at least (in historical order): i) tangible objects (immediately understandable by our, human, primary senses—*a la* Mach's positivism), ii) Ideals (*a la* Ilyenkov) which are socially established notions in search of operational representations by humans, and iii) what I want to name 'non-touchables'; the free floating ideas we have and are not (yet) able to be pinned down (even with the help of archetypes of a Jungian psychiatrist). Ilyenkov discusses in particular the Ideal 'value' the economic concept that demands an expression in operational terms. In physics we can think of

12. The term electromagnetism refers to physical phenomena related to electricity and magnetism.

13. Note that energy in the form of heat can be quantified by the measure calories. Heat is defined as an expression of kinetic motion and is measured by comparison with e.g., an expanding fluid (thermometer) or an electric current (thermocouple), which provide a measure named temperature. It is beyond the purpose of this paper to discuss thermodynamics and statistical mechanics in which we consider energy or entropy (as a measure of ordering) as a driving force.

concepts such as energy, entropy, and change as candidates. In part two we will deal with time as the measure of the Ideal 'change.'

2) Ilyenkov and models

Evald Ilyenkov (1924–1979) is the most important philosopher of the post-Stalin, but not post-Stalinist era. It was in the Khruschev thaw (~1956–1964) that he was able to develop his thinking, which was unfortunately slowly more and more repressed in the following stagnant period under Brezhnev.

Ilyenkov's Marxism is fighting a battle on two fronts: on the one hand against classical German philosophy since Kant, and, on the other hand against the (experimental or neo) positivists. Ilyenkov starts his analyses with Spinoza and the understanding that thinking is an attribute of the material human brain. He then follows Hegel and explicates the notion of the Ideal in Marxist terms, as a social activity. Ilyenkov exemplified this by the Marxist concept of value. (Ilyenkov [1960] 2017)

Immanuel Kant (1724–1804), the first modern philosopher, analyses in his *Critique of Pure Reason* (Kant [1787] 1998) the quest for a formal approach to attack the problem of human knowledge. This work resulted in a series of limited propositions, in order to build a 'logic', that is to say a self-consistent scientific grammar that explicates our way of knowing. Most important are his *a prioris,* things we cannot do without, which are simply there such as space, time, and causality; notions that are 'ingrained' in human thinking. Human culture is gridlocked into these notions and it is impossible (according to Kant) to dig deeper. The outstanding question is of course if this suggests a 'final truth', an ultimate bottom line of reality, or if it is the result of the way our species with its particular senses is (only?) able to grasp reality. Kant's approach is completely in line with Newtonian physics where space and time are *absolute* entities. It postulates the—given—frame in which everything happens (a receptacle), at this point and at this time, whilst going to that point at that time. Kant's second pillar, next to *a prioris,* is the notion of the *Ding an sich,* a notion that tells us that 'things' exist in and for themselves. Our human problem is then to, asymptotically, reach out for an understanding, a knowing, of what it is. This powerful argument reflects the idea that humans, by our systematically inquiring nature, are able to, potentially, make nature fully and mechanically operational for ourselves.[14] As argued above, the opposite is true: we constantly increase our ignorance; today's ultimate building blocks may turn out to be only ingenious contraptions typical for our historical period.

At bottom, these two Kantian notions say that we have a 'canvas' on which we paint the world and in principle objects are real, though not necessarily, intellectually, knowable to humans, like a cubist oil painting of a very recognizable oak. This notion of a fixed canvas is at odds with my view that things are a morphing of phenomena and theory.

A third characteristic of Kant is his introduction of categories, such as Quality, Quantity, Relation, and Modality in an attempt to sort out the various analytical concepts (Kant [1787] 1998, as from page 204). These categories are a weak point as they appear more —or less— 'colloquial' and are not presented as essential minima. As Ilyenkov says, in this way we have formal (trans-historical) schemas that 'hover' above ever-changing human understanding and knowledge acquisition. To quote Ilyenkov:

> And if logic claimed to be the science of thinking it must also develop just this doctrine of categories as a coherent system of categorial determinations of thought. Otherwise it simply had no right to call itself the science of thought. Thus it was Kant (and not Hegel, as is often thought and said) who saw the main essence of logic in categorical definitions of knowledge, and began to understand logic primarily as the systematic exposition of categories, universal and necessary concepts characterising an object in general, those very concepts that were traditionally considered the monopoly of metaphysical investigations. At the same time, and this is linked with the very essence of Kant's conception, categories were nothing other than universal forms (schemas) of the cognitive activity of the subject, purely logical forms of thinking understood not as a psychic act of the individual but a 'generic' activity of man, as the impersonal process of development of science, as the process of the crystallising out of universal scientific knowledge in the individual consciousness. (Ilyenkov 2008, 95)

Kant makes a simple distinction between the real and the idea, where the real is part of the material reality and the Ideal, the 'picture' of the real, resides in the thinking mind.

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14. A related popular notion is introduced by the French physicist and philosopher Bernard d'Espagnat (1921–2015), in his concept of "veiled reality" (*réel voilé*) (d'Espagnat 1995) in his discussions on quantum mechanics.

> It is notable that in his *Critique of Pure Reason* Kant does not formulate his understanding of "Ideality," but uses this term as a ready-made predicate requiring no special explanation when he is defining space and time and speaking of their "transcendental *Ideality*." This means that "things" possess space-time determinacy only in the consciousness and thanks to the consciousness, but not in themselves, outside and before their appearance in the consciousness. Here "Ideality" is clearly understood as a synonym for the "pure" and the a priori nature of *consciousness as such*, with no external connections. Kant attaches no other meaning to the term "Ideality." (Ilyenkov [1974] 1977, 73)

In his argument against the artificial split between thinking and body, Ilyenkov in his essay on *Thought as an Attribute of Substance* (Ilyenkov 2008, 27–74) is advancing Baruch Spinoza's (1632–1677) philosophy. [15] To emphasize the clarity of Ilyenkov's reasoning, it is useful to quote him extensively.

> There are not two different and originally contrary objects of investigation body and thought, but only one single object, which is the thinking body of living, real man (or other analogous being, if such exists anywhere in the Universe), only considered from two different and even opposing aspects or points of view. Living, real thinking man, the sole thinking body with which we are acquainted, does not consist of two Cartesian halves 'thought lacking a body' and a 'body lacking thought'. In relation to real man both the one and the other are equally fallacious abstractions and one cannot in the end model a real thinking man from two equally fallacious abstractions. (Ilyenkov 2008, 31) [16]
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> Thinking is not the product of an action but the action itself, considered at the moment of its performance, just as walking, for example, is the mode of action of the legs, the 'product' of which, it transpires, is the space walked. And that is that. (Ilyenkov 2008, 35)
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> The cardinal distinction between the mode of action of a thinking body and that of any other body, quite clearly noted by Descartes and the Cartesians, but not understood by them, is that the former actively builds (constructs) the shape (trajectory) of its own movement in space in conformity with the shape (configuration and position) of the other body, coordinating the shape of its

15. Ilyenkov refers mainly to the following propositions of Spinoza's *Ethics*. Part 1, prop. 5, 8, and 9. Part 2, prop. 13, 14, 26, 38, and 39. Part 5, prop. 23, and 24.
16. Note that throughout this paper we use the gender-neutral human. However, we don't change quotes where 'man' is used as the generalized noun for human.

own movement (its own activity) with the shape of the other body, whatever it is. (Ilyenkov 2008, 46)[17]

It is important to note that Ilyenkov, like Marx, is not strict in line with Spinoza but advances Spinoza's thinking as Bowring (2022) illustrates.[18] Also Oittinen (2005) analyses to what extent Ilyenkov remains within the Spinozist framework and where he departs. The main observation is that for Spinoza: "body cannot determine mind to think, neither can mind determine body to motion or rest or any state different from these" (Ethics III, 2, as quoted on page 328). "In other words, ideas in the human mind are generated, according to Spinoza, by God's attribute of Thought and not by the impression caused by the form of external things" (idem). Ilyenkov's 'thinking body' is not Spinozistic. Indeed, though Ilyenkov starts with Spinoza, he goes beyond him and investigates the 'cultural- historical' activity approach and does not recognize a "mediating factor between thought and matter." (Ibid., 333) This indeed is an important issue as the body as sensory organ is not explored by Ilyenkov[19]. In modern medicine and psychology psycho-somatic disorders as well as the other way around the influence of bodily disorders on mental states are taken most seriously. Ottinen's conclusion: "[. . .] consequently, thought must cope immediately with matter and burdened with it." (Ibid., 335) misconstrues Ilyenkov's fundamental materialism. Matter is not a burden but the source of thinking and ingenuity. Obviously, this goes beyond the vulgar materialist notions that try to reduce the brain to neurodynamics, which approach is prototypical for computer neural network models (see also Ilyenkov 2014, 27 ff., for Ilyenkov's critique on Narsky).

We now enter the important discussion of the relationship between sensory perception (like the notion of change, we discuss below) and thought. As mentioned above, Ilyenkov refrains from a discussion of the notion of human thinking as bodily labour.

The most developed mode of inter-human communication is language and there is strong tendency to reduce everything to linguistic, semantic

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17. For György Lukács (1885–1971), in line with the bodily source of human thinking, it is human labour that we have to take as ontology. This aspect needs further scrutiny (Lukács 1980). Ilyenkov could not discuss Lukács, as Lukács's discussions on ontology were only published just before he passed away in 1979, or postmortem.

18. In the same way, the present author does not try to develop his thinking in strict concordance with Ilyenkov, but try to advance Ilyenkov's thinking into natural science.

19. He also does not enter the discussion on the body as sensory agent of human emotions like pain and happiness. A weak point in Marxism, as Timpanaro addressed (Timpanaro 1975, 63 *ff*.).

expressions. In the discussion with the (neo) positivists it is therefore deemed necessary to dig deeper in understanding what senses we have and which limited set gave rise to the priority of language in communication and the human necessity of naming ideas and objects.[20]

With our senses, we experience ourselves and our environment and given the level of consciousness and scientific culture, we comprehend our sense impression in mental models, based on theories. These models go as far as we can, within the contingencies of the present experimental situation as well as available theories. For that reason, we experience the world as *objective*, it is presented to us as far as we can grasp it. It does not make sense to emphasise that this 'picture of the world' is incomplete if we are not able to address what is missing, other than wondering about what we do grasp. The only thing we know is that every new experience adds actively to our ever changing 'picture' of nature. It is an incomplete picture and many aspects might be antagonistic and unclear in the sense of not fitting into a coherent model. It is a moral and political point to accept this ever changing 'world-view' and we must adjust our dream for a 'better future' accordingly, in the light of new insights, e.g., fighting global warming, with nuclear, geothermal, chemical hydrogen, photonic solar energy and what we don't know yet as part of the puzzle.

We have to realise that the 'objective world,' as we perceive it, is a work in progress, a morphing between what is and what we (incompletely) experience on the one hand and our human-made models and theories on the other hand.[21] This holds certainly for basic notions such as space and time; primary dimensions of our understanding.[22] It is an open question

20. Note also that tactile contact (with or between deaf-blind people) or sign language (with or between deaf people) are clearly fully-fledged languages though not stratified in written language. See the massive literature on literacy. Be aware that it is language, in opposition to say touch, and in particular written language, that enables communication independently of time and place. It is literacy that boosted human intellectual and technical development.

21. Note that this is line with Lenin's polemics with Bogdanov: "Materialism says that the 'socially-organized experience of living beings' is a product of physical nature, a result of a long development of the latter, of development from a state of physical nature when no society, organisation, experience, or living beings existed or could have existed" (Lenin [1908] 1968, 229).

22. The acceptance that we can only map information onto human size (macroscopic) devices and notions is key to the thinking of Niels Bohr in his arguments on quantum mechanics: "...it is decisive to recognize that, *however far the phenomena transcend the scope of classical physical explanation, the account of all evidence must be expressed in classical terms.*" It is important

how other species experience the same world based on their specific senses.[23]

It does not help our understanding to posit a fully-fledged 'World out there' as if we play with Lego Bricks which have to be fitted together or count up to say 42 (Adams 1990, 27). Nor does it help if we catapult the issue up into the clouds in the sky, with or without a deity sitting on them and looking down. Obviously, the mechanistic dream of finding the ultimate 'cogwheels' of nature or the religious experience of being or becoming one with God or nature, can serve as an incentive for investigations. This observation is illustrated by the great number of religious scientists.

Our world view, that is to say, our ever-changing understanding of the world, is continuous social work in progress. Individuals do have unique visions and feelings about the objective world, but only the totality of human social experience and theory building, with all its twists and turns, makes us crawl further to a fuller human understanding. Only theories and models that are socially accepted within a community serve as temporally 'certified' knowledge, in particular if they are confirmed in experience and are able to predict yet unknown experiences, serving as the basis of technology (cf. Thomas Kuhn's notion of Paradigm shifts).

The Ideal as a bodily expression of thought as attribute—of substance—is part and parcel of social reality as constituted by culture and history; the only reality we have access to. Here, we immediately enter the discussion about reflection. Often, Engels and Lenin are denounced because they put an emphasis on the fact that reality (out there) is reflected into the human mind (in here). However, there is no other option, as the only other option is that the notion of the real object (out there) is already 'on the shelf' and the brain is only there to identify the impression with a pre-existing idea, like a catalogue of an online supermarket. This simplicity

to stress the fact that often this opinion is misconstrued as if Bohr wants to bring quantum mechanics back to classical mechanics. In fact, Bohr struggles with, in his view, the impossibility of having a kind of 'quantum language' inherent to the field, and that humans can only express phenomena in terms of classical notions such as particles or fields, which brought him to the notion of *Complementarity* (Bohr 1949, 209; Bohr 1999).

23. However, it is a prime challenge to investigate the behavior and communications among each other and with non-human species with other senses (e.g., the electric eel or the carrier pigeon), to augment or change our models and appreciate our human limitations. At present, superior animal sensory capabilities are mainly investigated in order to mimic and explore for a possible technological usage and not for an adjustment of our world view, which means it is all reframed in what we know we have (Prescott et al. 2018).

leads to the kind of realism in which all things are fixed and only need to be revealed by naming them.[24]

Nowhere, however, did Engels and Lenin defend this type of one-to-one realism (isomorphism) between name and object.[25]

This simplistic idea of reality is not necessary at all, because thinking and the brain, which we take for practical purposes as the sole seat of thinking, are intertwined, and neural activity and thinking are both attributes of the human body, experience and human activity and evolution develop these attributes constantly.

As Ilyenkov said, interpreting Spinoza:

> One does not ask how legs capable of walking are constructed, but in what walking consists. What is thinking as the action of, albeit inseparable from, the material mechanisms by which it is effected, yet not in any way identical with mechanisms themselves? In the one case the question is about the structure of an organ, in the other about the function the organ performs. The structures, of course, must be such that it can carry out the appropriate function; legs are built so that they can walk and not so that they can think. The fullest description of the *structure of an organ*, i.e., a description of it in an *inactive* state, however, has no right to present itself as a description, however approximate, of the *function* that the organ performs, as a description of the *real thing* that it does. (Ilyenkov 2008, 45) [26]

Although modern brain neurology is capable of identifying and monitoring brain activity and even is able to influence these activities in cases of damage or disorder (e.g., in cases of severe Parkinson's disease), it does not address the issue of knowing and understanding, other than intervening in

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24. The fascinating social reality is that if a name is given to an (elusive) object and used as an existing given, progress in understanding and operational usages of that named object is possible. A brilliant example is the struggle with the mathematical notion of 'infinity.' Whilst the late 19c French analytical mathematicians came to a grinding halt, the deeply religious Russian 'Name Worshipping' Christian mystics brought the field to a new level. For them, the strange concept of mathematical infinity was close to their religious notion of existing infinity and hence became an operational concept (Loren and Kantor 2009).
25. Note that even if we remain in the field of vision, a perfect mirroring is indeed a one-to-one mapping of the original object, however rotated on our retina. In a laughing mirror, or any, not-perfect mirror, the mirror image (reflection) can be far from being a homomorphism, as all kinds of aberrations occur. Here, the word reflection only suggests a perfect copy, or following Leibniz's notion of *The Identity of Indiscernibles,* it would suggest the most extreme notion of scientific realism.
26. Interestingly Maria Chehonadskih stresses the similarity of this quotation with Vygotsky's dealing with the unity of the psychical and the physical (Chehonadskih 2017, #2, 110–135).

the neurological processing thereof; just as the microbiome in the gut proves to play a role in the 'machinery' of the brain.[27] Unfortunately, all this, though being beautiful novel research, still remains on the pure mechanical behaviouristic level, as this is still the most promising avenue in medicine for the time being.

Increasingly, we learn that the sensory capabilities of animals are distinctly different from those of humans. That means that various biological species react differently to the same external environment. It is too easy to say that these reactions or reflections are simple stimulus-response effects (like the human chewing on food in the mouth), with a watertight screen between the superior human mental digestion of physical experience. Obviously, present-day knowledge is incapable of comprehending all this. But plenty of experimenting with e.g., rats, apes, dolphins, etc. shows a dynamics of learning activities that go beyond simple mechanics. [28] As with humans, nudges prompt activity, be it catching a ball or buying a product an Instagram influencer suggests to us. We don't yet understand how physiological processes give rise to thoughts and subsequently these, social-historically determined, thoughts get a life of their own (as an emerging property), and fire back on their substrate in e.g., psycho-somatic disorders.

3) Knowing as activity

Starting with the understanding that thinking is an expression of the living body, we immediately arrive at the notion of human activity, and in productive terms, human labour, as the source of contemplating, thinking and communicating.

Hence, the notion of activity becomes a pivot in the thinking of the philosophical school around Vygotsky, Luria, Leontyev, and later Ilyenkov.[29]

In the same collection of papers in which Ilyenkov's 'Dialectics of the Ideal' appeared, the psychologist A.N. Leontyev (1903–1979) formulates activity as:

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27. Microbiota is defined as all microbes present within an ecological niche such as the gut, whereas the microbiome is the combination of the microbiota and their genes (Schächtle and Rosshart 2021).
28. For the miraculous behavior of the octopus, a species that on a very early phase in evolution split off from the branch that resulted in humans, see Godfrey-Smith 2016, 2020.
29. See for a recent review see Maidansky and Oittinen 2015.

> The profound nature of mental sensuous images lies in their objectivity, in the fact that they are generated in processes of activity forming the practical connection between the subject and the external objective world. No matter how complex these relations and the forms of activity that realise them become, the sensuous images retain their initial objective reference. (Leontyev 1977, 192)

This means that what the active human in his/her context considers on the basis of the senses (and subsequent casted in models and theories) is the objective reality for us humans: a reality that is always contingent and contextual. There is no 'world out there' as discussed above.

And:

> Thus, meanings refract the world in man's consciousness. The vehicle of meaning is language, but language is not the demiurge of meaning. Concealed behind linguistic meanings (values) are socially evolved modes of action (operations), in the process of which people change and cognise objective reality. In other words, meanings are the linguistically transmuted and materialised ideal form of the existence of the objective world, its properties, connections and relations revealed by aggregate social practice. So meanings in themselves, that is to say, in abstraction from their functioning in individual consciousness, are just as "psychological" as the socially cognised reality that lies beyond them. (Ibid., 193)
>
> This derives from the very nature of mental phenomena. As we have said, mental reflection occurs owing to the bifurcation of the subject's vital processes into the processes that realise his direct biotic relations, and the "signal" processes that mediate them. The development of the internal relations generated by this division is expressed in the development of the structure of activity and, on this basis, also in the development of the forms of mental reflection. Subsequently, on the human level, these forms are so altered that, as they become established in language (or languages) they acquire a quasi-independent existence as objective ideal phenomena. Moreover, they are constantly reproduced by the processes taking place in the heads of specific individuals, and it is this that constitutes the internal "mechanism" of their transmission from generation to generation and a condition of their enrichment by means of individual contributions. (Ibid., 194)

In other words, given a certain level of culture, a 'picture' of reality is constructed and subsequently memorized and communicated in language (be it a natural language or mathematical sign language). Therewith it becomes socialised and in the same movement petrified in a semantic network.[30]

30. Note that mathematics only demands consistency, hence a large plurality of models is possible and developed, from plain curiosity to forced developments induced by human

This dialectics of language is expressed by the fact that, on the one hand it enables communication of experiences, knowledge and understanding, whilst on the other hand it 'reifies' these its semantic simplification. This simplification is heavily attacked by Ilyenkov in a paper on education. (Ilyenkov [1974] 2002):

> The verbal 'object' then turns into a synonym for the chaos of totally unorganised 'sense data'—into a synonym only for what I do not know about the object. In general, we obtain the well-known program of Neopositivism with its utopian hopes of erecting a system of 'rules' that provide procedures for going from language to facts that lie outside of language, and vice versa, where there must be no 'contradictions' within language. This leads to the main principle of the Neopositivist solution—if you have verbalised certain known facts but have nevertheless obtained a contradiction within language, then it means that you have verbalised the facts 'incorrectly'—not according to the rules. It means that you have 'broken' some 'rule of verbalisation.'
>
> The Neopositivist program, with its accompanying 'logic,' is therefore regressive in its very essence. It replaces the real problem of knowledge—as knowledge (cognition) of an object that exists not only outside of language but also independent of any self-organised language—by the problem of the verbal formation of verbally unformed material. Here the latter is thought of as the totally unformed chaos of 'sense data,' as the passive material of 'knowledge,' which can be formed verbally in one of two ways—either 'correctly' or 'incorrectly.' But here 'correctly' means according to the rules of available language, i.e., such that it is forced to fit without contradiction into available language, into the available semantic-syntactic 'framework,' into available 'knowledge.' The real problem of the cognition of the object has therefore been twisted around into a purely linguistic problem—the problem of first assimilating available language ('the language of science') and then of assimilating 'facts' in the forms of this (available) language.
>
> After all, this is what geometric figures drawn on the blackboard are, or counting sticks (it doesn't matter whether they are sticks of wood or of plastic—what's important is that they are an image of 'quantity,' or, more precisely, of number), and coloured pictures, and all the other 'real-object' stage props of the schoolchild.

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activity in the natural sciences. A simple example is the idea that the order of operations is not symmetric, hence A times B is not B times A, where 'times' has to be seen as an operation. This can easily be shown in three dimensional rotations. Pick a book and turn it first along its length then along its width and finally along its depth. Change the order and you will not end up in the same situation.

This observation emphasises that words in human speech have a certain fluidity of meaning. In mathematical language the contrary is most beautifully presented if we deal with the pragmatic reduction of mathematical knowledge in well-defined sign language (or 'hieroglyphs').[31]

The Ideality transcends the materiality, not in the Kantian sense of finding a home outside the human body, but as a human activity shaped in human society. Ideas evolve as a result of socio-historical developments. Hence, we witness a clear historicity of 'mental' socialised notions whose material form is ever changing.[32] A fine example of this is the plural concept 'Atom', which we will elucidate below.

In the ancient Greek world, the atom was considered as the smallest part of matter. For a long period, the atomists discussed the form or constitution of these most elementary units of matter (stuff). With the chemical revolution, the notion of an atom changed to the notion of the smallest possible entity of a chemical element. However, in due course this smallest entity was split up into an electrically positive nucleus with negative electrons circling around it. The nucleus is further split into protons and neutrons. As a single chemical element is defined by the number of protons whilst the number of neutrons can vary, we have various versions of the same chemical element: so called isotopes. Now the proton and the neutron are considered to be mixed bags of quarks of which we now know six. However, the electron remains a fundamental entity (like the original Greek atom). But even worse, the unity of an elementary chemical atom as a particle is broken. In quantum mechanical language, the atom behaves as a wave, and, indeed, we can do interference experiments with atoms where they, like light waves, interfere. We can also add energy to the outer electrons, so that they 'excite' to a high (Rydberg) orbital and the size swells to that of a small bacterium, which makes the notion of the smallest particle ambiguous. Given this fact, we then have to ponder the empty space

31. See e.g., the charming book of the Amsterdam theoretical physicist Sander Bais in which he lyrically explains some fundamental physics laws in their pictorial form e.g., the amazing formula for gravity, a beauty only for the connoisseur. (Bais 2005)

$$R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu}R + g_{\mu\nu}\Lambda = 8\pi G_N T_{\mu\nu}$$

32. See also Lenin ([1908] 1968, 260) in which he stresses the historicity of knowledge and firm notions after the discovery of radio activity: "'Matter disappears' means that the limit within which we have hitherto known matter disappears and that our knowledge is penetrating deeper; properties of matter are likewise disappearing which formerly seemed absolute, immutable, and primary (impenetrability, inertia, mass, etc.) and which are now revealed to be relative and characteristic only of certain states of matter."

between the electron orbitals and the nucleus and wonder why this emptiness in terms of matter per volume is way less than that in the cosmos.

Nevertheless, in colloquial speech, the atom is the metaphor for the smallest of something. Just as DNA is now a generalised metaphor for the uniqueness of, e.g., a commercial company.[33] There is nothing wrong with metaphors but in developing a novel Marxist world view, we have to be careful to be clear about what we mean, want, and try to develop.

Above, we said that reflection is in strong realist theories, seen as a perfect copy of reality.[34] But this is insufficient. Indeed, we can assume that the picture projected upside down on our retina is a perfect reflection for all practical purposes (give and take the resolution of the retina cells), but when these impressions are translated into neural activity, we still can speak of a reflection, though—in modish language—in a neurological electric(?) data representation. The understanding of this 'picture' is still unknown until the object of our vision resembled a known object in language. This is the basis of the short-sighted statement that for Caucasians all Chinese look the same and the other way around. The object must have sufficient unique determination to be recognized, and this determination is part of the totality of human social knowledge. This development of discriminative determination is a social process and includes conflations of notions which once were considered as fundamentally distinct such as the bizarre idea that God created various races, even though (Genesis 1:27) "God created man in his own image." Today we are confronted not only with the proof from genetics that Homo Erectus species of all stripes have almost the same genetic make-up, but also that there are more related Homo Erectus species than the plethora of creation myths can digest.

Ilyenkov devotes ample space to his argument against mechanistic thinking and is, as stated, closely related with the work of e.g.: Vygotsky, Luria, and Leontyev.

The hardest nut to crack is of course the notion of consciousness (Azeri 2019).

An Ideal is more than a stable semantic notion, as argued above in the example of the notion of an atom. Meanings change and therewith individual mental activity in all its ramifications, activity fundamentally embedded in the social context. It is in that context that the inter-human use of Ideals and concepts, that is to say, communication, shapes meaning. The

33. "How to Discover Your Company's DNA" in Harvard business review https://hbr.org/2016/12/how-to-discover-your-companys-dna
34. For a full-blown study on realism see Psillos 1999.

reverse is also true: a meaning is a carrier of communication between people in the same situation. Think about so-called dog-whistles in the racist speech of certain American politicians. For evolutionary reasons it so happens that speech, language, and labour became the engines of human development, and in that sense, language is a productive tool for the 'tool-making animal', as it allows common activities.[35]

The essential, Lukács speaks even of ontological, aspect of labour in human development is its capacity to create extensions, in the form of tools, needed to create a surplus product, and communication to bootstraps social progress. (Lukács 1980, chap.1, '*Die Arbeid*') Human labour is also key in the discussion of how we transact, that is to say, communicate among ourselves, our material and mental products. In other words, the entanglement of activity and communicative thinking by speech and language.[36]

> However, the brain, worked over and reproduced by labour, *becomes an organ – moreover, the authorised representative of 'ideality', the ideal plane of life-activity – characteristic only of man, an entity that socially produces his own material life*. This is the essence of real scientific materialism that is capable of resolving the problem of the 'ideal.' (Ilyenkov 2014, 75)

A very interesting suggestion is made by the neurologist Wilson, expert on the hand. His conjecture is that the whole unique human musculature from the shoulder to the fingertips is necessary for the extreme versatility of our hands in picking-up an object and that communicating this activity to fellow humans, demands language. His suggestion is that we can speak of a co-evolution of the articulation of the hand and languages, as both occupy highly complex neurological structures.

> This (human, JK) hand could, and did evolve under the influence of novel opportunities. No longer did this hand simply sports an opposable thumb; it transformed itself into an organ with a vastly increased manipulative range, with the capability to grasp and control objects of various sizes and shapes, powerfully or delicately—and constructively. [. . .] We have seen that the hominid brain, like the hand, was free to "experiment" under a new set of conditions (from the

35. Although Marx (Marx [1867–1886] 1976, 286.) refers to Benjamin Franklin for the quote 'tool making animal' Bhattacharya (2015) contest this.
36. Compare McLuhan's famous study of *Media as extensions of man* (McLuhan [1964] 2003). A most interesting approach is Azeri's notion of Conceptual cognitive organs (CCOs, human organs of cognition that allow concept formation and 'bear the mark of their socio-historical determination' and demand language to socialize (Azeri 2013).

> forest to the savannah, JK), [. . .] The structural changes based on a division of labour between the two upper limps. (Wilson 1999, 168–9)

Which materialism fits Ilyenkov's approach:

> Inside the human head—when understood naturalistically (namely as it is examined by a physician, an anatomist, a biologist, a physiologist of the higher nervous activity, a biochemist, and so on [. . .].)—there is no 'ideal,' there never was and there never will be. What exist there are material 'mechanisms,' which provide, with their complex dynamics, for the activity of man in general, including activity on the ideal plane, according to the 'ideal plane,' which confronts the brain as a special object, which is, in one way or another, the reified form of social-human life-activity, as purpose (the inseparable component of this life activity) as the human meaning of a thing. (Ilyenkov 2014, 75)
>
> The ideal form is the form of a thing created by social-human labour, reproducing forms of the objective material world, which exist independently of man. Or, conversely, the form of labour realised in the substance of nature, 'embodied' in it, 'alienated' in it, 'realised' in it and, therefore, presenting itself to man, the creator, as the form of a thing or as a special relationship between things, a relationship in which one thing realises, reflects another, in which man has placed these things, his labour, and which would never arise on its own. This is why man contemplates the 'ideal' as being outside himself, outside his own eyes, outside his own head – as existing objective reality. It is only because of this that he frequently and easily confuses the 'ideal' with the 'material', assuming those forms and relations between things that he created himself, [forms that have been 'placed' in them socio-historically, as natural-innate properties, historically transient forms and relations, as eternal and unalterable forms and relations between things, as relations dictated by 'laws of nature'—E.I.]. (Ilyenkov 2014, 76)

4) Value and money

Ilyenkov concretises the notion of the Ideal in his analysis of value in Marx's economic works (Ilyenkov [1960] 2017). In ch.1 of *Capital* vol. 1 Marx starts the discussion with the notion of the commodity, which confronts each other in human exchange. In the exchange the usability of a good expressed in its use-value is not relevant because the essence of exchange is the swap of different forms of use-values (e.g., potatoes for shoes).

> We have seen that when commodities are in the relation of exchange, their exchange-value manifests itself as something totally independent of their use-value. But if we abstract from their use-value, there remains their value, as it has just been defined. The common factor in the exchange relation, or in the exchange value of the commodity, is therefore its value. The progress of the

> investigation will lead us back to exchange-value as the necessary mode of expression, or form of appearance, of value. For the present, however, we must consider the nature of value independently of its form of appearance [Erscheinungs form]. (Marx [1867–1886] 1976, 128)

And

> By means of the quantity of the 'value-forming substance,' the labour, contained in the article. This quantity is measured by its duration, and the labour-time is itself measured on the particular scale of hours, days etc. [. . .] What exclusively determines the magnitude of the value of any article is therefore the amount of labour socially necessary, or the labour-time socially necessary for its production. (Ibid., 129)

The notion of human labour as measure (explicated in labour-time) is then obvious, as it is the only common human factor in comparing growing potatoes, making shoes, or stealing from the rich in order to give it to the poor. However, value as such remains an Ideal. It is only in exchange, when projected onto each other (10 kg of potatoes equals a pair of shoes), or expressed in a universal equivalent (money), that we can we reach countable abstract social notions.

Ilyenkov elucidates his notion of the Ideal with the example of the notion 'value' in the works of Marx.

> The value of a thing presented itself as the reified labour of man and, therefore, the value-form turned out to be nothing other than the reified form of that labour, a form of human life-activity, appearing to man in the form of a thing. And the fact that this is by no means the form of a thing by itself (that is, the thing in its natural determination), but is instead a form of socio-human labour or the form-creating activity of social man embodied in the material of nature—this fact contained the solution to the riddle of 'ideality'. An entirely rational, factual solution—a materialist interpretation of all the mystical-mysterious determinations of the value-form as the ideal form. Precisely the understanding of the 'value-form in general' as a 'purely ideal form' gave K. Marx the possibility, for the first time in the history of political economy, to distinguish with confidence material forms of relations between people—as relations that bind them in the process of producing their material life, which are entirely independent of their conscious intentions (of their will and consciousness) – from the ideal expression of these relations in forms of their conscious, purposeful will, that is to say, in the form of their stable ideal formations, which Marx called 'objective forms of thought.' (Ilyenkov 2014, 64)

For Ilyenkov, the understanding is that Ideals are social human notions of a special category; a category which is supplemented with operational notions in a specific historical period. Here, Marx discusses the fundamental difference of value and its dialectical complements, use-value and exchange value. In the exchange of use-values we enter the discussion of dimensions, stable measures that enable comparison in barter and trade. For a deeper understanding of Marx's materialist dialectic, the value discussion is a standard example. How do we produce value in social terms and how does value express progress in human well-being and emancipation?

Value must be created. The analysis of Marx in *Capital* shows how pertinent Marx concludes that labour power is the only commodity that can create an increase of value (surplus-product), as trade might increase prices but not value. Again, we stay close to Ilyenkov:

> The inner nature of value is theoretically expressed only in the concept of value. The distinctive feature of the Marxian concept of value is that it is revealed through identity of mutually exclusive theoretical definitions. (use-value and exchange-value, JK). (Ilyenkov [1960] 2017, 258)
>
> Value, the inner essence of each commodity, is only manifested or revealed (reflected) in the relation to another commodity. This value, this objective economic reality, is not created or born in the exchange but only manifested in it, being one-sidedly reflected in the other commodity as in a mirror that is only capable of reflecting that side that is turned to it. In the same way the real mirror reflects only man's face, although he also has the back of the head. Being reflected outside, value appears in the form of external opposites that do not coincide in one commodity—as exchange—and use-values, the relative and the equivalent forms of expression. (Ibid., 259)

In the commodity mode of production, all those measures between goods become standardised and in the exchange (prices in trade) elevated to the universal notion of money. In itself this is again a pure social construct to suggest universal 'neutral' expression of what ultimately is the result of human labour (or the price of land fit for agriculture or mining).

> Because all commodities, as values, are objectified human labour, and therefore in themselves commensurable, their values can be communally measured in one and the same specific commodity and this commodity can be converted into the common measure of their values that is into money. Money as a measure of value is the necessary form of appearance of the measure of value which is immanent in commodities, namely labour-time. (Ibid., 189)

Important here is that on the one hand Marx is clear about the historicity of the productivity of labour and its effect on the price of commodities, on the other hand Marx takes the standard notion of duration, the hour, as measure.

Although forms of money such as simple tokens that lubricate exchange of goods and trade are very old, it does not mean that the concept of money (expressed in a currency) as universal equivalent is prior to the notion of universal exchange in a full-fledged commodity production-based society. It is not the plurality of possible representatives (tokens, shells, coins, etc.) of quantities of goods on the market of use-values, but the transcendence to a universal and generally accepted abstract notion of money, which conflates use and exchange value. This is the central discussion in Marx's *Critique of Political Economy*.

> Direct commodity exchange, as a phenomenon in considering which one may obtain a universal definition of value, as a phenomenon in which value is represented in pure form, is realised before the appearance of money, surplus-value and other particular well-developed forms of value. That means, apart from other things, that the form of economic relations which becomes genuinely general under capitalism, was realised before that as quite a particular phenomenon or even as an accidental individual phenomenon. (Ibid., 83)

In other words, the *universality* of value finds its actualisation in well-defined situations, and expressed in dialectical opposites such as use-value and exchange value.

Part two

5) Time

Below, I elaborate on the notion of the Ideal as elucidated by Ilyenkov in the field of physics; a field in which many concepts serve as expressions of inner and deeper phenomena and relations. Physics, like chemistry and biology, is the field that deals with understanding the real material world. Problems in physics are mapped onto mathematical models, hence physics is sometimes seen as that part of applied mathematics that demands 'boundary conditions' or 'reasonable simplifications' in order to restrain the full possibilities mathematics provides. Below, I stick to the notion that physics deals with material reality, which does not mean that this reality is always understood as our models and theories suggest. Physics is a to and fro between ever more ingenious experiments and ever more ingenious theories. At the end of the day (to paraphrase William James) the cash value is our ever deeper understanding of real nature, which means theories must always be able to explain reality in well-defined terms, as well as suggest next steps. In that way physics is an open-ended field.

Boldly Ilyenkov states: "All the philosophical and logical principles applied by Marx to the study of the system of capitalist relations as a historically established system of interaction, are applicable to any natural or social science" (Ilyenkov [1960] 2017, 124).

Hence, let's try it.

Introducing the Ideal into a field known for its claim of rigorous thinking is not easy as it demands a fair understanding of physics as well as its historical pathway, and the fundamental difference between physics and its tool: axiomatic mathematics. Therefore, some comments on physics are necessary because many popular books avoid the underlying problems, and often equate physical phenomena with their mathematical models and descriptions. Obviously, readers who only want the gist of the reasoning are kindly invited to skip sentences if they look too technical.

Phenomena, which are articulated and used in the development of the sciences, a human activity *par excellence*, are always prone to re-evaluation and reformulation. Our body experiences our environment as well as its own 'operations': movements, metabolism, and thinking. Slowly our experiences are socialised, refined and mental models are invented to grasp them; in that way metaphors, models and theories take the place of our primary physical experiences. The model and its related language supplant these primary physical experiences and can become a source of reification. In this socialisation process communication between humans and consequently collective investigations and labour become possible. It is one of the tenets of historical materialism to analyse this process of increasing knowledge and understanding in its socio-historical contingency.

This historicity means that our metaphors, models, and theories are always changing to ever wider (or more refined) and interconnected 'pictures' of the world of which we are part.

In all these endeavours of human ingenuity to create novel models and theories, we are confronted with the issue of what is a representation of a physical phenomenon (e.g., the blueness of the sky) and what is only a measure of this phenomenon? More often than not such a measure is equated with the phenomenon itself. The experience of fever is expressed as: "this morning I had 40 degrees." [37]

I argue that time, a notion to measure change, is, certainly in colloquial speech, wrongly seen as a real-life thing, such as in expressions like: the

37. For the Anglo-Saxon reader this is 104.

beginning of time, the arrow of time, or the amount of time. I consider a measure (of e.g., time or change) as a mapping to an Ideal (change in our case), an object that either physically exist and is countable or is simply countable. In the case of countability we also introduce units (like hours or years).

Following Marx and Ilyenkov, I argue that the notion of the Ideal as discussed above can be used in physics and can be made operational by expressing it in useful abstract models. As Ilyenkov says:

> The rational kernel and at the same time the mystifying feature of the schema described here are most easily considered by analogy (although it is more than a simple analogy) with the metamorphoses that political economy brings out when analysing commodity-money circulation. Just as accumulated labour concentrated in machines, in the instruments and products of labour, functions in the form of *capital*, in the form of 'self-expanding value', for which the individual capitalist functions as 'executor', so too scientific knowledge, i.e., *the accumulated mental labour* of society functions in the form of Science, i.e. the same sort of impersonal and featureless anonymous force. The individual professional theoretician functions *as the representative* of the self-developing power of knowledge. His social function boils down to being the individual embodiment of the *universal* spiritual wealth accumulated over centuries and millennia of mental labour. He functions as the animated tool of a process that is completed independently of his individual consciousness and his individual will, the process of the increase of knowledge. He does not think here as *such*—Knowledge, which has taken root in his head during his education, 'thinks'. He does not control the concept; rather the Concept controls him, determining both the direction of his research and the modes and forms of his activity. (Ilyenkov 2008, 242).

I want to illustrate my claim that the Ideal can be used in physics with the universal notion of 'change.' To be precise, I consider 'change' to be an Ideal. Change means that an object never remains the same; all is in a permanent state of process, normally measured with the notion of time. How do we make change operational and what dimensions (features of change) are helpful, in what situation? Human thinking is prone to dealing with change via comparison to situations in which 'rest' plays a central role. This can be exemplified by sayings such as: 'wait a moment' or 'let us first be clear where we stand now.' Contrary to nouns (fixed objects), categorisation and stratification of verbs (indicating change) is much more difficult.[38] It seems that humans cannot get an 'overview' of change.[39] The whole field of the calculus is based on the problem of how to define e.g., the velocity of an object at a precise point.[40]

On the subject of understanding what time 'is', whole libraries are filled with studies.[41] Apart from the question of what time is, we will argue that in most cases time as seen as a measure of change and motion has been conflated with time as a physical thing, in human communications, just like value and money. "The abstractness of the time in the abstract of space-time of physical theory is forgotten, and it is treated as if it could be equated with the temporal structure of reality itself" (Griffin 1986, 22).

In this quotation of Griffin in his introduction to his anthology about time, we already spot the conflation clearly, he uses the words "temporal structure" where he means simple succession, abstractly measured with the help of the notion of time. This quotation shows the complication because we are accustomed to using the word 'time' for completely different notions: time as an expression of physical change and time as a well-defined measure for change.

The key issue is whether we can consider time as a physical object (metaphorically Heraclitus's flowing river in which we never step twice, or Oceanos who flows as a great river around the rim of the earth), or as an auxiliary tool to measure change and motion.

In the development of physics, the notion of time is more and more constrained to enable mathematical manipulations and establish mathematical models. The emotional value of time, mainly seen as duration (a more or less stable situation) or repetitive occurrences, is like the emotional value of colour, reframed in theories of physics.

A famous quote is: "Time is defined so that motion looks simple" (Misner et al. 1973, 23). In its brevity it describes our subject perfectly. The world is in constant change and in order to grasp this we need parameters

38. There exists a whole academic field of lexical semantics dealing with nouns; their categorization (see for an overview Cruse 1986) and their mutual relations (e.g., Fellbaum 1998), but we find hardly any works dealing with verbs.
39. See for an interesting discussion on this issue David Bohm's essay: The rheomode – an experiment with language and thought (Bohm 1980, 34–60).
40. It is more or less easy to define average velocity as the time spent travelling between point A and B. However, if the distance between A and B reduces to a (mathematical) point and we talk about the now, we cannot simply divide meters by seconds.
41. A most readable illustrated introduction to the enigma Time is given by (Callender et al. 2012).

to objectify this in order to compare and communicate the findings with each other. Hence, the notion of time, as a measure of motion enters our language.

However, in this "looks simple", the notion 'motion' has already the implicit meaning of 'from here to there' and is explicitly projected onto a linear (flat), Euclidean geometry: a line. It also suggests a kind of continuity and regularity. For that reason, I make a distinction between 'change' and 'motion,' where change is defined as a *universal,* seen as something that indicates that an object is not always the same, but where we do not indicate (yet) how we measure that change in all its aspects.[42] Motion is a particular example of the broader concept of change, namely 'change in space.' Thus, motion does not describe the octopus changing its colours, whereas the concept 'change' does.

If an octopus changes its colours, obviously this happens not momentarily and only parts of its skin cells alter. If a society changes from feudalism to capitalism, calendar time differs in each situation and the duration of the process is defined by e.g., the level of commodity production. Hence, the process time (duration) from start to completion can vary considerably depending on the context as even in a full-blown capitalist society feudal remnants stay for a long period. Motion, made simple by introducing time as measure, is only one of the many forms of change, namely change projected onto space, making it a notion of 'from here to there.' Time itself, on the other hand, became a measure of change 'from then to now' or vice versa and not for changes like blushing or the changing steepness in a mountain range.[43] In those later cases we also like to have a measure of change. Hence, it is important to note already that time in physics (or fields that use the definition for time in physics) is always intrinsically coordinated time in close relation to coordinated space. Coordinated time and space are endowed with units of some kind: meter and hour, to make comparison possible.

Realize that space and time are different things. If we got a burst tyre, we can read of the location from our GPS. The location is just a point in space (mapped on the screen of your GPS), and the repair service can find you, any time. On the other hand, it does not make sense if you want to be found, to inform the garage that the tyre busts six minutes past three in

42. Note that an important issue is if an object here is the same object over there.

43. As it is not my intention to invent a new semantics, below, time is often used in the sloppy colloquial usage of standard language with no explicit reference to motion or change.

the afternoon.

Duration as measured by the difference between two readings of a clock is telling you that you have been waiting for more than two hours already and that makes sense when complaining to the garage.

Time and duration are measured by a clock, which is a mechanism that regularly ticks 'time away,' according to some agreed measure, such as the precise electric crystal oscillations of your quartz watch.[44] Again, reading and comparing time (the now) on a watch needs an agreed starting point (e.g., midnight); naming duration is the difference between readings.

6) Towards time as an absolute measure of motion

The historian Wilcox elaborates on historical time, that is to say, the consecutive ordering of stories, which had different characteristics before the Newtonian revolution. Historical narratives often remain within the frame of the story at issue.

> For historians before Newton the time frame did not include a group of events; a group of events containing a time frame. This perspective led them to use a variety of relative dating systems, none of which had an absolute temporal significance apart from the group of events that gave it its meaning. (Wilcox 1987, 9)

Apart from the natural philosophy of time across human civilisation, in daily practice time is 'measured' (chronology) in a cyclic fashion based on day and night, the lunar phases, or the zodiac. The cyclic experience in biology, agriculture, the weather, etc. is projected onto calendars with plenitudes invented in many cultures (Dershowitz and Reingold 1997).

As argued above, a key issue is if we can consider time as a physical object (though not a substance) as Newton thought (metaphorically Heraclitus's river), a God given entity; a regulator above nature. Or is time an auxiliary tool to measure change and motion, which can be assigned to physical phenomena, such as Einstein is doing by defining time as what the clock reads (see below).

For theories of physics, time is first of all a measure for duration. And in a Newtonian sense it is part of an absolute receptacle (scaffolding) in which we measure spatial objects (particles) that change from place A to place B 'over time,' as on a stage.

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44. We e.g., talk of calendar time if the measure is e.g., the periodicity of the rotation of the earth around the sun, the rotation of the moon around the earth, or the daily rotation of the earth itself. Note that any repetitive phenomenon can serve as basis for clock readings.

Physics became fully mathematized over the past centuries, that is to say physical experiments are mapped onto formal mathematical models that describe our experimental observations as best we can.

Only after the Newtonian revolution in which time (and space) acquired a geometrical meaning, could it be endowed with parameters and units on a coordinate system (based on Descartes's invention of analytical geometry). Historical continuity was expressed in equidistant time intervals on an absolute scale, e.g., in the cyclic motion of the zodiac. Only after Newton, geometrical boundary posts such as the perceived birth date of Mr. Jesus could introduce the BC/AD notation and could suggest a linear development in which some periods took 'longer' (more ticks) and others 'shorter' (less ticks), all with reference to the counting of a regularly ticking clock. (Wilcox 1987, chap. 2) Note that in such a linear 'picture,' time is taken as a continuous flow, whilst the processes to be measured, lose their role as measure for a defined period (e.g., the government of Boris I).

The most important experimental finding is that in the real world an object, or collection of objects, which moves rectilinearly with constant velocity, remains the same, in the sense that we cannot experience the difference between 'inertial motion' and rest (stasis). In other words, we witness that there is no difference between rectilinear uniform motion and absolute rest.[45] Here we must point to the difference between a reference frame (a train wagon, the earth) and a coordinate system, which is a mathematical object designed to make sense of e.g., time and space. The coordinate system is like shrink foil, an envelope around a physical situation that makes measurements possible.

The above phenomenon, that we cannot distinguish difference between uniform rectilinear motion and rest, is the basis of what we call an inertial system. Obviously, we are confronted with the choice of ether (a) first declaring the notion of an inertial system and then discovering that in such systems defined by a rectilinear constant velocity the mechanical laws of physics hold the same, or (b) from concrete experimentation we arrive at model/mathematical systems as abstractions and subsequently consider them as fundamental notions underlying physics research and name them

45. Realize that Newton's first law "That if a body is at rest or moving at a constant speed in a straight line, it will remain at rest or keep moving in a straight line at constant speed unless it is acted upon by a force.", in fact says that if we follow a 'free' body, the trajectory it follows is what we call straight (a line in two dimensions and a great circle if the body moves on the surface of a sphere). The geometrical term straight is defined by the geometry we employ.

'inertial.'

The story starts with Galileo Galilei (1564–1642), the initiator of classical mechanics. He used the example of people sitting in the hull of a windowless ship, unable to see the sea outside. When the ship has a constant rectilinear velocity, they drink a cup of tea. Pouring tea into their cups is as easy as pouring it, without spilling, in a stationary situation in the harbour. The people drinking tea will not notice if they are moving or not. We name such a smooth moving system, where we cannot decide if we are at rest or on the move, an inertial system or frame. Einstein uses the example of a train that travels with constant velocity. Everybody knows the experience of sitting in a train waiting to travel, that if a train on the opposite platform starts moving, it looks like you are moving yourself in the opposite direction. The only check is if we feel pressure from the seat, in that case it is us who accelerate and move and are no longer in the same inertial frame as the adjacent train.

A modern example is if watching a basketball game, we see that the ball bounces straight down on the floor, following the running basketball player, ball and player stay together and form an inertial system.

The 'existence' of inertial systems means that if we in our train (where we are at rest) measure what happens in the other train (where they are at rest) we need coordinate transformations as we move with a relative velocity to each other. And we see them moving, whilst they see us moving. In Newtonian mechanics these are the so-called Galileo-transformations; transformations that make use of the suggestion that the velocity of light is infinite, as well as those physical interactions are instantaneous.

Isaac Newton (1643–1727) the founder of classical mechanics struggled with the problem of defining and measuring motion and time and concluded that we have to postulate an *absolute* time and space frame as a reference for our measurements.[46] Newton founded classical mechanics on the view that *space* is distinct from matter and that *time* passes uniformly without any relation to matter. For this reason, he spoke of *absolute space* and *absolute time*, so as to distinguish these entities from the various ways

46. Newton's approach is, following experimental facts, to postulate his first law stating that: a rectilinear constant motion exists in relation to his postulate that an absolute space exists. This stipulation means that such a motion will continue forever provided that no force pushes it away from its trajectory. This last consideration is the essence of Newton's second law. A consequence is that we can define infinite reference systems in which motion is also uniformly rectilinear. The class of such systems are called inertial systems. The caveat is then which of these systems is in rest in relation to absolute space?

in which we measure them (which he called *relative spaces* and *relative times*) (Newton [1689] 2011).[47] This is the basis of Newton's mechanics, in which the motion of things (bodies in physics jargon) could be described in unambiguous mathematical formulae, allowing predictions of what will happen next.[48] Important here is that as Newton poses absolute space and time, it is possible to discuss the question: is the position of a thing here identical to the position there?

Time and space are endowed with units of some kind. The notion 'motion' which has the implicit meaning of: *from here to there*, is projected onto a linear Euclidean geometry (a line, or a surface).

Newtonian absolute space and absolute time can be mathematically understood by a three and one dimensional Euclidean (mathematical) space (three for physical space and one for time) stitched together in a certain way. The use of Euclidean space naturally allows us to introduce orthogonal coordinates to coordinate space with an absolute time. These coordinates can be linked to measurements made by physical systems such a measuring rods and clocks (clocks which model cyclic and repeated motion of physical systems).[49]

This allows us to define the mathematical notion of a coordinate as a projection on a physical object such as a straightedge (a rod in the jargon), which becomes a ruler when endowed with equidistant signs depending on a convention of units, e.g., centimetres or inches.

In Newtonian theory, 'time' can be seen as a physical entity, as well as a measure.

In Newton's own words:

> Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration: relative, apparent, and common time, is some sensible and external

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47. For discussion see Rynasiewicz 2014.

48. Note that this absolute space and time does not imply that we have a concrete material scaffolding. "For Newton, the existence of absolute space and time has to do with providing a structure, necessarily distinct from ponderable bodies and their relations, with respect to which it is possible systematically to define the basic *kinematical* properties of the motion of such bodies. For Newton, space and time are not substances in the sense that they can act, but are real things nonetheless" (Brown 2005,142).

49. Note that this 'cubic,' Cartesian, picture of geometry is equivalent to e.g., polar coordinates. The essence is that internal characteristics (e.g., the metric) are invariant (stable). Beware of the fact that the Pythagoreans only used geometrical forms. It was René Descartes (1596–1650), who merged geometry and algebra and introduced coordinate systems, enabling algebraic calculations of figures.

> (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year. (Newton [1689] 2011)

Then, be it a continuation of continuous linear motion (inertial motion) or by the experience of a force (gravity, collision, magnetism, etc.), place and time change to new values. A key discussion since the famous Leibniz-Clarke (the stand-in for Newton) correspondence (Alexander 1998) is: do we need an infinitely bi-directional stretched-out measure of time and space skeleton (framework) in which motion happens, or are we only dealing with a *relative* measure of motion, the position Leibniz (1646–1716) defends.

Based on Newton, Kant hits a bottom line by declaring space and time as indispensable *a priori*; we cannot do without them. An event is at a certain place at a certain time.[50] Newton's immensely important mechanical edifice became the standard model of mechanical thinking for centuries (Dijksterhuis 1986). It is this, most productive, thinking that we have to overcome, as the world is more than a mechanical contraption.

In Newtonian dynamics, the role of forces in the 'change' of the motion of objects, don't influence the status of the coordinates. The framework does not guide the motion of bodies. Forces, inducers of change, operate within the postulated absolute Euclidean geometric framework but there is no reciprocity, the framework itself does not change due to the physical activity[51], contrary to the situation in General Relativity Theory which we discuss below.

This consideration is part of the millennia old discussion of the question is geometry physical or only a tool to project our observations onto an operational framework on which we can define structure and mathematical operations? In a more poetic way we can say that, for Newton absolute space and time are the stage of the play between physical objects, where the stage remains always the same.

As discussed above, for Newton space and time constitute a real framework, though not a substance, hence physical. Albert Einstein (1879–1955), the creator of relativity theory, 'materialises' the notions of time and space and stipulates:

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50. For the development of Kant's thinking from Leibnizian to Newtonian see Friedman, 1992.
51. Be aware that coordinates are human contraptions to make the geometrical framework mathematically operational.

> The 'time' of an event is that which is given simultaneously with the event by a stationary clock located at the place of the event, this clock being synchronous, and indeed synchronous for all time determinations, with a specified stationary clock. (Einstein [1905] 1952, 40).

Einstein also stipulates that space can be measured by a physical measuring rod. The question is now if we can compare clock readings of events (the term in physics for: something that is happening) which are a distance apart, say the burning of a candle. This central issue is called relativity of simultaneity; can we compare events, and in the case of reading a clock, can we compare the event with what the clock says at place A with what a similar clock says at place B? In order to compare time readings in different places and thus by different clocks. Einstein's fundamental insight was that absolute time was in contradiction with the finite and universal speed of light. Thus, he had to deal with the question of simultaneity at a distance. His analysis leads to the relativity of simultaneity, i.e. that whether two events are simultaneous depends on the inertial system in which space and time are measured.

In other words: is time as the measure of motion the same at two places? Einstein investigated the problem of synchronisation. He gave an operational instruction on how to synchronize two clocks a distance apart; if they indicate the same time then events taking place near each of the clocks are simultaneous.[52]

A clock reading is a local physical affair and clocks must be synchronised to enable comparison between things here and there. Local here means in the close vicinity of the observer, the person that reads the clock. Einstein designs his so-called 'light clock' by considering the reflection of a light ray sent by thing A reflected by thing B and received again by A. This is under the (experimentally proven) assumption of the constancy of the velocity of light in both directions.

More technically one can say that Einstein replaced Newton's absolute time by basing time on simultaneity. Firstly, by defining 'time' as what a nearby clock shows, and secondly by then spreading this time to the rest of the inertial system through his convention for distant simultaneity. Duration can be based on the postulate that the speed of light is a constant c, thus we can define duration such that this is the case. This is similar to

52. For an overview of this notion of 'happening at the same moment' see the work of the amazing encyclopedist Max Jammer (2006).

how in classical mechanics we define time and duration, by taking the existence of freely moving bodies moving according to Newton's first law, as a given. By defining Einstein-time through clock readings, Einstein founded his time on the physical principles that govern clock behaviour; the simplest or ideal clock is the so-called light clock which again makes use of the light postulate. Any other clock works as well, which underwrites the correctness of special relativity in its area of applicability; just as basing Newton's time, defined on the basis of Newton's first law, on the regular swing of a pendulum testifies to the correctness of classical mechanics in its area of applicability.

The fixity of the velocity of light, more formally, that the speed of light is a universal constant c in each inertial system, is the basis of Einstein's special relativity theory. Hermann Minkowski (1864–1909) dropped the distinction between space and time and merged the notions in space-time, which now becomes an absolute entity in so-called Minkowski spacetime; see further below.

7) Time versus space

In Marxism, space and time are considered as forms of matter, a notion Engels and Lenin forcefully stressed. Often quoted is also that the natural world is defined by 'matter in motion;' like walking is seen as a form of being human (see discussion above), motion is seen as intrinsic to matter. This statement is certainly a big step forwards in human thinking away from the long discussion on the Cartesian and religious ideas that mind and matter are worlds apart. Although many people understand and often use this 'wise crack' *matter in motion*, there is a next level of investigation in order to remain in tune with the latest levels of scientific knowledge. Given our understanding of matter (see the example of the notion 'atom' above) and the notion of motion discussed here, as changing 'over time,' standard sayings like *matter in motion* demand further analysis.[53]

Space and time, though intertwined in our experiences and formalised in (e.g., Newtonian) physics, are very different kinds of abstractions. Space, considered as a bidirectional, three-dimensional (lengths, height, width) model for objects we experience by vision (two dimensional in the plain of the retina, but three dimensional if we see depth by binocular vision), touch (picking up a stone to throw) or by bodily motion (dancing,

53. This holds for all one-liners and simplified laws such as "The unity of oppositions" or the "Transition from quantity to quality." For the last case see Kircz and van der Linden 2022.

walking, nodding), has a long history of interpretation. (Whitrow 1955, 13–31; Jammer 1993; Schemmel 2016)

Time, on the other hand has no direct sensory organ but is experienced in memory, an organ we don't understand yet. Though space and time are closely related, as we mentioned above, time is a measure for the one-way (uni-directional) duration of a change of a body from place A to place B in space, called motion.

Time is of a totally different nature than space. Not only is time defined as one dimensional, always forward, but despite science-fiction pipe dreams we can never go back. I consider it a fallacy if it is argued that e.g., ideal billiard balls show symmetry in time, because if we run a film of a collision of balls backwards, we cannot distinguish the presentations. This observation only holds if we define time in this case as a pure—local—mathematical measure, void of the environment and context, in which the parameter 'time' is on equal footing with the parameter 'length.' In the totality of nature, even repetitive things (e.g., the pendulum clock) are always changing compared to other pertinent objects in their environment or within their own organs (e.g., the weights that enable the pendulum ticking), which is the very reason we can use them as measuring devices, known under the name of clocks.

An important result of the mix-up between Newtonian physical time and its mathematical representation is the question of the so-called 'arrow of time.' Why is the time-axis unidirectional? In real life we don't see an old person getting younger and retire back into the mother's womb. This impossible happening can be explained as a consequence of the thermodynamical observation that heat flows from hot to cold and never the other way around, provided we don't apply work (which compensates or reverses the flow). Time is then seen as a measure of the flow of heat (a form of energy) that has the tendency to spread out.

If we abstract and picture the world in a mathematical space and follow Ludwig Boltzmann (1844–1906), the founder of statistical mechanics, we reach the conclusion that the increase in disorder (a form of change) is an increase in time. Boltzmann theory is not free from 'reasonable' but pertinent assumptions, such as, in the case of a gas, that the number of particles at issue is very large but not infinite and confined by a rigid wall, that the probability that any particular particle initially moves in a particular direction is the same as the probability that it moves in any other direction, etc. (Torretti 2007, 743.) That way, it can be shown that the probability of returning from a disordered state to an ordered state is extremely small.

Hence, following the process of interacting particles with the parameter time, we see an 'arrow.' This shows that here the whole problem of a 'time arrow' due to the introduction of a most effective and reasonable reduction of real life into a theoretical model including the notion of the measure 'time.'

This is totally different from the everywhere metaphorical use of the term space as an expression of plurality or plenum (e.g., The Eurasian Economic Space).[54] Physical, as seen as material, space is also distinct from mathematical space, which is defined by axioms and can have as many dimensions, up to infinity, as is deemed necessary for tackling the problem under review. A prime example of space is so-called *phase space* in which all states (degrees of freedom) of all particles of a collection are represented by a point in this extremely large mathematical 'phase space.' Many theories make use of so-called vector spaces (a kind of multi-dimensional geometry), well-defined mathematical objects onto which physical entities are projected for arithmetical reasons, with the aim of easing the analyses and the goal of projecting back the results onto physical reality to be checked by experiments. Here the infinite dimensional 'Hilbert' space of quantum mechanics is a well-known example.

A notorious example of taking mathematical space as a true representation of physical space is the popular (11 or more dimensional) String Theory, a heavily researched and equally heavily advertised subject with still completely uncertain physical results. The supplementary spatial dimensions are considered to be rolled-up like a carpet (hence then taken as physical) and become invisible in ordinary physical space.[55] It is an example of how we can catapult physical phenomena up to multi-dimensional mathematical space in which the dimensions can be freely defined. However, at the end of the day, the results have to be projected back onto physical space fit for human measurements.

The above digression into the notion of space shows that abstractions of physical phenomena onto beautiful mathematical models can have a runaway character if the models don't provide us with real life physical effects and deepen our understanding of fundamental notions such as *space* as we know and experience it.

We will not further explore the discussion of 'space' in this paper. It is important to inform the reader that physical space as we know it, that is

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54. For an extensive lexicon on space philosophies see Günzel and Kümmerling 2012.
55. See for a 'popular' defence the works of Greene 1999, 2004 and a harsh critique Smolin 2007.

to say as we experience it, is three dimensional, within the theories of physics we master, as Ehrenfest already showed in 1917 (Ehrenfest [1917] 1959, 200–208). More dimensions will lead to unstable situations, e.g., in the motions of the planets travelling around the sun.

8) More on time

Below, we will dig deeper into the problem of time as measure, as we have to get a clearer understanding of the difference between physical and mathematical time.[56]

Things become more focused just before the 'industrial revolution,' the ongoing commodification of all things and relations, with the emergence of international trade and the need for standardisation of the chaos of local measures for e.g., weight, temperature, lengths, etc. In order to exchange goods, military information and mutual understanding of 'amounts,' standardisation efforts began. Maurice Crosland even suggests that the very first international scientific conference ever was just on this issue (Crosland 1969).[57]

Harking back to the purpose of this exercise in expanding the notion of the Ideal into physics, the similarity between time and money as universal measures, suitable for exchanging knowledge and commodities, becomes obvious. Both represent something 'deeper' that allows abstraction into a societally accepted standardized measure. They share the following features: a) They are represented in a linear fashion, b) they serve as measures of communication, comparison, and trade, c) they allow for simple arithmetic, we can add and subtract amounts of money and of time, d) we can store them, in the case of money (represented e.g., in coins or banknotes) in the form of a shoe box or a bank account. In this case it is completely unclear if after a long period the stored amount of money still represents the same amount of goods in the market: inflation. In the case of time, considered as an abstract measure of change, representations of incidents are stored in memories. These memories can be human material memories in the brain, or tattoos on the skin, or artefacts in the form of writings,

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56. For a comprehensive historical overview see e.g., the classic, Whitrow 1990. For a post-Stalinist dialectical approach see Akhundov [1982] 1986. For deep discussions in physics see e.g., Griffin 1986, and Landsberg 1985.

57. For a study of the standardization of measures of trade see Kula 1986. For the role of synchronizing railway timetables see Galison 2004. For the cartography of the world and the introduction of a global location for land surveying systems in the French case see Alder 2002.

pictures, or totems. Note again that humans are not able to grasp change as such, we need comparison. The fading tattoo on an old skin is a proof of change, because we remember the original colours. Also, here after 'some time' we are not sure if the original representations are still intelligible the way they once were; dementing as a kind of inflation.

And by becoming generally accepted measures for exchange, money and time lose their underlying material reality: value in the case of money, and change in the case of time. Interestingly, the materialisation of change in human memories is less abstract than the materialisation of money in banknotes.

9) Special Relativity

The notion of time was redefined at the beginning of the twentieth century.[58] We observe, to a very high precision, that light has always the same velocity (in empty space) in all directions. This became the fundamental starting point of (special) relativity the theory that merges mechanics and electromagnetism. We can measure a round-trip of light to e.g., a mirror on the moon in terms of ticks of a local, earthly, clock and given the constant finite velocity of light, we calculate the distance.[59]

It was Albert Einstein who promoted the finite and invariant velocity of light to a principle. A physical consequence thereof is that this velocity is also the maximum velocity for all types of physical interactions, in particular electromagnetic waves. In his Special Relativity theory Einstein builds on two postulates:

> [. . .] the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good. We will raise this conjecture (the purport of which hereafter be called "Principle of Relativity") to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely that light is always propagating in empty space with a definite velocity c which is independent of the state of motion of the emitting body. (Einstein [1905] 1952, 37–38)

Rindler explicates this as follows:

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58. For a nice book on the relationship between the 19c needs for standardization of e.g., train timetables and the developments of Einstein's thinking see Galison 2004.

59. Given that the velocity of light is extremely precisely measured as well as that its speed is independent of the spatial orientation, was the death knell for 19 century ideas that electromagnetic waves demanded a substance to travel: a luminiferous (light bearing) ether, like sounds in a medium, e.g., air. See for a classic history of ether theories, Born 1965, for a recent study Brown 2005. Of a more philosophical nature, and close to my thinking, see Bohm 1996, appendix.

- The principle of relativity: "The laws of physics are identical in all inertial frames, or equivalently, the outcome of any physical experiment is the same when performed with identical initial conditions relative to any inertial frame."[60] This is an extension of Galileo's example of people drinking tea in the hull of a vessel (see above).
- "Light signals in vacuum are propagating rectilinearly, with the same speed c at all times, in all directions, in all inertial frames" (Rindler 1991, 7–8).

The crucial kernel now becomes that when dealing with physical invariants, things that remain the same independently of how we measure them, we can switch between various descriptive coordinate systems at will, meaning that, independently of the coordinate system, we can stipulate that some entities simply hold. Example: in two-dimensional flat space (a sheet of paper), the Pythagorean Theorem rules that the hypotenuse squared equals the sum of the squared length of the two opposing sides in a right-angled triangle (the well-known expression $c^2= a^2 +b^2$, where a, b, and c are lengths; distances between points). No algebra or numeracy is needed, as squares are only the algebraic expression of, indeed, squares (rectangles with four equal sides). This fixed value c^2 is called an interval and is independent of the coordinate system we use.

In special relativity space and time, contrary to Newtonian mechanics, are now firmly coupled, due to the speed of light being constant, in an inertial system. Time and space now only exist together as a novel 'animal' named spacetime. It is now stipulated that in four dimensional spacetime, next to the three Cartesian space coordinates, we also have Einstein's time coordinate, our interval becomes $ds^2=dx^2+dy^2+dz^2-(cdt)^2$, we call this Lorentzian coordinates. Here ds^2 is a called the interval, while dx, dy, dz are the spatial separations between events, here c is the constant c: the velocity of light, and dt is the time separation between events. If we multiply the time separation (in seconds) and the constant velocity of light (say metres per second) we reach four coordinate axes, all with the dimension of length. That way, we can build a four-dimensional frame with three distance (length) axes and one modified time axis also with the dimension length. This geometric model keeps the interval invariant, that is to say: independent of the choice of coordinates (in the formulae, *space separation-*

60. Note that this is a generalization of what was already stipulated by Galileo and Newton. Again, we define an inertial frame with a scaffolding of coordinates that moves linearly with a constant velocity. For the traveler in the train with shutters down the experienced velocity is zero, as we can only "feel" change of velocity called acceleration.

squared minus *time separation times constant c* -squared). This model is known under the name Minkowski (formally, a pseudo-Euclidian) space after its originator, who famously claimed that the very notions of time and space as separate entities can be abolished.[61]

Many famous results follow from the constancy (invariance) of the speed of light such as length contraction (shrinking of rods) and time dilation (slowing down of clocks), showing that different observers in different moving inertial frames measure different values in experiments, proving precisely that the relativity principle holds. Due to the integration of a finite velocity of light into spacetime, the Galileo transformations don't work anymore if we compare situations, and have now to be replaced by the so-called Lorentz transformations between two inertial systems, named after Hendrik Lorentz (1853–1928), in which the ratio between the velocity of the body and the fixed velocity of light is essential.

A famous example is that we measure the arrival of cosmic particles called muons on the earth's surface. In local earth surface experiments, the lifetime of these objects measured by our local clocks is extremely short. Nevertheless, the muons need a much longer time (measured with our local clocks) to reach the earth's surface from outer space. In other words, the 'clock' of the cosmic muon runs slower: 'life' for the cosmic high-speed muon differs seemingly from slow-moving muons on earth. We are dealing with two different inertial systems. In this observation we measure what we call proper time, the time measured by a clock in the local frame (environment) of the body at issue.

For the present discussion what is important is that spacetime measures in special relativity are like Newtonian space and time measures, abstract measures that are detached from the physical dynamics of the underlying physical process.[62] So, time is now tied to the velocity of light, one

61. For a good introduction to SR see Taylor and Wheeler 1992.

62. For the technically versed reader I quote:

> What if we were now to ask, how do we know whether Euclidean space—something we could never directly observe—is really the cause of these measurement results? Or how do we know that a measured length represents length relative to Euclidean space? Evidently such questions miss the point. Spatial measurement has been defined by coordination with a basic physical process (motion of rigid bodies). To claim that space is Euclidean *only means* that measurements agree with the Euclidean metric; Euclidean geometry, if true, can't *causally explain* those measurements, because it only expresses the constraints to which those measurements will conform. This clearly does not imply that the content of spatial geometry somehow reduces to measurement operations. For Euclidean geometry systematizes those measurements and exhibits them as aspects of a formal

of the building blocks of special relativity, which is postulated as constant. The unit second is defined as a fixed amount of atomic 'clicks.'[63]

In that sense the velocity of light plays the role gold had in the period of the Gold Standard for money; a monetary system in which the standard economic unit of account is based on a fixed quantity of gold. The velocity of light as a relation between space and time is now a fixed relation.

And once again, change is reduced to time as a measure of motion in fixed four-dimensional space. The question remains if and how we are able to understand all forms of change in terms of what we call time, which is now only a measure. Obviously, we can try to project all types of change onto a 'time axis,' but we are then confronted with the question of why some processes take more or less time, in what situation. This might be compared with the discussion on the difference of money and price, where money is the fixed measure, linked to a fixed quantity of gold while price is determined by the social context of exchange on the market.

10) GRT

In particular, after the introduction of the Einsteinian Gravitation Theory, better known under the name General Relativity Theory (GRT), a thorough reconsideration of time as seen as "what makes motion simple" is needed, and consequently the role of time as a stable measure. As mentioned above, coordinate transformations don't change the (invariant) object under discussion. These attributes, coordinates and transformations, 'objectify', abstractly in mathematical sign language, the already objective real object. Coordinates are tools to project the characteristics of an object onto a well-defined framework, fit for calculations and communication between people in different situations. The equivalence of coordinate systems is called manifest covariance. This allows the scientist to choose a

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structure, something more abstract and more exact than the appearances could express by themselves. To claim that that formal structure is *really* the structure of actual space is not to posit an underlying cause of the appearances. It is only to claim that, *modulo* the initial coordination, the appearances conform to the laws of that structure. This claim is no less a form of realism than the supposed causal postulate. But it is a form of realism that captures much more clearly the relationship between geometry and experience. (Disalle 1995, 324).

63. See for the international standardisation organisation: https://www.bipm.org/en/home. The second, symbol "s", is the SI unit of time. It is defined by taking the fixed numerical value of the caesium frequency $\Delta\nu_{Cs}$, the unperturbed ground-state hyperfine transition frequency of the caesium-133 atom, to be 9 192 631 770 when expressed in the unit Hz, which is equal to 1/s.

local coordinate system in which the calculations are the easiest. Note that this understanding holds for all physics in flat space, because we have to make the clear distinction between physical reference frames and mathematical coordinate frames.

Einstein's goal, after the integration of electromagnetism and classical mechanics into his special theory, was to also integrate gravity. Gravity is the only (as far as we know) attractive force that rules over all types of physical phenomena; particles (stuff) as well as fields (radiation). Unfortunately, Einstein's endeavours to integrate gravity within SR failed.

GRT suggests that 'preferred' reference frames do exist and move along so-called geodesics. These are the generalised 'straight' lines we discussed above.

The physics of gravity leading to the *Einstein equations* could be moulded into a theory based on the notion that space-time is NOT Euclidean (flat) space, but must be described in Semi-Riemannian (curved) mathematical space with a smooth symmetric metric.[64] The metric is the 'geometrical object' expressing all the geometric and causal structure of spacetime, being used to define notions such as time, distance, volume, curvature, angle, and the separation of the future and the past.

Working in curved spacetime means that every point in this mathematical four-dimensional spacetime has only local coordinates and, crucially, the coordinates are in general not orthogonal (at right angles) as in Newtonian and Minkowski space.

Working in curved space-time means that the standard instruments of clock time and fixed straightedges are literally under heavy pressure. For that reason, we still have to postulate that our measuring instruments (rods and clocks) remain fixed and don't change their characteristics locally. Hence at the local level around points in curved spacetime, we postulate that the mathematical techniques used for flat Minkowski space are good enough. Also, the velocity of light is now not anymore a universal number, but globally depends on the level of curvature, that is to say the strength of the gravitational field.

According to this theory time (proper time) is the coincidence of the object itself and its clock reading. Notice that every object is itself an object that (internally) changes and the function of a clock is only to demarcate

64. There exists an enormous amount of textbooks on GRT, many with the enticing word 'introduction' in the title. For a more-or-less understandable book for the layman see Geroch 1978. For Einstein's own struggles with the subject see e.g., his autobiographical notes see Einstein 1949, 1–96.

change in equidistant amounts (clicks). In a strong gravitational field, all processes slow down to reach a standstill in a gravitational sink: a black hole. This is not 'visible' for the object (or observer) itself as its own change is in step with the changes of its own wristwatch. However, observers in other systems measure a slowing of the clock rate (time) of an object in a strong gravitational field.[65]

So, to hark back, we can say that the Gold Standard for the velocity of light is under review, as gravity influences the velocity of light.

The key question is then: how can we compare change between different reference frames? In Newtonian mechanics the speed of light was infinite and we could use the Galileo transformations to compare reference systems that move relative to each other (the trains in the station), with special relativity we could complicate these transformations due to the constancy of the speed of light. In gravitation theory, the velocity of light is influenced by local gravitational fields. The velocity of light stops to have a global physical meaning, as it had in flat space. It is not the subject of this paper, but the most remarkable conclusion is that due to gravity, the velocity of light is now firmly coupled to a physical phenomenon (gravity), which poses the tantalizing question of whether light after being abstracted as a source for a mathematical measure (time), can be redefined as a physical phenomenon again. [66]

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65. Although this might sound strange, most people make daily use of this effect in their GPS devices for locating him/her-self. In the GPS system, time dilation (slowing down of the clock, see example of the Muon) due to the satellite speed of about 4km/sec, is not that big. But the gravitational effect, because the satellite is high in the sky, and therefore the satellite clock runs faster than on earth, is larger. A very refined calculation system coupled to the most precise 'atomic' clocks ultimately gives the readings in your devise screen. An amazing feat and triumph of technology (Ashby 2002).

66. A complication is the highly abstract mathematics needed to describe these effects. Einstein started working in so-called tensor algebra (an extension of vector algebra: a vector can be seen as a geometrical object with a value and a direction, such as a velocity, a tensor is an extension to a multilinear object that described multiple relations). Driven by works on gravitational theories and curved space, it became compulsory to start over with just swarms (sets) of points as basic ingredients. Endowing these collections of (mathematical) points with structure, so-called manifold theory was designed, and in the case of gravity even differential manifold theory, as we need the calculus to grasp change, where the formal parameter "t" serves as measure for change. Abstractions don't stop here. Products of manifolds, with the prosaic name fiber-bundles are presently the playground for philosophers and theoreticians of physics to try to find a solution to the outstanding issue of how to merge quantum mechanics (using flat space) and gravity. Apart from the aesthetics of the abstractions, ultimately measurable objects (observables) have

11) Time is money

The aim of this discussion is to suggest that the Ilyenkovian notion of the Ideal can be use more widely than just in economic or pedagogical theory.

The Ideal is a social (but material) notion of human thought in a well-defined historical context. In a way, I think that the now defunct notion of a deity belonged long ago also in this category, people perceived God as a real existing active object with which they could communicate. However, the Ideal is a notion which we can represent in various real-life human social situations. The notion of value as a result of human labour finds its expression in two opposing projections. On the one side we have use-value, the material product which is used and consumed by humans. On the other side we have the abstraction of exchange value, which is the ratio of the exchange of commodities on the market. In order to ease this exchange, a universal equivalent—christened money—is applied, a commodity in itself, which works as unifier of an immense amount of commodity transactions.

It is an historical fact that already in an early period of humankind we see tokens as a pre-curser of money. As trade (opposed to barter) as the next phase of economic activity developed, an increasing need for standardisation was felt (Chown 1994), and an equivalent emerged.

It is in the Marxist theory of economy that the notion of money in the capitalist mode of production is coupled to and seen as an offspring of the notion of value. For that reason, debates in monetary studies of who was first, money or value, does not make much sense in our discussion. It is only in the contingent situation of full commodity production (the capitalist mode of production), that money becomes a universal equivalent, and might wither away in post-capitalist societies. Interestingly, after the Bretton Woods period in which money was coupled to gold, money became a floating measure, fit for present day casino capitalism as we see in the financialization of the economy and the emergence of electronic digital 'coins' of various tastes.

In the physical sciences, we see a look-alike development. In order to grasp the change of objects, including humans, early on, recurrent phenomena were used as 'clocks,' a token for comparison, and the notion of time was born. This is also the birth of astrology, which basically say no

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to be projected on real number lines. Hence, coming back from the upper clouds of mathematics to the real world we still deal with physical measurements.

more than that we might be able to forecast on the basis of recurrent phenomena, here projected onto the clock (zodiac) of the regular motion of the heavenly bodies. Say, the time to sow or to harvest, or maybe to compare the characteristics of children born in midsummer or midwinter, when heat and foodstuff differ considerably. After a while we witnessed an inversion and human characteristics were no longer projected onto the heavenly clock, but the heavenly clock became the source of e.g., human characteristics, and human potentialities were seen as predefined, 'written in the stars,' a nice comparison with money fetishism.

The very notion of time as a universal linear measure only blossomed after the Newtonian revolution. It is remarkable that in the period when money is equated to value, time is equated to change and in particular reduced to motion *per se*. Interestingly, Isaac Newton became warden of the Royal Mint in 1696 and later master for 30 years. In this position he was a fierce prosecutor of coiners, many of whom were hanged.

We discussed that change was stripped of its complexity and in a *Procrustean* way reduced to mechanical thinking, to fit into a system of time and space. Obviously, this pragmatic reduction served us and our whole culture well and historically unprecedented wealth resulted from it. We also see that in furthering physics we encounter the observation that in some situations, in particular in strong gravitational fields, where we must integrate space and time into the new notion spacetime, the standardisation of time remains pragmatically possible, but time as a measure of change becomes ever more problematic.

A new kid on this block is our deeper knowledge of biological changes, which can hardly be measured with the stopwatch, and show very different 'time-lines,' e.g., from bacteria which survive tens of thousands of years in the soil to birds or fish that adapt fast to environmental changes (Brown and Brown 2013). This is also reflected in current discussions on the timescales of biological evolution (Buranyi 2022; Laland et al. 2014). Also, in the realm of (inner) cell structures on the nanometre scale, time is not the most obvious parameter for change. Such a statement confronts the tradition, founded by Galileo, which stipulates that all physics could ultimately be cast as motion in space and time and that all change was motion.[67] An

67. In the recent literature on consciousness we find overtures to break out of the mechanical tradition of motion, and hark back to panpsychism, which stipulates that mentality is fundamental and ubiquitous in the natural world (see https://plato.stanford.edu/entries/panpsychism/). Although these current challenges the mathematising of physics as

important novel notion is autopoiesis (from the Greek αὐτο- *(auto-)* 'self,' and ποίησις *(poiesis)* 'creation, production') which refers to a 'system' producing and maintaining itself by creating its own parts, the biological cell which houses many intricate processes is seen as the epitome of this. The various forms of time are an ongoing discussion, hence, I think the notion of change is better suited than the mechanical notion of time (see e.g., Varela 1999).

To conclude, I can only suggest that in the future we hopefully find better and more universal comparative measures that transcend the notions of money and time as measures. Nevertheless, obviously, the present notions serve us well for practical purposes and pragmatic goals. The beauty of Ilyenkov's Ideal is that it gives us an opportunity to grasp notions that have a life in our material brain, but are not yet made operational in computational forms; an important argument against the bizarre, essentially sadistic, dreams of so-called clever, and fundamentally mechanical, artificial intelligence.

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we know it, it goes against the materialist notion that thinking is an attribute of substance. This heralds a new stage in the struggle of materialism as an expression of human praxis against idealism.

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APPENDIX

In the above I did not discuss quantum mechanics. In this field of physics, the state of a physical system is described by an element (a state vector) of an infinite vector space, called a Hilbert space. This state vector can be linked to probability to measure certain values of physical quantities called observables. The space-time background of non-relativistic quantum mechanics is ordinary three-dimensional Euclidean space with time as a parameter. The space-time background of relativistic quantum mechanics, or rather quantum field theory (which is the combination of field theory, quantum mechanics and special relativity) is Minkowski space. How to merge gravity into this framework is still an open question. For an in-depth review of time in quantum mechanics see Hilgevoord 2005.

Biography

Joost Kircz has a PhD in molecular physics and studied and worked at the Universities of Amsterdam and Utrecht in The Netherlands. After his academic carrier he started working for the international science publisher North-Holland /Elsevier. Among his roles were Publisher of the renowned physics list and researcher in digital publishing. Hereafter he started his own research company in digital knowledge transfer: Kircz Research Amsterdam. From 2006-2014 he was a part time research professor/ program leader on electronic publishing at the Amsterdam University of Applied Sciences. As from his early student years, as part of the national leadership of the student movement of 1968/9, he is involved in socialist politics and activism. He was a board member of the International Institute for Research and Education (1982-2019), founded by the Marxists economist Ernest

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