On the Synergy between the Extension Theory of Technology and the Literacy Doctrine

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За синергията между теорията за технологията като екстензия и доктрината за грамотността

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Abstract: The paper presents the extension theory of technology and its synergetic relation to the "literacy doctrine". By "literacy doctrine" the author means the discourse which encourages the discussions about the existence of many types of literacy, each related to the respective type of communication technology. The thesis of this paper is that the concept of literacy acquires completeness based on the philosophical grounds of the theory of technology as "extension". The purpose of the article is to present the two research fields and their mutual reinforcement and to address the question to what extent can we agree with the usually refuted principle of technological determinism, which is evident in them, given that the concept of literacy is widely used in contemporary discussions of education in pedagogy, media research, and policy documents. The article consists of three parts: the first presents the theory of technology as an "extension", the second presents the doctrine of literacy and its interaction with the theory of technology as an extension, and the third one discusses the idea of the pre-set structure of knowledge form the point of view of Heidegger's analysis on the essence of technology. The conclusion of the article recommends the strong definition of multiliteracy as a principle in education.

Keywords: extension theory of technology, literacy, multiliteracy, truth, education.

Резюме: (За синергията между теорията за технологията като екстензия и доктрината за грамотността) Настоящата статия представя т.нар. теория за технологията като "екстензия" и нейната връзка с "доктрината за грамотността", която се определя като синергетична. Под "доктрина за грамотността" тук се има предвид дискурсът, който окуражава дискусиите за съществуването на много типове грамотност, всеки от които е съотнесен към определена комуникационна технология. Тезата на статията е, че

понятието за грамотност добива смисъл и пълнота, поставено на философската основа на теорията за технологията като "екстензия". Целта на статията е да представи двете изследователски полета и тяхното взаимно усилване и да постави въпроса доколко можем да се съгласим с обикновено отхвърляния принцип на технологичния детерминизъм, който прозира в тях, при положение че понятието грамотност е широко използвано в съвременните дискусии за образованието в педагогиката, медийните изследвания и политическите документи. Статията се състои от три части: първата представя теорията за технологията като "екстензия", втората представя доктрината за грамотността и нейното взаимодействие с теорията за технологията като екстензия, а в третата се дискутира идеята за предварително зададената структура на знанието от гледна точка на анализа на Хайдегер за същността на технологията. Заключението на статията препоръчва силната дефиниция за мултиграмотността като принцип в образованието.

Ключови думи: теория за технологията като екстензия, грамотност, мултиграмотност, истина, образование.

1. The extension theory of technology

The main idea of the extension theory of technology is that technology externalizes the limited human physical and cognitive abilities into various and more powerful weapons and tools which causes profound cultural and social transformations.

The *extension theory* of technology can be traced back to 1877 when the German philosopher of technology and geographer Ernst Kapp writes about the technical artifacts as projections of human organs (Kapp 2018; Brey 2000).

Eighty years later, M. McLuhan (McLuhan 1994) also writes about technology as "extension": According to Logan, he uses the words "extend", "extensive", "extension" 93 times in *The Gutenberg Galaxy* and 367 times in *Understanding Media* (Logan 2013: 48). McLuhan's ideas directly influence or infiltrate media and technology research and are valuable for understanding human and technology relations in the following decades. The essence of the extension theory can be introduced by his words: "All media are extensions of some human faculty – psychic or physical". "The wheel is an extension of the foot", clothing is an "extension of the skin" and electric circuitry is "an extension of the central nervous system" (McLuhan, Fiore 1967: 26). McLuhan uses the word "media" for all technologies and tools and regards communication media as special extensions of the psyche: all technologies are considered media in the sense that they "mediate our interactions with our environment" (Logan 2013: 47). In particular, communication media become extensions to human senses that expand and alter the abilities to perceive the world (McLuhan 1994).

In the 1990s D. Rothenberg approaches the question of technology and argues that only mechanical faculties can be extended by technology - like the function of eyes, arms, legs, and ears – while the faculties of judgment, moral reasoning, and spirituality are not extendable (Robertson 1994).

The theory of technology as an extension inspires the development of the "extended mind theory" in the works of the media ecologist R. K. Logan who explores the origin of

language (Logan 2004, 2006, 2013; McLuhan, Logan 1977). Simultaneously, in the field of cognitive science and philosophy of mind, Chalmers and Clark suggest their extended mind thesis, according to which the human mind is distributed among brain, body, and external technical devices (Clark, Chalmers 1998; Clark 2001).

At the end of the 1990s, one of the leading proponents of extension theory in French philosophy becomes B. Stiegler who defines technology as *a prosthesis* (Stiegler 1998) taking inspiration from David Will's (1995) idea of "prosthesis". Stiegler goes deeper into the concept of technology as a prosthesis of knowledge. He describes the prosthesis as not a supplement, nor a replacement, but something that is "set in front", "set in advance" adding to our cognition a preliminary structure (Stiegler 1998: 152). He literary writes: "Technique is what is placed before us" (Stiegler 1998: 235) referring to how technology works as a mediator of knowledge. This defines technology as a very substantial and influential agent of cognition, not simply a "'means' for the human, but its end" (Stiegler 1998: 152).

Brey (Brey 2000) makes an important contribution to extension theory rejecting the thesis that the technological "artifacts are functional copies of human organs" (Brey 2000: 8), which Kapp proposes, and redefines Rothenberg's claim that technology extends human intentions in the following way: "technology extends the means by which human intentions are realized" (Brey 2000: 8). His thesis overcomes the initial flaw of the extension theory to claim morphological or more abstract similarities between organs and technology. It admits that artifacts add "functional features" to the human body but also "accounts for artifacts that have functional abilities not possessed by human faculties, such as the ability to give light, ionize, or magnetize" (Brey 2000: 9). He distinguishes between *amplificatory extensions*, which amplify existing function, and *separate extensions* which "form a new functional unit" like the piano that does not enhance the "already existing capacity of the hands to produce music" (Brey 2000: 15).

His argumentation strengthens the extension theory and its connection with the perspective of embodied cognition. He writes that both types of extensions – amplificatory and separate – form a "symbiotic relationship with human organs" and engage in *embodiment relations*. The proximity between ideas of embodied cognition and extension theory (in particular extended mind) can be explained by the factor of mediation: in the embodied cognition argument cognition is mediated by the human body, while in the extension theory argument the prosthesis of technology is the mediator of cognition. In the idea of "prosthesis", the point is that computers, as well as eyeglasses, are perceived as inseparable from the cognitive process. The symbiosis is considered so full that the evolution of the prosthesis is regarded as constituting the very reality of human evolution (Stiegler 1998: 50).

Brey explicates why the extension theory of technology is important: it raises the questions about human nature and the implications of technology for society and culture; the theory contributes to the analysis of the evolution of technology, as well (Brey 2000: 15).

The author here proposes that the framing and justification of the literacy concept are among the important implications of the extension theory of technology. The opposite, however, is also valid: the literacy concept strengthens the extension theory. The following section will present how studies on the cultural and social effects technology facilitates are used for the reinforcement of the theory of technology as an extension with empirical data and analysis.

2. Literacy doctrine

There is a common base of ideas that unites the extension theory of technology, shaped within the field of philosophy of technology mainly in the second half of the 20th century, and literacy doctrine whose origins are in the field of Classical Studies and Linguistics. This common base can be expressed in the following way:

Communication technologies mediate the way we produce, store and communicate information. The mediator affects the form and content of information. The form and the content of information affect our concept of truth and knowledge. And our concepts of truth and knowledge affect our concept of reality.

Literacy doctrine provides a model about how we produce our reality by means of communication technology and how we can reach the message communicated through the respective technology. By the concept of "literacy doctrine" here is defined the discourse which encourages the discussions about the existence of many types of literacy, related to different technologies and the skills, associated with them.

The understanding that there is no single type of literacy has built up gradually in the last century. As contributors to this field could be considered many researchers who study and describe the effects of technology on knowledge, perception, truth, illusion, public opinion from the point of view of various disciplines like literature studies (M. Parry, A. Lord, I. Watt), social anthropology (J. Goody), history (W. Ong), linguistics (Saussure), aesthetics and visual arts (E. Gombrich), journalism (W. Lippmann), political studies (H. Lasswell), media studies (L. Masterman, D. Buckingham), philosophy (S. Sontag, R. Barthes, J. Baudrillard) and many others who never explicitly worked in support of literacy thesis, but their contributions provided valuable insights, analysis, and data.

Since the 1920s the ideas about oral and written cultures as different modes of knowledge gradually built up following the pioneering work of Antoine Meillet and M. Parry. Parry developed the oral-formulaic theory of epic poetry which introduced the memory-friendly form of knowledge – the poetics of formulas – as an important feature of oral memory (Parry 1930, 1932, 1933). The uniqueness of oral cultures comes from the particular way human speech acts as a technology for communication. The effects of oral culture on knowledge lead to a number of specifics like the identification of knowledge with the knower (Havelock 1994), construction of "memory aids" (Havelock 1994), "communal development of knowledge" (Carr 2020: 47) situational learning (Ong 2013), no difference between recollection and doing (Illich, Sanders 1989: 15), sound, action, and power (Ong 2013). Here the content of knowledge is stored in the artistic and entertaining forms of myths and legends, poems and songs, sayings and proverbs, and the very way for production and transmission of this knowledge facilitate the formation of ahistorical, anthropomorphic, situational, and pluralistic truths - very different from the truths that later technologies for transmission and production of knowledge facilitate.

Oral literacy seems to be what we call today "fluid" competencies: social competence – communication skills, soft skills, burgeoning skills, negotiation skills, problem-solving skills; emotional competence – body language recognition, empathy. Cultivating oral culture today means to maintain competencies coming from a time when trust, memory, emotion, community, and face-to-face communication were the main facilitators of knowledge.

However distant it may appear, orality and its respective literacy have intransitive importance, because they are part of the process of individual cognitive development. Every person goes through the years of purely oral culture. The world of pre-literate children is full of animated-natural forces and magical thinking. Orality seems to be a stage of importance for the way one tends to frame reality later in life too. For example, even among literate adults, we can find a strong inclination to magical thinking associated with the belief in conspiracy theories (Uscinski 2019).

An influential wave of studies concerns the cultural transformation from oral to written societies and it is important for the formation of **literacy thesis** (Ong 2013; Goody, Watt 1963; Havelock 1994; Goody 1973, 2011) claiming a causal connection (dependence) between technological development and cultural changes. The critique and opponent of the thesis Halverson summarizes it in the following way: "the development of logical thought ('syllogistic reasoning', 'formal operations', 'higher psychological processes') is dependent on writing, both in theory and in historical fact" (Halverson 1992: 301).

McLuhan and Logan express their conviction that the phonetic alphabet "played a particularly dynamic role" and provided the "ground" for the mutual development of "codified law, monotheism, abstract science, formal logic, and individualism" (McLuhan, Logan 1977: 374; see also Logan 2004). The supporters of literacy thesis (Ong 2013; Goody 2005; Goody, Watt 1963; Illich, Sanders 1989) agree that formal logic and categories deny the myth and magical thinking the right to be a truth carrier and open the way to the logical, infinite, abstract, formal, and exclusive concept of truth. In this line of thinking Homeric Greece and Plato's Greece shape two different worlds living in two different modes of knowledge and truth (Havelock 1994).

The "causal" and "deterministic" parts of the original thesis have been often contested later, but the idea that there is a relation between the type of communication technology and the forms, in which knowledge is transferred, has proved very agile and was revived and refined many times by each literacy concept and finally by the spread of literacy doctrine. The literacy doctrine today discards the explicit claim about causal connections between writing and syllogism, communication technologies, and progressive cognitive development, but adheres to the idea of the different modes of reality communication technologies create.

The same principle of distinguishing between periods as shaped by different modes of knowledge and truth starts to apply in the next decades to differentiate changes in the mediators of knowledge following the main revolutions in communication technologies. The controversies and conclusions surrounding the literacy thesis encourage further the idea of research and consideration of the specific cultural outcomes of each communication technology.

There is a widespread agreement that the invention of the printing press, for example, stimulates scientific thinking and discoveries and conditions the development of science. The printing press is credited for the spread of alternative views critical of the Catholic Church and the advance of Reformation and Enlightenment in Europe (Rubin 2014).

Today there are skills and competencies associated explicitly with science and research. **Scientific literacy** is not discussed in the literature in terms of "literacy", but it is possible to define it as a set of skills and competencies to perform a "set of reasoning processes that permeate the field of science: induction, deduction, experimental design, causal reasoning,

concept formation, hypothesis testing" (Dunbar, Klahr 2012: 2). What Einstein describes as exclusive for the scientific approach is the "painstaking and systematic choice of experimental material, and greater logical economy" (Dunbar, Klahr 2012: 2). The point of scientific literacy is also to be able to understand and follow scientific reasoning and to be able to think in abstract concepts and ideas, to reflect on them, to create and test a hypothesis, to apply methods, and to construct a scientific concept of causality, which is different from the transductive (particular to particular inference) operations, characteristic of purely oral stages of human cognitive development (Piaget 1930). The scientific ideal of truth is presented as mathematical, empirically provable, experimentally reproducible, and also reaching logically consistent and universal knowledge. It is expected to be empirically verifiable or falsifiable with clearly defined scope and validity.

The research on photography (Sontag 2005, Barthes 1996), studies on visual arts (Berger 1972, Gombrich 2014), advertisement, and propaganda (Lasswell 1938) add more analysis and data. This results in the rise of the **visual literacy** concept. Light, space, color, brightness, patterns, stereotypes, models and schemes, etc. are analyzed as key elements of the "world of images" (Sontag 2005), which is seductive, suggestive, and on its way to substitute the real world for the imagined one. The world of images is believed to generate hyper-reality, and the human world is seen as a simulacrum - a simulation of the real without the real (Baudrillard 1988). Visual literacy comes as a response to the advance of hyperreality and the reversal of the Plato cave concept of truth.

In the second half of the 20th century, awareness is raised about the consolidation of power, knowledge, and technology. There is a wave of studies on techniques and effects of propaganda, on social psychology and the formation of public opinion (Lippmann 1998; Lasswell 1938). Frankfurt school engages with the critical theory of consumer culture. Marcuse notes the transformation of individual rationality, based on free reason, into technological rationality, based on efficiency (Marcuse 2004). In Europe Deleuze and Guattari (Deleuze, Guattari 1983) speak of machines as systems for re-making the world to their logic. French philosophers of the 20th century as Althusser, Deleuze, and Foucault, are particularly critical of the state as setting the rules for the production of truth. In the second half of the 20th century, the ability to distinguish truth from untruths becomes increasingly important. In the 1980-1990s media has the indisputable status of the fourth power, capable to rule public opinion, and **media literacy** is recommended to provide the skills to evaluate media content (Buckingham 1990, Masterman1990).

At the beginning of the 21st century, **digital literacy and computer literacy** come into usage following the spread of the internet and the advancement of computer technologies. Now in the second decade of the 21st century, the concept of **information literacy** is also in use. The concept is applied either in the narrow sense of "digital literacy" (EU Science Hub 2021) or in the broader sense of multiliteracy (see Breivik 2005, Chart 1).

At present, the concept of **multiliteracy** gains popularity since the turn of the century and is proposed as a leading paradigm in education for the 21 century (Cope, Kalantzis 2005; Cope 2015; Cope, Kalantzis 2020). It is a uniting concept which signifies the whole complex of literacies, each with its relevant skills to access, understand, evaluate and use the knowledge provided in different technological modes (oral, written, visual, and digital). Today any concept of literacy assumes that the transfer of knowledge requires a

process of coding and decoding information via certain technology like speech, alphabet, science, images, algorithm all of which we have to be able to "read". These technologies create different modes of knowledge as different as "independent languages each with its own unique semantics and syntax" (Logan 2006*).*

The concept of "literacy" is often used in various contexts concerning the ability to navigate in the complex techno-cultural environment. The credo of literacy doctrine today can be expressed in the following way: "Historically, each new type of communication technology – language, writing, printing, photography, and video, digital computing - is related to changes in the way we frame the information and consequently requires the respective type of literacy which consists of the skills and competences to decode, evaluate and use this information as truth or untruth".

The theories for technology as extension and literacy thesis here form a unity, which responds to the problem of adaptation to the changing technological environment. We can choose to use the concept of literacy in the narrow sense only – like the technical ability to read, write, produce and process images and digital content. This usage sets the limits of literacy to the technical skills and job market.

In a broader philosophical sense, the concept of literacy presents the challenge to recognize that we "set in front" of our knowledge about reality a certain mediator. It requires not only certain technical skills to use the media, but also awareness of the different settings of this media environment for the production of knowledge and truth. The philosophical idea of how technology creates a pre-set structure for knowledge and truth synergistically intertwines with the spirit of literacy thesis, literacy doctrine, and multiliteracy concept. Together they work best in a techno-deterministic philosophical environment and take their meaning and explanatory power from it.

It is logical to ask the question is this all the human knowledge can be – always dependent on the pre-set frames of the human body or its prosthetic extensions? The analysis of Heidegger on the essence of technology and truth introduces more aspects of the problem.

3. The medium is the message

Heidegger's philosophy of technology goes deeper into the relation between truthful knowledge and technology and explains the difference in truths we can reach by two different approaches – philosophical and technological (Heidegger 1977). Each of them has distinct goals.

The philosophical approach depends on the ability to contemplate the world and to keep a distance from it. Here we delve into philosophical questions like those about the ultimate reality of being and for the reasons the things to exist. Here one of the main interpretations of causality is created – the so-called "ontological dependence" argument, according to which one thing is dependent on another which ultimately leads to the conclusion that there is the first cause of existence. Knowing the first cause since the time of Hinduism and Vedas is equal to knowing the truth about being – what it is and why it is. Modified by Aristotle in Europe this theory of causality teaches that to know the truth about a single thing we have to ask about the four causes of its existence – the material, formal, moving, and end cause. Knowing the four causes reveals the authentic, primordial truth about the object. This is a

philosophical knowledge achieved in the state of contemplation or meditation. The phenomenological approach of Heidegger teaches that when we know the four causes, we reveal the authentic truth – then truth goes from concealment into unconcealment (Heidegger 1977).

Unlike philosophy, technology reveals truth only framed by utilitarian ends. This is because the technology by definition is a tool and defines its object as a means to an end. Technology does not care about contemplating the authentic philosophical truth. It primarily cares about the moving and end causes of object existence as a resource. This makes technology a medium of a certain concept of truth and it is important to pay attention to it.

In the history of the development of human culture, there are three main philosophical theories of truth created – the correspondence theory, the coherence theory, and the pragmatic theory. In the correspondence theory, the concept of truth applies to *being*. Our statement about reality needs a referent like fact. (For example, in the case of a deepfake video, we know that it should have a real referent). In the coherent theory, the concept of truth applies to *thinking*. Our statement is true if it is a part of a coherent system of beliefs. A deepfake video can be considered authentic if it satisfies the condition of coherence, for example, on a visual and technical level. Correspondence theory as much as the coherence theories are part of the philosophical paradigm starting with Parmenides which equals being and thinking. At the end of the 19th century, the paradigm of equivalence between being and thinking is abandoned for the sake of a new one - the pragmatic theory of truth: it applies to *doing* (Drucker 1993). Truth is usefulness and we may ask about who did the deepfake video and for what purposes. In comparison to the first two theories which refer respectively to the material and formal cause of being, the pragmatic truth is external to any essential features of being or thinking and refers to the moving and end reasons of its object. The pragmatic theory of truth defines expediency as the main criterion of truthful knowledge. Here the truth value is linked to the fluid concept of "the best interest" when truth becomes itself a technology.

It is noteworthy that historically the pragmatic concept of truth follows the advance of technological revolutions when capitalism strengthens the priority of instrumental reasoning. At the end of the 19th century, truth falls from the realm of absolute values. Then Nietzsche writes that "there is *no truth*" (Nietzsche 1968: 14) that "will to truth" is "only a form of the will to power" (Nietzsche 1968: 314). In the pragmatic approach, truth becomes a resource, a means for power which is well discussed by the Frankfurt school and referred to by Foucault's concept of "truth regimes" (Foucault, Gordon 1980). The utilitarian approach is neither based on consistency, nor relevance between words and facts. In the 21st century, even science is framed by the new paradigm of utilitarianism and the "apparatus", which employs the concept of "expediency". Truth is simply a technology for achieving certain goals. The concept of truth regimes of the 20th century reveals that truth is not an epistemological, but also a political question. In its turn education is seen to be not a search for truths but a part of something bigger like the ideology, the state, the political order, the global arrangement of the "apparatus" which unites technology, business, human wishes, and culture into one powerful and inescapable world (Althusser 2014 and French philosophy of the 20th century). The excessive accent on truth as technology seems to be what produces the

epidemic of post-truth today. To the extent the economic crises in 2008 resulted from the bubbling credits, post-truth today results from the bubbling pragmatic concept of truth.

However, there are limitations to its approach – literacy has limits set by technology and utilitarian attachment to resources. As far as we wish to take a philosophical stance towards reality, to keep a distance from it, we can see a certain difference between adaptive learning (obtaining technology-relevant skills and adaptation to environment) and reflective thinking, which can embrace a certain level of pragmatic irrelevance. Searching for truths free from instrumental reasoning opens a different horizon.

Let's go back to the time of the cognitive revolution. Speech is the main advanced technology for communication which makes it possible to talk about non-existing things including past and future and having no referent in the present. Here the problem of truth starts. Thus, the state of pre-orality has a certain philosophical value. It describes the goal of the ancient teachings, which develop meditation as a special technique for freeing the mind from thoughts and concepts and subjugating the senses and instincts to the goal of disembodied cognition. This state of mind is valued because of the belief that concepts, language, thinking are hiding the truth about reality. To reach this hidden truth, mind and body need to be trained until the chain of embodied cognition breaks. Freedom comes in the momentous and unmistakably clear experience of enlightenment when one reaches the truth beyond body senses and embodied mind. In Hinduism, it is believed that in the state of nirvana (enlightenment) the self merges with the non-I and man reaches the universal principle of Brahman, which is the material, formal, moving, and end cause of all existing things.

There is no contradiction to be sought between technological skillfulness and the philosophical search for authentic truths. They are complementary approaches to knowledge. In terms of education, they both are necessary either to automate live skills, or to wisely reflect on stereotypes, schemes, and prejudices (to name a few well-known pre-set structures). Yet, a good point of view presents Heidegger's analysis on the essence of technology which shows that it is a mistake the reality framed by technology, by the pragmatic concept of truth, to be regarded as authentic truth. It is worth thinking why meditation (which is the practice assisting philosophy of enlightenment for ages) has become one of the most popular activities around the world, including in Silicon Valley, in time when technological revolutions permanently cage reality in the fast-paced, instrumental frame of techno-logos. Today we face unprecedented growth of knowledge and truths and the highest ever chaos concerning what truthful knowledge is. The luxury to slow down, pay attention, concentrate and reflect on the environment, own feelings, thoughts, and actions is becoming the biggest challenge to the future of learning.

4. Conclusions

The question, finally, is when we think about the future of education and the task of edifying not only literate but also (self-)reflective human beings, can we recommend the extension theory of technology as a proper approach to knowledge and truth or we can disregard it?

Only a century ago, defining technology as a driving force in history is more a questionable feeling than a convincing reality. Today we witness the creation of a brain-computer interface, we live with the concept of disruptive biotechnologies and cyborgs of the future, and we read about AI hacking humans and techno experts' expectations of singularity. The influence of technology on everyday human life and history is so pronounced that we are even forced to surrender our capacity and pride to be producers of knowledge and truth to algorithms and our own life gets datafied and profiled beyond our control. This could mean that the controversial discourse of technological determinism is growing in relevance and its philosophy is getting difficult to disregard.

To a certain extent multiliteracy in education is possible without the philosophical background of the extension theory. Yet, we have a meaningful justification of literacy doctrine only when we question the problems of "truth" and "semantics" of each medium. The "strong" definition of multiliteracy resulting from the synergy between literacy doctrine and extension theory of technology can be defined as literacy which develops the skills to understand and use all the different technological frames of knowledge through which we form our knowledge and concept of truth and reality. The different framings mean a different truth – it could be the truth of myth or magic, bureaucracy or sacred books, science or data science. They all have a different concept of truth – how to produce it, how to transfer it, where it applies.

This strong version of multiliteracy principle can be easily adapted to the school system, because the school system is adapted to the stages of human cognitive development. There is a clear parallel between skills the children develop in their individual cognitive development and the basic types of literacies following the historical development of speech, writing and science. The multi-literacy principle aligns very well with the stages of human cognitive development as studied by psychologists. It just has to be more pronounced, well understood and justified in school strategies and educational schedules.

The advantages of applying the strong version of multilitaracy to education include awareness of how the pre-set structure of knowledge works; a concept of how human mind and technology interact; well-defined limits of utilitarian approach to truth and reality. Knowing the different frames of knowledge is a step to the future of prostheses and hybrids, when we will need both technical literacy and (self)reflection in order to live with the truths which information technologies and biotechnologies are about to open.

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